Available online at www.sciencedirect.com
SCIENCE DIRECT
ELSEVIER
Economics and Human Biology 3 (2005) 388–404
ECONOMICS AND HUMAN BIOLOGY
http://www.elsevier.com/locate/ehb

Healthcare infrastructure, contraceptive use and infant mortality in Uttar Pradesh, India

Alok Bhargava [a,*], Sadia Chowdhury [b], K.K. Singh [c]

[a] *Department of Economics, University of Houston, Houston, TX 77204-5019, USA*
[b] *The World Bank, Washington, DC, USA*
[c] *Banaras Hindu University, Varanasi, India*

Accepted 14 September 2005

Abstract

This paper analyzes data on approximately 30,000 women from a survey in Uttar Pradesh in 1995 together with the data from surveys of public and private providers of healthcare and family planning services. A framework was developed for analyzing the effects of quality of services on utilization, and for understanding the gradual evolution of the healthcare infrastructure. The empirical results from logistic regressions for use of female sterilization and IUD showed significant effects of quality of services in government and private hospitals, and of socioeconomic variables such as education, caste, and an index of household possessions. Secondly, models for infant mortality of children born in the preceding 3-year period showed significant effects of socioeconomic variables, quality of healthcare services and birth spacing. Lastly, analysis of data at a more aggregated (Primary Sampling Unit) level indicated differential effects of economic development on the quality of services available in the public and private facilities.

JEL classification: C5; C35; I12; O12

Keywords: Infant mortality; Contraceptives demand; Birth spacing; Healthcare; Economic development; Uttar Pradesh

1. Introduction

Economic development generally entails the availability of a skilled labor force capable of exploiting the opportunities afforded by technological advancements in the production of goods and services. Creating a skilled labor force, moreover, requires resources for educating children and is facilitated by small family size especially for poor households (Bhargava, 2001). It is

* Corresponding author. Tel.: +1 713 743 3837; fax: +1 713 743 3798.
E-mail address: bhargava@uh.edu (A. Bhargava).

1570-677X/$ – see front matter
doi:10.1016/j.ehb.2005.09.001

therefore natural for social scientists to be concerned with issues of high fertility in less developed countries. However, the previous demographic literature has followed different approaches for exploring the inter-relationships between fertility and child mortality. While Taylor et al. (1976) have argued that a high probability of child survival is necessary for reducing fertility, Scrimshaw (1978) and Cleland (1996) have emphasized that 'unwanted' fertility is likely to exacerbate child mortality. These views can be reconciled by recognizing that they potentially apply to different time frames. Historically, a decline in child mortality was likely to precede reductions in fertility. At a given point in time, however, households without access to health care typically have large families and experience greater child mortality especially at high parities (Bhargava, 2003).

Further, following the work by Becker (1982), economists have emphasized that family planning programs in developing countries may be ''endogenously'' placed in response to health conditions in the region; more complex statistical techniques are necessary to tackle such problems (Angeles et al., 1998). While governments often require placement of public health facilities on basis of population (Koenig et al., 2000), the quality of services is likely to depend on economic development in the region; it is often difficult to relocate skilled medical personnel in remote areas. Moreover, in countries such as India, there has been a rapid rise in private providers of healthcare (Peters et al., 2002) that is likely to increase utilization and can in turn influence the quality of care in public facilities. Such issues merit analytical and empirical investigations; poor quality of public services in backward regions and increased role of private providers have different implications for child mortality than models emphasizing the endogenous placement of public facilities.

The data set on 'performance indicators' of healthcare programs ('PERFORM') in Uttar Pradesh (SIFPSA, 1996) on approximately 40,000 households, and 2400 'fixed service delivery points' such as clinics and hospitals, and 22,000 'private agents' (e.g. doctors) offer an opportunity to model the proximate determinants of contraceptive use and infant mortality using indicators of service quality in public and private sectors. Previous analysis by Stephenson and Tsui (2002) has provided insights by modelling the demand for contraceptive use for a subset of households in five districts of Uttar Pradesh. However, the authors did not differentiate between terminal methods such as sterilization and the methods for birth spacing such as condoms and birth control pills. Because a majority of couples in rural areas rely on sterilization after surpassing their fertility goals, the proximate determinants of contraceptives for birth spacing and terminal methods are likely to be different. Moreover, little medical expertise is necessary for dispensing condoms and pills. By contrast, sterilization and intra uterine device (IUD) insertion require skilled services. Timing of couples' decisions to opt for terminal methods is likely to be influenced by the quality of the healthcare infrastructure.

Another attractive feature of the PERFORM survey is that detailed information on ante-natal care, delivery, and post-natal care was compiled for all births in the 3 years preceding the survey. In addition, the women were asked if the child born was wanted or if they would have preferred to have had the child 'later' or 'never'. While responses to such questions might not fully assess the intensity of 'unwantedness' of births, such measures have been employed in previous demographic research (Bongaarts, 1990, 1993; Montgomery et al., 1997; Marston and Cleland, 2003). From the standpoint of utilization of healthcare and family planning services, one can investigate if the approximate degree of unwantedness of births had a negative impact on the chances of infant survival.

The structure of the paper is as follows: Section 2 describes the PERFORM data and outlines the variables used for constructing indices to approximate the healthcare infrastructure in public and private facilities. Section 3 develops the analytical framework; it is argued in Section 3.1 that in view of the biological and socioeconomic processes involved, it is appealing to analyze the

supply and demand for contraceptives rather than for children. Section 3.2 discusses the gradual evolution of the healthcare infrastructure with economic development and its impact on utilization and quality of public and private services available in the region. The empirical models are outlined in Sections 3.3 and 3.4, and certain estimation issues are briefly discussed. The results from estimating models for contraceptive use are presented in Section 4.1. The results from models for infant mortality are in Section 4.2 and those from an analysis of data on healthcare infrastructure in public and private facilities at the Primary Sampling Unit (PSU) levels are in Section 4.3. The conclusions are summarized in Section 5.

2. The data

The PERFORM survey was designed to measure indicators of reproductive health at three levels. First, data were compiled on public and private providers of healthcare. Second, the work experience of staff in the delivery points was investigated. Finally, detailed information was compiled on married women who were likely to utilize healthcare and family planning services. The survey used a systematic multi-stage cluster sample of households and service delivery points. Two districts from each of the 14 administrative divisions were selected. The survey was carried out in 1995 in 1539 villages and 738 urban blocks within 1911 Primary Sampling Units (PSUs), interviewing 40,633 households, 2428 fixed service delivery points and 6320 staff members, and 22,335 individual service agents such as health workers and medical shops (SIFPSA, 1996).

The Urban Block and Village questionnaires investigated the number of households, clinics, private practitioners, cooperatives, voluntary organizations, and industries in the region. The Household questionnaire investigated demographic composition of the household, land holding and other variables. For example, households were questioned about six possessions, i.e. if they owned a clock or a watch, fan, radio, television, bicycle, and a motorcycle, scooter, car, or a tractor. The affirmative answers were summed to form an index of possessions for approximating the socioeconomic status; the use of factor analysis led to very similar results. The Women's questionnaire covered variables such as marital status, reproductive history, access to healthcare and family planning services, quality of services, fertility preferences, and contraceptive use. There was detailed information on up to three births in the previous 3-year period. Vaccinations against tetanus and complications during and after the pregnancy were recorded.

The Fixed Service Delivery Point questionnaire investigated the availability of services such as male and female sterilization, IUD insertion and medical termination of pregnancy. Providers were mapped to households in the PSU. The number of months of supply of contraceptives such as condoms and pills were inquired. Staff in the facilities, including doctors, nurses, and social workers, were interviewed to assess their qualifications. Several indices were constructed to approximate the healthcare infrastructure (Mensch et al., 1996).

The number of allopathic doctors (i.e. trained in ''Western'' medicine) performing male or female sterilization, inserting IUD, and terminating pregnancies was calculated separately for government hospitals, community health centers, private hospitals, and private agents (i.e. medical personnel such as doctors and nurses). The total numbers of staff as well as the averages calculated over the respective types of facilities were used as indicators of the healthcare infrastructure. The use of averages enabled comparisons across groups though aggregate figures were sometimes used in the analyses. Similarly, the number of 'full-time equivalent' staff and those devoted to family planning services in public and private facilities were calculated; averages over the facilities and for private agents were used. The numbers of months of supply of condoms and birth control pills in public and private facilities and by private agents were

calculated from responses of the providers. Because some private agents were ''unqualified'', the indices aggregated over the personnel that were trained for specific procedures such as sterilization and IUD insertion. Overall, indices based on the data from fixed service delivery points and private agents and the information on numbers of government and private hospitals and allopathic doctors provided an assessment of the healthcare infrastructure available to women in the PERFORM survey.

The sample means and standard deviations of selected variables are presented in Table 1. The calculations were performed in SPSS (1999) using the data on contraceptive use and for women who had a birth in the previous 3-year period. Approximately 68% of the women had never attended school; average number of children was 3.49 in the sub-sample covering contraceptive use. Female sterilization was the most common method of family planning, with 15% women opting for the procedure; only 1.4% of men were sterilized. Percentages of couples using IUD, birth control pills and condoms were, 1.5, 1.7 and 3.7, respectively; only 0.7% of the women

Table 1
Sample means (or percentages) and standard deviations of selected variables in the models for contraceptive use and infant mortality estimated from the PERFORM survey from Uttar Pradesh[a]

	Mean	S.D.
Woman's age in years	29.74	8.54
Ever attended school (1 = yes, 0 = no)	0.32	0.47
Number of children born	3.49	2.27
Number of surviving children	2.99	1.85
Household possessions index (0–6)	2.67	1.79
Backward caste (1 = yes, 0 = no)	0.51	–
Woman sterilized (1 = yes, 0 = no) (%)	15	–
Man sterilized (1 = yes, 0 = no) (%)	1.4	–
Women using IUD (1 = yes, 0 = no) (%)	1.5	–
Women using birth control pills (1 = yes, 0 = no) (%)	1.7	–
Man using condoms (1 = yes, 0 = no) (%)	3.7	–
Number of women with a birth in the 3-year period	19,620	–
Children who died before reaching age of 1 year (%)	3.9	–
Births wanted 'later' (%)	7.5	–
Births wanted 'never' (%)	5.5	–
Birth interval for birth in years	3.09	2.07
Women vaccinated against tetanus (%)	54	–
Number of women with two births in the 3-year period	2037	–
The second birth wanted 'never' (%)	5.9	–
Average number of government hospitals in PSU	0.63	2.58
Average number of private hospitals in PSU	0.13	0.58
Average number of private allopathic doctors in PSU	0.33	0.85
Average number of private doctors trained in terminal FP methods in PSU	0.029	0.024
Average family planning staff—government hospitals	2.45	7.50
Average family planning staff—private hospitals	1.72	7.20
Average family planning staff—community health centers	11.03	60.37
Months supply of birth control pills and condoms—government hospitals	0.21	1.08
Months supply of birth control pills and condoms—private hospitals	0.21	1.09
Months supply of birth control pills and condoms—community health centers	0.54	1.52
Number of private agents trained in dispensing birth control pills in PSU	0.22	0.82

[a] There were 30,966 and 19,632 women in the samples for contraceptive use and infant mortality. PSU = Primary Sampling Unit.

reported using a ''traditional'' method such as withdrawal. These figures were comparable to the findings from other surveys in India (Ramesh et al., 1996).

The data on 19,620 children born in the previous 3-year period were used for the analysis of infant mortality; 2037 of the women had an additional birth in this period. For women with one birth in the 3-year period, 7.4% reported that they would have preferred to have had the birth 'later', while 5.4% would have liked not to have had the birth ('never'). The infant mortality rate calculated from data on births in the 3-year period was 3.9% (39 per 1000 live births). Average birth interval was 3.09 years and the vaccination rate against tetanus was 54%.

The average numbers of government and private hospitals for the PSU were 0.63 and 0.13, respectively. While there were several private agents operating in the PSU, on the basis of qualifications to perform sterilization, terminate pregnancies and insert IUD, average for the PSU was 0.029. Average numbers of family planning staff available in government hospitals, community health centers and private hospitals were 2.45, 11.03 and 1.72, respectively; there was wide variation in staff availability that was reflected in the standard deviations in Table 1. Also, the distributions of these variables were skewed to the right and the fourth moments were above the normal values of 3. To economize on space, the supply of birth control pills and condoms were combined in Table 1; average months of supply were approximately 0.21 for government and private hospitals and private agents, and 0.54 for community health centers.

3. A framework for analyzing the effects of healthcare infrastructure on contraceptive use and infant mortality

There has been a decline in child mortality rates and an increase in life expectancy over the last half century in developing countries such as India (Preston, 1976; UNDP, 1990). Improvements in maternal nutritional status and better access to healthcare afforded by economic development are likely to lower child mortality and, with some delays, decrease the fertility rates. Because the role of socioeconomic factors has been underscored in many analyses, we reappraise some analytical issues and develop a framework for analysis of the PERFORM data encompassing the economic and demographic approaches.

3.1. Demand and supply schedules for contraceptives

Easterlin and Crimmins (1985) underscored the role of economic factors affecting the demand and supply of children, building on the earlier contribution of Becker (1965). With economic development, there is clearly a need to educate children for gaining employment in skilled occupations. This, together with a decline in child mortality and easier access to healthcare and family planning services, are likely to lower the desired family size. Because cultural factors play an important role in adoption of family planning methods (Cleland and Wilson, 1987; Dreze and Murthi, 2001), it is important to reappraise some of the postulates invoked in economic analyses of fertility behavior.

The supply schedule is used in economics to deduce the quantities of commodities offered at different prices, holding certain relevant variables constant. However, the number of children born to a married woman mainly depends on her fecundity; fecundity, in turn, is determined by biological processes that are not easily amenable to empirical modeling. By contrast, the desired numbers of children are likely to depend on economic factors such as expenditures that households can afford on food, clothing, education and healthcare, and on social and cultural factors (Cadwell, 1982). Furthermore, the *actual* number of children born to a woman is influenced by efficacy of the contraceptives used. Because factors affecting the supply schedule

for children are somewhat opaque, and demand for contraception is a ''derived'' demand for avoiding unwanted births, it would be appealing to analyze fertility behavior employing demand and supply schedules for contraceptives rather than for the children.

Further, there are differences between demand for commodities that yield utility or satisfaction and the demand for contraceptives that are inconvenient to use. It is perhaps not surprising that many couples in backward states such as U.P. rely on female sterilization after surpassing their fertility goals. This, however, does not diminish the importance of contraceptives for birth spacing. Firstly, it would take approximately two years after a birth in U.P. to ensure that the child will survive with a high probability (Bhargava, 2003). If contraceptives are unavailable in this period, the woman could become pregnant again thereby increasing her unwanted fertility; birth spacing methods are critical for achieving the *exact* number of desired children. Secondly, due to low iron and calcium stores among under-nourished women, birth spacing can improve intra-uterine growth and increase survival chances of children. Thus, the demand for contraceptives for birth spacing and that for terminal methods merit separate treatments; the supply of these services would also depend on different factors.

Terminal methods for family planning such as sterilization require skilled services and entail risks such as excessive bleeding and sexual dysfunction. The availability of qualified staff and adequate drugs are essential for encouraging couples to opt for such procedures. Moreover, the fees for services in private clinics can hinder utilization especially if public facilities do not function smoothly when judged by criteria such as ''dignity'' and ''respect'' shown towards patients (World Health Organization, 2000). Thus, variables reflecting quality of services in public and private facilities are likely to affect the use and timing of terminal methods. For example, less educated women could delay sterilization in spite of unwanted births if women in the community have reported complications. In contrast, the demands for birth control pills and condoms are influenced by economic factors and the couples' awareness of benefits from birth spacing. The supply of these contraceptives can be increased via subsidies to non-governmental organizations (NGO) and need not entail major investments in the public healthcare infrastructure.

3.2. Gradual evolution of the healthcare infrastructure versus endogenous facility placement

In India, the healthcare infrastructure has evolved gradually over time and comprises of public facilities, private providers and NGO's. Initially, healthcare was available mainly in urban areas via government facilities and from private practitioners offering services to those who can afford them. It is also common for doctors employed in public facilities to engage in private practice outside the working hours. Because life in urban areas affords opportunities such as education for children, urban areas are attractive venues for medical personnel and their families. A concentration of public and private facilities staffed by qualified personnel is likely to increase competition among providers thereby enhancing the quality of services. Even the poor seeking treatment for serious illnesses, for example, may spend their savings in private facilities if public care is viewed to be inferior.

In the absence of major public investments, healthcare infrastructure in rural areas is likely to evolve very slowly. While governments often mandate placement of hospitals or community health centers based on population, quality of services is likely to depend on the allocated resources and on the willingness of qualified personnel to serve in remote areas. Low purchasing power of households in under-developed areas reduces incentives for private providers to set up facilities. To fill the healthcare gaps, NGO's supported by the government and external agencies

often deliver basic services. The quality of services as measured, for example, by number of trained personnel providing healthcare, is likely to be poor. This would be reflected in lower utilization rates and higher child and maternal mortality.

In contrast with the gradual evolution of the healthcare infrastructure, some economists have emphasized the role of pressure groups for placement of public facilities. If, for example, programs were placed because of high infant mortality rates, then errors affecting infant mortality relationship could be correlated with variables such as distance to the nearest public facility. Such formulations, however, seem applicable to situations where government is the sole provider of healthcare and acts appropriately without delays. Moreover, governmental efforts to improve service quality are likely to be hampered by logistical difficulties in transferring advanced equipment to remote places that may lack even electricity. The facts that a high proportion of healthcare is privately provided in India and quality differentials in services have been unexplored suggest that it would be useful to analyze the effects of healthcare infrastructure on contraceptive use and infant mortality in a broader analytical framework. For example, the errors affecting a model for infant mortality that includes several variables approximating the healthcare infrastructure are less likely to be correlated with the explanatory variables since these have gradually evolved over time.

Lastly, an analysis of the proximate determinants of healthcare infrastructure in public and private facilities can be conducted using data at the PSU level. Because the PERFORM data are available only at a single point in time (in 1995), it would not be feasible to model the gradual evolution of the healthcare infrastructure. Instead, certain issues such as the effects of economic development on quality of services available in public and private facilities can be investigated. The models are outlined in Section 3.4, following the specification of models for individual level data on contraceptive use and infant mortality.

3.3. Empirical models for contraceptive use and for infant mortality

Proximate determinants of the use of family planning methods can be analyzed via binary, multinomial and ordinal regressions. As noted in Section 3.1, the supply and quality of skilled services are likely to influence decisions to opt for female sterilization and IUD use. First, the empirical model for the chances of female sterilization (or IUD use) is given by:

$$\begin{aligned}(\text{Female sterilization})_i =& a_0 + a_1(\text{woman's age})_i + a_2(\text{ever attended school})_i \\ &+ a_3(\text{no. of surviving children})_i + a_4(\text{no. of surviving children})_i^2 \\ &+ a_5(\text{possessions index})_i + a_6(\text{backward caste})_i \\ &+ a_7(\text{no. of govt. hospitals})_i + a_8(\text{no. of pvt. hospitals})_i \\ &+ a_9(\text{avg. qualified staffgovt.})_i + a_{10}(\text{avg. qualified staff-pvt.})_i \\ &+ a_{11}(\text{avg. qualified staff-pvt. agent})_i + u_{1i}(i = 1, \ldots, N)\end{aligned} \tag{1}$$

The variable 'ever attended school' was an indicator (0–1) variable that was unity if the woman had attended school and 'backward caste' was an indicator variable that was one if the household belonged to a scheduled caste or a tribe; an indicator variable for rural/urban location of the household was not significant in these models. The staff qualified to perform sterilization, terminate pregnancy and insert IUD were calculated for each facility; 'average qualified staff' variables in Eq. (1) were averages over the respective facilities, and for private agents in the PSU.

The error terms u_{1i} were assumed to be distributed as a logistic distribution for the N women in the sample; u_{1i} were assumed to be normal for probit models.

Second, the model for the chances of use of birth control pills is given in Eq. (2):

$$\begin{aligned}(\text{Pill use})_i = {} & b_0 + b_1(\text{woman's age})_i + b_2(\text{ever attended school})_i \\ & + b_3(\text{no. of surviving children})_i + b_4(\text{possessions index})_i \\ & + b_5(\text{backward caste})_i + b_6(\text{no. of govt. hospitals})_i \\ & + b_7(\text{no. of private hospitals})_i + b_8(\text{months supply pills-govt.})_i \\ & + b_8(\text{months supply pills-CHC})_i + b_{10}(\text{months supply pills-pvt.})_i \\ & + b_{11}(\text{average supply pills-pvt. agent})_i + u_{2i}(i = 1, \ldots, N) \end{aligned} \tag{2}$$

A similar model was estimated for condom use by replacing variables representing the supply of birth control pills by the respective supplies of condoms. While the stocks of birth control pills and condoms are potentially important for encouraging birth spacing, it is possible that they are influenced by the contraceptive demand; disaggregation of the stocks in public and private facilities could shed light on this issues. Non-linearities with respect to the number of surviving children were not evident in the models for the chances of birth control pills and condom use. Moreover, the models for IUD, birth control pill and condom use were re-estimated dropping from the sample women who were sterilized.

Third, in view of the fact that female sterilization was the main method for family planning, we defined an (ordered) categorical variable as zero if the couple was not using contraceptives, 1 if the woman or the man was sterilized, and 2 if the couple was using birth control pills, condoms, or IUD (i.e. $\{0, 1, 2\}$). An enlarged version of the model containing the explanatory variables in Eqs. (1) and (2) was estimated by ordinal and multinomial logistic methods (McCullagh, 1980). These regressions addressed potential inter-dependence in the choice of contraceptive methods and the estimated parameters were likely to be useful for assessing the robustness of the results from binary models.

Fourth, the model for chances of infant mortality for the births in 3-year period preceding the survey is given by:

$$\begin{aligned}(\text{Infant mortality})_i = {} & c_0 + c_1(\text{woman's age})_i + c_2(\text{woman's age})_i^2 + c_3(\text{ever attended school})_i \\ & + c_4(\text{no. of surviving children before 3-year period})_i \\ & + c_5(\text{no. of surviving children before 3-year period})_i^2 \\ & + c_6(\text{possessions index})_i + c_7(\text{backward caste})_i \\ & + c_8(\text{avg. no. of private allopathic doctors})_i \\ & + c_9(\text{avg. no. of trained FP-CHC})_i + c_{10}(\text{tetanus vaccination})_i \\ & + c_{11}(\text{birth interval})_i + c_{12}(\text{birth wanted 'never'})_i + u_{3i}(i = 1, \ldots, N) \end{aligned} \tag{3}$$

'Tetanus vaccination' was an indicator variable that was one if the woman was vaccinated against tetanus during the pregnancy. The indicator variable 'birth wanted never' was one if the woman

stated that she did not want that child. The model in Eq. (3) addressed some of the possible non-linearities in woman's age, child's birth order and/or the number of surviving children. Moreover, owing to unobserved factors that can affect infant mortality, the variable 'no. of surviving children before 3-year period' may be correlated with the error terms u_{3i} (Bhargava, 2003; Arulampalam and Bhalotra, 2004). Alternative versions of the model for infant mortality in Specification 2 replaced the surviving number of children by 'no. of children born before 3-year period'. Also, Specification 1 was estimating treating the number of surviving children before the 3-year period as an endogenous variable using a conditional maximum likelihood estimation approach (Smith and Blundell, 1986); the numbers of children born before the 3-year period and the numbers of government allopathic hospitals in the PSU were used as instrumental variables. Lastly, in Specification 3, the indicator variable 'birth wanted never' was replaced by the variable 'both births wanted never' that was one if the woman had two births in the 3-year period and stated that she would have preferred not to have had them; this variable was likely to reflect the intensity of feeling that the births were unwanted.

3.4. Proximate determinants of public and private healthcare infrastructure at the PSU level

While the gradual evolution of healthcare infrastructure cannot be modelled using cross-sectional data on providers, the government hospitals and community health centers are established on a population basis; private providers are attracted by economic opportunities in the regions. It would be useful to analyze the proximate determinants of quality of services in public and private sectors and those offered by private agents using data at the PSU level. The model for the number of family planning staff in government hospitals is given in Eq. (4):

$$\begin{aligned}&(\text{Family planning staff-govt.})\\&\quad = d_0 + d_1(\text{rural indicator})_i + d_2(\text{no. of govt. fair price shops})_i\\&\qquad + d_3(\text{no. of cooperatives})_i + d_4(\text{no. voluntary organizations})_i\\&\qquad + d_5(\text{avg. infant mortality})_i + d_6(\text{avg. possessions})_i + v_{1i}(i = 1, \ldots, N)\end{aligned} \tag{4}$$

The average infant mortality rate in the PSU was included as an explanatory variable in (4) to assess its impact on public healthcare infrastructure, as emphasized in the endogenous facility placement literature. A similar model was estimated for family planning staff in community health centers. Because healthcare services available in private facilities can be influenced by services in the public sector, the model for family planning (FP) staff in private facilities is given by:

$$\begin{aligned}&(\text{Family planning staff-pvt.})\\&\quad = e_0 + e_1(\text{rural indicator})_i + e_2(\text{no. of govt. fair price shops})_i\\&\qquad + e_3(\text{no. of cooperatives})_i + e_4(\text{no. of voluntary organizations})_i\\&\qquad + e_5(\text{avg. infant mortality})_i + e_6(\text{avg. possessions})_i + e_7(\text{FP staff-govt.})_i\\&\qquad + e_8(\text{pvt. agents trained in FP})_i + v_{2i}(i = 1, \ldots, N).\end{aligned} \tag{5}$$

In Eq. (5), the family planning staff in government facilities was an explanatory variable that might be correlated with the error terms v_{2i}. Such problems can be addressed by applying instrumental variables estimators such as two-stage least squares. The numbers of private allopathic doctors, industries, and full-time equivalent staff in community health centers were used as instruments and their validity was tested using Chi-square tests for over-identifying restrictions (Sargan, 1958). Moreover, for checking robustness of the results, the variables family planning staff in government hospitals and trained private agents were dropped from the model and a 'reduced form' version was estimated. Finally, a model similar to that in Eq. (5) was estimated for services provided by private agents trained in family planning services.

4. The results from PERFORM data from Uttar Pradesh

4.1. Empirical results for contraceptive use

The maximum likelihood estimates from binary logistic models for the chances of women opting for sterilization, and for use of IUD, birth control pills, and condoms are presented in Table 2; coefficients significant at the 5% level are marked with asterisks. In the model for female sterilization, the woman's age and having attended school significantly increased ($P < 0.05$) the chances of sterilization. There were non-linearities with respect to the number of surviving children in that birth of an additional child increased the chances of sterilization though at a decreasing rate. The households' possession index was estimated with a positive and statistically significant coefficient. While the average number of government hospitals for the PSU was not a significant predictor, the average number of private hospitals was positively and significantly associated with the chances of women opting for sterilization.

The average number of private doctors trained in performing sterilization, IUD insertion and terminating pregnancies significantly increased the chances of female sterilization. By contrast, the availability of such personnel in government and private hospitals were not significant predictors of female sterilization. Because indices based on the PERFORM data on healthcare infrastructure primarily reflected the availability of services in the PSU, these results highlight the importance of access to trained medical personnel in public and private sectors for increasing the chances of female sterilization.

The results for IUD use were similar in many respects to those for female sterilization but there were some differences. For example, coefficient of woman's age was estimated with a negative sign indicating that younger women were more likely to use IUD, presumably for birth spacing. Also, women from backward castes and tribes had significantly lower chances of IUD use. Coefficients of the indicator variable for school attendance and the number of surviving children were similar in the models for female sterilization and IUD use. The average number of trained private doctors and staff available in government hospitals were positively and significantly associated with IUD use.

The empirical results for the use of birth control pills and condoms were similar in many respects. The relationships were linear in the number of surviving children; older women and their husbands were significantly less likely to use birth control pills and condoms, respectively. The household possessions index was positively and significantly associated with birth control pill and condom use. However, women from backward castes and tribes were less likely to use these methods. While the supplies of pills and condoms in government hospitals and community health centers were not significantly associated with pill use, the number of trained private agents was a positive and significant predictor. The number of months of supply

Table 2
Maximum likelihood estimates of binary logistic regressions for the use of female sterilization, IUD, birth control pills and condoms explained by demographic, socioeconomic and healthcare infrastructural variables using the PERFORM survey[a]

	Female sterilization		IUD		Birth control pills		Condoms	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Constant	−7.043*	0.115	−4.437*	0.239	−3.026*	0.199	−3.248*	0.149
Woman's age	0.082*	0.002	−0.036*	0.008	−0.063*	0.007	−0.040*	0.005
Backward caste	0.010	0.034	−0.664*	0.170	−0.380*	0.091	−0.398*	0.069
Ever attended school	0.430*	0.040	0.835*	0.108	0.505*	0.097	0.930*	0.073
No. of children surviving	1.300*	0.046	0.318*	0.104	0.168*	0.029	0.045*	0.023
(No. of children surviving)^2	−0.150*	0.005	−0.040*	0.014	–		–	
Household possessions index	0.121*	0.010	0.254*	0.030	0.136*	0.027	0.245*	0.021
Average number of governmental hospitals	0.014	0.076	−0.557*	0.283	−0.434	0.267	−0.116	0.156
Average number of private hospitals	0.088*	0.025	0.059	0.064	−0.027	0.071	0.112*	0.041
Average number of private doctors trained in terminal methods	0.053*	0.024	0.080*	0.036	–		–	
Average number of trained in FP methods—government hospitals	0.038	0.025	0.200*	0.049	–		–	
Average number of trained in FP methods—private hospitals	−0.033	0.022	−0.064	0.052	–		–	
Months supply pills (condoms)—government hospitals	–		–		−0.052	0.134	0.008	0.010
Months supply pills (condoms)—CHC	–		–		−0.024	0.030	−0.055*	0.025
Months supply pills (condoms)—private hospitals	–		–		0.109	0.094	0.156*	0.023
Number of private agents trained in pills and condoms	–		–		0.188*	0.083	0.073	0.065
R^2	0.198*		0.102*		0.043*		0.118*	

[a] There were 30,966 women in this sample; slope coefficients and standard errors are reported.
* $P < 0.05$.

of condoms in private hospitals was positively and significantly associated with condom use. This was not true for the supply of condoms in government hospitals and in community health centers. Because birth control pills and condoms can be obtained in a more discreet manner from private suppliers by households that can afford them, it was perhaps not surprising that the results underscored private sources. The (pseudo) R^2 (Cox and Snell, 1989) for the model for condom use was higher than that for birth control pill use, partly because greater number of

Table 3
Maximum likelihood estimates of the enlarged ordinal and multinomial regression models for the categorical variable for three categories of contraceptive use explained by demographic, socioeconomic and healthcare infrastructural variables using the PERFORM survey[a,b]

	Ordinal regression		Multinomial logistic regression (non-user group)		Multinomial logistic regression (sterilized group)	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Constant	4.549*	0.081	3.361*	0.126	−3.979*	0.160
Woman's age	0.048*	0.002	0.024*	0.004	0.118*	0.004
Backward caste	−0.189*	0.029	0.466*	0.051	0.395*	0.057
Ever attended school	0.755*	0.033	−1.017*	0.054	−0.350*	0.061
Number of children surviving	0.085*	0.033	−0.425*	0.048	0.941*	0.062
(Number of children surviving)^2	−0.094*	0.004	0.042*	0.006	−0.118*	0.008
Household possessions index	0.172*	0.009	−0.258*	0.015	−0.114*	0.017
Average number of governmental hospitals	−0.106	0.068	0.298*	0.127	0.284*	0.137
Average number of private hospitals	0.079*	0.022	−0.085*	0.035	0.002	0.039
Average number of private doctors trained in terminal methods	0.050*	0.021	−0.051	0.030	0.026	0.031
Average number of trained in FP methods—government hospitals	0.183*	0.023	−0.267*	0.033	−0.138*	0.037
Average number of trained in FP methods—private hospitals	−0.013	0.020	−0.026	0.030	−0.061	0.034
Months supply pills—government hospitals	−0.159*	0.050	0.232*	0.075	0.095	0.085
Months supply pills—CHC	0.033*	0.011	0.001	0.022	0.052	0.024
Months supply pills—private hospitals	0.169*	0.039	−0.271*	0.058	−0.194*	0.067
Months supply condoms—government hospitals	−0.004	0.009	0.002	0.013	0.004	0.014
Months supply condoms—CHC	−0.051*	0.011	0.045*	0.021	−0.010	0.024
Months supply condoms—private hospitals	−0.001	0.045	0.038	0.070	0.074	0.079
Number of private agents trained in pills and condoms	0.079*	0.031	−0.115*	0.050	−0.069	0.056
R^2	0.179*		0.271*		0.271*	

[a] There were 30,966 women in this sample; slope coefficients and standard errors are reported.
[b] The categorical dependent variable ({0,1,2}) was 0 for non-users of contraceptives, 1 for female or male sterilization, and 2 for use of condoms, pills or IUD.
* $P < 0.05$.

couples were using condoms. Lastly, dropping sterilized women from the sample led to very similar results in the models for IUD, birth control pill and condom use.

The results in Table 3 for the categorical variable ({0, 1, 2}) for type of contraceptive used from ordinal and multinomial logistic regressions were broadly consistent with the results from binary models. The coefficients from ordinal regression model were very similar to those in Table 2 and all the significant coefficients remained significant in Table 3. While binary regressions explained contraception choice by the respective measures for availability, the ordinal regression incorporated availability of other methods. For the multinomial regression in Table 3, the signs of the coefficients were switched because the results are presented with respect to the group using birth control pills, condoms or IUD. The magnitudes of the coefficients were often different in the two groups of contraceptive non-users and sterilized couples. Overall, in view of the natural ordering of the categorical variable for households from U.P. with limited access to family planning services, it was perhaps not surprising that the results from ordinal regression were easy to interpret and supported the findings from binary models.

4.2. Empirical results for infant mortality

The empirical results from estimating binary logistic models for infant mortality are presented in Table 4 for three alternative specifications. Specification 2 replaced the variable 'no. of children surviving before 3-year period' by the corresponding variable for the number of children born; Specification 3 replaced the indicator variable 'birth wanted never' in Specification 1 by 'both births wanted never'. The results for Specification 1 indicated that, firstly, there were significant non-linearities in infant mortality with respect to maternal age and with respect to the

Table 4
Maximum likelihood estimates of binary logistic regressions for infant mortality explained by demographic, socio-economic and healthcare infrastructural variables using the PERFORM survey[a]

	Specification 1		Specification 2		Specification 3	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Constant	0.511	0.676	1.383*	0.691	0.527	0.676
Woman's age	−0.185*	0.049	−0.246*	0.051	−0.188*	0.049
(Woman's age)^2	0.003*	0.001	0.004*	0.001	0.003*	0.001
Backward caste	0.241*	0.087	0.233*	0.086	0.248*	0.087
Ever attended school	−0.202*	0.107	−0.140	0.107	−0.194	0.107
Number of children surviving before 3-year period	−0.378*	0.072	–		−0.382*	0.072
(Number of children surviving before 3-year period)^2	0.031*	0.010	–		0.031*	0.010
Number of children born before 3-year period	–		−0.128*	0.060	–	
(Number of children born before 3-year period)^2	–		0.014*	0.006	–	
Household possessions index	−0.116*	0.028	−0.108*	0.028	−0.116*	0.028
Birth interval	−0.157*	0.023	−0.140*	0.023	−0.152*	0.023
Tetanus vaccination	−0.248*	0.085	−0.216*	0.085	−0.249*	0.085
Average number of private allopathic doctors	−0.131*	0.060	−0.132*	0.060	−0.133*	0.060
Average number of trained in FP methods—CHC	−0.029	0.016	−0.028	0.016	−0.029	0.017
Birth wanted 'never'	0.025	0.211	−0.128	0.210	–	
Both births wanted 'never'	–		–		1.120*	0.282
R^2	0.045*		0.039*		0.048*	

Specification 3 replaced the indicator variable 'birth wanted never' in Specification 1 by 'both births wanted never'.

[a] There were 15,875 births in this sample; slope coefficients and standard errors are reported.

* $P < 0.05$.

number of surviving children. Some of the non-linearities with respect to maternal age have been reported in the previous literature.

Secondly, women from scheduled castes and tribes experienced significantly higher infant mortality; infant mortality was lower for better off households as reflected in the possessions index and for women that had attended school. Thirdly, longer birth intervals decreased the chances of infant mortality as reported in previous studies (Hobcraft et al., 1983). For women vaccinated against tetanus, infant mortality was significantly lower supporting the earlier findings for U.P. (Bhargava, 2003). Fourthly, average number of private allopathic doctors and the average number of staff trained in family planning methods in community health centers were estimated with negative signs that were significantly associated with chances of infant mortality at the 5 and 10% levels, respectively. Because approximately 25% of the women received ante-natal care and 85% of the babies were delivered without qualified personnel, it was perhaps not surprising to find small effects of healthcare infrastructure on the chances of infant mortality. Fifthly, the indicator variable if the women would have preferred 'never' to have the birth was estimated with a positive coefficient but was not statistically significant.

The results for Specification 2, where the number of surviving children was replaced by the number of children born, were close to the results from Specification 1 for most variables. However, the coefficient of the variable for whether the woman had ever attended school was no longer significant at the 5% level. Moreover, there was slight loss in the goodness of fit in Specification 2 where the R^2 declined from 0.045 for Specification 1 to 0.039. Coefficient of the indicator variable 'both births wanted never' in Specification 3 was positive and significant implying that infants whose mothers stated that they would have preferred not to have had the two children in the 3-year period had higher chances of mortality. While it would be useful to develop more elaborate measures for the degree of unwantedness of births, greater utilization of family planning services is likely to reduce infant mortality in U.P., partly because birth spacing was associated with lower infant mortality. Also, indicator variables for the sex of the child and for rural areas were not significant in the models for infant mortality.

Lastly, because the survival chances of infants born to the same woman could be related, Specification 1 was re-estimated with the number of surviving children before the 3-year period treated as an endogenous variable. The numbers of children born before the 3-year period and the numbers of government allopathic hospitals in the PSU were used as instrumental variables in the probit framework. While the test for exogeneity of the number of surviving children rejected the null hypothesis, the results from this version of the model were similar to the estimates for Specification 1 in Table 4.

4.3. Empirical results for the healthcare infrastructure using PSU level data

The results from estimating multiple regression models for family planning staff available in government hospitals, community health centers, private hospitals and via private agents at the PSU level are presented in Table 5. First, for government hospitals, indicator variable for rural areas was estimated with a negative and significant coefficient. While infant mortality rate in the PSU was not a significant predictor, the variable averaging households' possession index over the PSU was significant. However, the explanatory variables were not jointly significant at the 5% level. Thus, family planning services in government facilities were not significantly predicted by the explanatory variables in the model and may have been influenced by other variables such as indicators of economic activity not covered in the PERFORM survey. Secondly, in the results for

Table 5
Efficient estimates of regression models incorporating potential inter-dependence in family planning staff available in government hospitals, community health centers, private hospitals and via private agents using Primary Sample Unit level data from the PERFORM survey[a]

	Government hospitals		Community health centers		Private hospitals		Trained private agents	
	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.	Coefficient	S.E.
Constant	38.751*	6.909	0.307	0.976	12.441	8.683	−0.294*	0.079
Rural indicator (1 = rural, 0 = urban)	−11.015*	4.250	7.417*	0.619	0.483	5.271	0.006	0.048
Number of government fair price shops	0.417	2.108	0.522*	0.268	5.813*	2.547	−0.008	0.023
Number of cooperatives	0.494	2.713	−0.143	0.335	11.229*	3.258	0.006	0.030
Number of voluntary organizations	0.510	3.521	−0.502	0.441	−8.836*	4.241	−0.002	0.039
Average infant mortality in the PSU	−13.080	17.942	−3.288	2.339	−10.234	22.706	−0.100	0.207
Average household possessions index for PSU	−4.401*	1.587	0.229	0.212	−2.337	1.997	0.128*	0.018
Number of family planning staff—government hospitals	–		–		0.554*	0.028	0.0003	0.0002
Number of family planning staff—private hospitals	–		–		–		0.0001	0.0002
Average number of trained in FP methods—private agents	–		–		1.298	2.556	–	
Chi-square (2)[b]	–		–		3.133		–	
R^2	0.005		0.119*		0.190*		0.038*	

[a] There were 1911 PSU in this sample; slope coefficients and standard errors are reported.
[b] For the Chi-square test for mis-specification in the model for private hospitals, the number of family planning staff in government hospitals was treated as an endogenous variable using as instruments, the numbers of private allopathic doctors, industries, and full-time equivalent staff in community health centers.
* $P < 0.05$.

community health centers in the second column of Table 5, the rural indicator variable and number of government fair price shops were significant predictors. Moreover, in spite of the low R^2, explanatory power of the variables was significant at the 5% level. Another version of the model included family planning services available in government facilities; this variable was estimated with a negative sign and was statistically significant. Thus, there seemed some inter-dependence in governmental decisions to allocate personnel between hospitals and community health centers. However, the results for this formulation were not included in Table 5, partly to economize on space and also because of the simultaneity issues discussed next.

Thirdly, in the results for family planning services in private hospitals, the numbers of government fair price shops and cooperatives were positive and significant predictors, while the numbers of voluntary organizations were significantly negatively associated. As noted above,

voluntary organizations are likely to operate in remote areas. Coefficient of family planning services available in government hospitals was positive and was a highly significant predictor of the services in private hospitals. This was partly an indication of the gradual evolution of the healthcare infrastructure. The model was also estimated by instrumental variable method, treating services in government hospitals as an endogenous variable; the results were similar in terms of signs and significance of the coefficients. Coefficient of trained private agents was not significant in the model explaining the availability of family planning services in private hospitals. Finally, the last column in Table 5 presents the results for private agents trained in family planning services. Only the average household possession index for the PSU was a statistically significant predictor with a positive coefficient; the coefficients were jointly significant at the 5% level. These results indicated that private agents were likely to be located in regions with economically better-off households.

5. Conclusion

This paper analyzed the data from Uttar Pradesh on healthcare and family planning services, contraceptive use, and infant mortality, emphasizing gradual evolution of the healthcare infrastructure. Previous theories of demand and supply of children were extended for devising a unified framework for research in economic demography. Implications of the endogenous placement of public facilities hypothesis were examined and, in view of the increased role of private providers, a more general framework was adopted for the analysis.

The empirical results underscored the importance of quality of available services for use of methods such as female sterilization and IUD; the use of birth spacing methods was significantly associated with female education, socioeconomic status, and contraceptive stocks. While terminal methods are appropriate for couples not desiring additional children, birth spacing is essential for achieving the desired number of children. Because the empirical results indicated that short birth intervals exacerbated infant mortality, it is important to facilitate birth spacing especially in remote areas. Such interventions need not entail major investments in the public healthcare infrastructure since the services can be delivered via subsidies to NGO's and private agents. More serious complications during pregnancies and deliveries can be tackled by improving the quality of services in community health centers and government hospitals and by enhancing transportation links between rural and urban areas.

The analysis of demographic data and information on government and private facilities and private agents provided insights into the inter-relationships between the services and their likely impact on child mortality. While the costs of services in private facilities were not assessed in the survey, owing to the increased availability of private services, governmental facilities are likely to be under-utilized if quality of care is inferior. Thus, additional resources are essential for improving the public healthcare infrastructure and for monitoring the quality of services. It is important for policy makers to exploit the synergisms between various components of the healthcare infrastructure to achieve more equitable outcomes especially for the poor in backward regions of Uttar Pradesh.

Acknowledgements

While retaining the responsibility for the views, the authors thank the Research Committee of the World Bank for supporting these analyses, and Melanie Fox-Kean for assistance with the data. The present version has benefited from the comments of seminar participants at Cambridge

University, London School of Hygiene and Tropical Medicine and the World Bank, and from the suggestions of Bob Retherford, John Komlos and the referees.

References

Angeles, G., Guilkey, D., Mroz, T., 1998. Purposive program placement and the estimation of family planning program effects in Tanzania. J. Am. Stat. Assoc. 93, 884–899.

Arulampalam, W., Bhalotra, S., 2004. Sibling death clustering in India: genuine scarring versus unobserved heterogeneity. Mimeo: Department of Economics, University of Warwick, UK.

Becker, G., 1965. A theory of the allocation of time. Econ. J. 75, 493–517.

Becker, G., 1982. A theory of competition among pressure groups for political influence. Quart. J. Econ. 98, 371–400.

Bhargava, A., 2001. Nutrition, health and economic development: some policies priorities. Food Nutr. Bull. 22, 173–177.

Bhargava, A., 2003. Family planning, gender differences and infant mortality: evidence from Uttar Pradesh, India. J. Econometrics 112, 225–240.

Bongaarts, J., 1990. The measurement of wanted fertility. Pop. Dev. Rev. 16, 487–506.

Bongaarts, J., 1993. The supply-demand framework for the determinants of fertility: an alternative implementation. Pop. Stud. 47, 437–456.

Cadwell, J.C., 1982. Theory of Fertility Decline. Academic Press, London.

Cleland, J., 1996. Population growth in the 21st century: cause for crisis or celebration? Trop. Med. Int. Health 1, 15–26.

Cleland, J., Wilson, C., 1987. Demand theories of fertility transition: an iconoclastic view. Pop. Stud. 41, 5–30.

Cox, D., Snell, E., 1989. Analysis of Binary Data, second ed. Chapman & Hall, London.

Dreze, J., Murthi, M., 2001. Fertility, education, and development: evidence from India. Pop. Dev. Rev. 27, 33–63.

Easterlin, R., Crimmins, E., 1985. The Fertility Revolution. University of Chicago Press, Chiacgo.

Hobcraft, J.N., McDonald, J.W., Rutstein, S., 1983. Child spacing effects of infant and early child mortality. Pop. Ind. 49, 585–618.

Koenig, M., Foo, G., Joshi, K., 2000. Quality of care within the Indian family welfare programme: a review of recent evidence. Stud. Fam. Plann. 31, 1–18.

Marston, C., Cleland, J., 2003. Do unintended pregnancies carried to term lead to adverse outcomes for mother and child? An assessment in five developing countries. Pop. Stud. 57, 77–93.

McCullagh, P., 1980. Regression models for ordinal data. J. R. Stat. Soc. B 42, 109–142.

Mensch, B., Arends-Kuenning, M., Jain, A., 1996. The impact of the quality of family planning services on contraceptive use in Peru. Stud. Fam. Plann. 27, 59–75.

Montgomery, M., Lloyd, C., Hewett, P., Heuveline, P., 1997. The consequence of imperfect fertility control for children's survival, health, and schooling. Demographic and Health Surveys Analytical Reports No. 7. Macrointernational, Calverton, MD.

Peters, D., Yazbeck, A., Sharma, R., Ramana, G., Pritchett, L., Wagstaff, A., 2002. Better Health Systems for India's Poor. World Bank, Washington, DC.

Preston, S., 1976. Mortality Patterns in National Populations. Academic Press, New York.

Ramesh, B., Gulati, S., Retherford, R., 1996. Contraceptive use in India, 1992–93. National Family Health Survey Subject Reports Number 2. East West Center, Honolulu, Hawaii.

Sargan, J.D., 1958. The estimation of economic relationships using instrumental variable. Econometrica 26, 393–415.

Scrimshaw, S., 1978. Infant mortality and behavior in the regulation of family size. Pop. Dev. Rev. 4, 383–403.

SIFPSA, 1996. Performance indicators for the innovations in family planning services project. State seminar report. Lucknow, UP, India.

Smith, R.J., Blundell, R.W., 1986. An exogeneity test for a simultaneous equation Tobit model with an application to labor supply. Econometrica 54, 679–685.

Stephenson, R., Tsui, A., 2002. Contextual influences on reproductive health service use in Uttar Pradesh. India. Stud. Fam. Plann. 33, 309–320.

SPSS, 1999. SPSS for Windows version 10. SPSS, Inc., Chicago, IL.

Taylor, C., Newman, J., Kelly, N., 1976. The child survival hypothesis. Pop. Stud. 30, 262–278.

United Nations Development Program, 1990. Child mortality since 1960's: a data base for developing countries. United Nations, New York.

World Health Organization, 2000. World Health Report 2000. World Health Organization, Geneva.