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Healthy mothers, healthy children: does maternal demand for antenatal care matter for child health in Nepal?

Nafisa Halim,[1]* Alok K Bohara[2] and Xiaomin Ruan[2]

[1]Department of Sociology, University of New Mexico, Albuquerque, NM, USA and [2]Department of Economics, University of New Mexico, Albuquerque, NM, USA

*Corresponding author. Department of Sociology, MSC05 3080, 1 University of New Mexico, Albuquerque, NM 87131, USA.
E-mail: nhalim@unm.edu

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Nepal's Safe Motherhood Programme has failed to deliver expected gains in maternal and child health. Nepalese mothers and their children continue to dispense with (or be denied) antenatal care, experience high maternal mortality rates and suffer chronic malnutrition. We address the correlates and consequences of antenatal care utilization in Nepal by applying two-stage least squares, binomial logit and Heckman selection bias estimates to data drawn from the Nepal Health and Demographic Surveys of 1996 and 2001. Results indicate that maternal education, even at low levels, significantly increases the use of antenatal care; paternal education plays a more important role in the use of routine antenatal care than the conventional wisdom suggests; and when mothers use routine professional antenatal care and maintain good health their children tend to stay healthy through infancy and early childhood. Since health-seeking behaviour is circumscribed by patriarchal gender norms in Nepal, health policies should not only focus on female education and women's status, but also involve husbands in the process of maternal care utilization.

Keywords Maternal health, child health, maternal care, utilization, education, Nepal

KEY MESSAGES

- Years of Safe Motherhood interventions have failed to deliver expected gains in maternal and child health in Nepal, with low use of antenatal services, high maternal mortality and common chronic malnutrition.
- We found that education, both maternal and paternal, increases routine antenatal care utilization and that child health improves as a result.
- In the face of strict gender norms, religious and cultural health practices in Nepal, efforts should be made to involve fathers in maternal care, maternal health and child health, in addition to focusing on female education and women's status.

Introduction

Safe motherhood and a healthy childhood are still challenges in Nepal. More than a decade after the launch of the Safe Motherhood Programme, Nepal faces one of the highest rates of maternal mortality and chronic child malnutrition in the world (WHO 2004).[1] According to the 1996 Nepal Demographic and Health Survey (NDHS), the country experiences 539 maternal deaths per 100 000 live births.[2] One in every two Nepalese children is underweight for his or her age and height, and one in 10 is short for his or her age. Low use of maternal care

prevails and continues to threaten both mothers and their children in infancy and early childhood (Asian Development Bank 1999). In this article, we ask why antenatal care use is not universal in Nepal and whether variation in antenatal care use influences child health.

Health depends on care, and the utilization of health care in developing countries like Nepal allegedly depends on the availability, affordability and accessibility of services (Magadi *et al*. 1993; Nwakoby 1994; Frankenberg 1995; Acharya and Cleland 2000; McCray 2004). With a per capita GDP of US$250, and a development budget that is largely donor financed (WHO 2004), Nepal has trouble funding its social programmes. But the government has increased the provision of health services over the course of the past two decades by establishing rural clinics, outreach services and obstetric services in public hospitals, and by appointing village health workers and female community health workers who are supposed to improve the provision of maternal care services to hard-to-reach pregnant clients (Ministry of Health 1996; Acharya and Cleland 2000; Pokhrel and Sauerborn 2004; Futura and Salway 2006). Nonetheless, health gains are dismally low. No more than 40% of women use antenatal care; mothers pay an average of one visit to an antenatal care provider during their pregnancies;[3] and 90% of births take place at home without a professional birth attendant (NDHS 1996, 2001).

Limited maternal and child health gains in the face of supply-induced increases in health services indicate that a comprehensive understanding of maternal and child health demands not only an analysis of the supply side, but also a no less comprehensive understanding of the demand-driven utilization of maternal health care. To contribute to the latter, we focus in this article on the 'social' determinants of the use of routine antenatal care in Nepal and estimate the value to child health of a safe and healthy motherhood. (Explaining variation in antenatal care utilization and child health with proximate determinants, such as biological or medical conditions specific to women, children, etc., is beyond the scope of this analysis.)

Antenatal care, maternal health and child health in Nepal

Nepal's combination of high fertility rates (TFR = 3.9) and high maternal mortality reflects high parental demand for children and suggests that safe motherhood is a key human development challenge in the country. The main causes of maternal mortality worldwide are haemorrhage, sepsis, hypertension, abortion and obstructed labour (Maine 1991). Antenatal care in the form of early detection of high-risk pregnancies with (a) routine measurement of weight and blood pressure, (b) abdominal examinations, (c) vaccination against tetanus and (d) the prevention and treatment of anaemia minimizes not only the risk to maternal health from pregnancy-induced complications, but also the likelihood that the child or children will suffer from low birth weight, prematurity and intrauterine growth retardation (Mosley and Chen 1984; McCarthy and Maine 1992; Bloom *et al*. 1999).[4]

In Nepal, the institutions governing pregnancy are traditional and stratified, favouring older women in the family. The mother-in-law, usually the older woman in an extended family context in rural areas, who is devoid of exposure to formal educational or health institutions, has the legitimate and traditional authority to make decisions because of her pregnancy-related knowledge.[5] She restricts the would-be mother from moving about during her 'shameful' state of pregnancy and enforces her ritualistic separation from her husband during and after the 'polluting' event of childbirth (Futura and Salway 2006; Mumtaz and Salway 2007). Following the cultural and religious practices in Nepal, menstruation, childbirth and the 10 days after childbirth are impure, and often pose health threats to mothers and children (WHO 2004).

How then does a would-be mother in Nepal, who enters into an arranged marriage within a few years of puberty, and generally bears her first child before she completes her teenage years, decide to utilize antenatal care? What is the 'shadow price' she pays as she becomes the first in the family to have the option of maternal health care from a modern institution and perhaps decides to utilize it? Some believe female education comes to her rescue even in the patriarchal social and economic institutional context in Nepal. Others disagree and therefore question those who would promote female education as the solitary effort to improve maternal and child health (Schultz 1993; World Bank 1993).

The dynamic of female education and utilization of antenatal care purportedly takes hold by (a) encouraging learning about secular organizations, and (b) altering the structure of the relationships between wife and husband, and sister-in-law and mother-in-law. Firstly, despite the fact that parents who send their female daughters to co-ed or girls' schools are in all likelihood more tolerant of secular institutions from the outset, years of experience with educational institutions further help to maintain or reinforce their trust in modern health services. Secondly, compared with their illiterate counterparts, educated mothers are perhaps empowered to go beyond traditional practices related to pregnancy and more willing to exercise autonomy in seeking antenatal care (Caldwell 1979, 1986; Cleland and van Ginneken 1988; Pebley *et al*. 1996; Levine *et al*. 2004).

Others doubt that education alone will empower women to reject traditional health practices in favour of professional antenatal care (Fedierici *et al*. 1993; Jeffery and Jeffery 1996), however, and worry that, in the patriarchal social and economic institutional context of Nepal, even educated women will seek the social and financial support of their husbands and in-laws before utilizing professional maternal care (Jeffery *et al*. 2002). Considering his traditional role as the primary breadwinner and provider of old-age insurance for retired parents, the husband can provide financial assistance as needed and mobilize older members to 'approve' of maternal care utilization, and his education *vis-à-vis* awareness of potential maternal health hazards therefore helps him to encourage the process of maternal care utilization.

Empirical evidence provides support for both positions in this argument and the relationship between education and the utilization of antenatal care therefore demands further scrutiny. For example, some studies support the idea that low female education and a paucity of health knowledge are inveterate

obstacles to maternal care utilization in Nepal (Glewwe 1999; Webb and Block 2004).[6] In fact, Matsumura and Gubhaju (2001) deployed binomial logistic regression estimates using the NDHS of ever-married women aged 15–49 years in 1996 and found that educated mothers were more likely to seek antenatal care than those with no education. And education appears to be a no less critical factor in the demand for antenatal care in surveys of women aged under 35 in India (Bhatia and Cleland 1995), in the Fertility and Family Health Survey in Jordan (Obermeyer and Potter 1991) and in a comparison of 51 maternal deaths and 177 women survivors in a hospital in Indonesia (Taguchi *et al*. 2003). Other studies, however, fail to establish a causal link between education and the use of antenatal care. For instance, Magadi *et al*. (2000) fail to establish an association between maternal education and the use of antenatal care in their hierarchical linear regression analysis of the 1993 Kenya Demographic and Health Survey. Their findings are consistent with Miles-Doan and Brewster's logistic regression analysis of Cebu Longitudinal Health and Nutritional Survey data in 1983 and 1984 (Miles-Doan and Brewster 1998).

Lack of appropriate controls arguably explain these inconsistent findings (Desai and Alva 1999; Magadi *et al*. 2000). The following hypotheses therefore merit further investigation and are tested here.[7]

Hypothesis 1 Educated mothers are more likely to use professional antenatal care than their non-educated counterparts.

Hypothesis 2 Mothers who have access to the media and, presumably, health-related information are more likely to use professional antenatal care than mothers who lack such access.

Hypothesis 3 Mothers are more likely to use maternal care if their husbands are educated.

Hypothesis 4 Educated mothers tend to visit professional antenatal care providers more frequently than their less-educated counterparts.

Hypothesis 5 Mothers who have access to the media and, presumably, health-related information tend to visit professional antenatal care providers more frequently than those who lack such access.

Hypothesis 6 Mothers will tend to visit professional antenatal care providers more frequently if their husbands are educated.

Hypothesis 7 Children whose mothers have sought routine professional antenatal care during pregnancy are healthier in their infant and toddler years than the children of mothers who have not sought such care.

Data and methods

Data

The NDHS provides health information on children, maternal health care, and family, household and community attributes from a sizeable and representative sample of ever-married Nepalese women of childbearing age. However, the survey offers limited information on maternal medical histories and we are thus forced to explain variation in antenatal care utilization and children's health with social and behavioural covariates (Stewart *et al*. 1997; Glei *et al*. 2003; Koenig *et al*. 2007). Using a stratified cluster-sampling design, the NDHS interviews a nationally representative sample of 8429 women aged 15–49 who have been married at some point in their lives. Our analysis therefore includes data on as many as 3549 mothers and 2460 children (aged 0–36 months) for which anthropometric data are available in 1996 and 2001. We are interested in the health of young children and therefore look only at mothers of children in that age group rather than the full sample.

Outcome variables

Antenatal care use

We measure antenatal care with (a) a binary outcome: 1 when a mother utilizes professional antenatal care, and 0 otherwise, and (b) a continuous variable: the frequency of visits during pregnancy.[8] Professionals include obstetricians and gynaecologists, general practitioners, medical officers, midwives and nurses, and auxiliary midwives (WHO *et al*. 1992). Mothers ostensibly need not only professional antenatal care but regular antenatal visits to secure healthy pregnancies (WHO 1994), and our measures therefore capture both the nominal (professional vs. traditional or none) and continuous (frequency of visits to professionals) dimensions of care utilization. In practice, antenatal care identifies women at risk, prevents complications, treats pathological conditions and educates would-be mothers about healthy practices and behaviour (Coria-Soto *et al*. 1996). In addition, routine antenatal visits are expected to maximize the amount of care that a pregnant woman can receive, raise awareness about the need for care at delivery, familiarize expectant mothers with health facilities, and thereby reduce maternal or child health hazards (Ahmed and Das 1992; Coria-Soto *et al*. 1996; Bloom *et al*. 1999).

Child health

The health status (weight-for-age) of children aged 0–36 months is calculated as:

$$WA_i = \frac{X_{it} - X_{Mt}}{\sigma_{Mt}}$$

Where X_{it} is the weight of the i^{th} child at age t, X_{Mt} is the median weight, and σ_{Mt} is the standard deviation of weight for children at age t in the reference US population.

Table 1 shows that children in their infant and toddler years in Nepal are severely underweight for their age. An overwhelming 94% of Nepalese children fall below the median nutritional status in the reference population, and 16% (13%) were at least 3 standard deviations below the median in 1996 (2001). Figure 1 further shows that health deteriorates as an average Nepalese child ages; he or she will experience significant weight loss at 6 months—the time associated with weaning. However, a gradual deterioration of health status after 6 months suggests that socio-economic constraints in addition to weaning itself continue to threaten child health. A policy can perhaps be recommended to educate mothers on weaning foods during antenatal visits.[9]

Table 1 Child nutritional status in Nepal, 1996 and 2001

				Percentage of weight-for-age z-scores				
	Year	**Mean**	**SD**	>0	Between −1 and 0	Between −2 and −1	Between −3 and −2	Below −3
Weight-for-age	1996	−1.87	1.15	6	17	31	30	16
	2001	−1.79	1.11	6	17	33	31	13

Source: NDHS, 1996 and 2001.

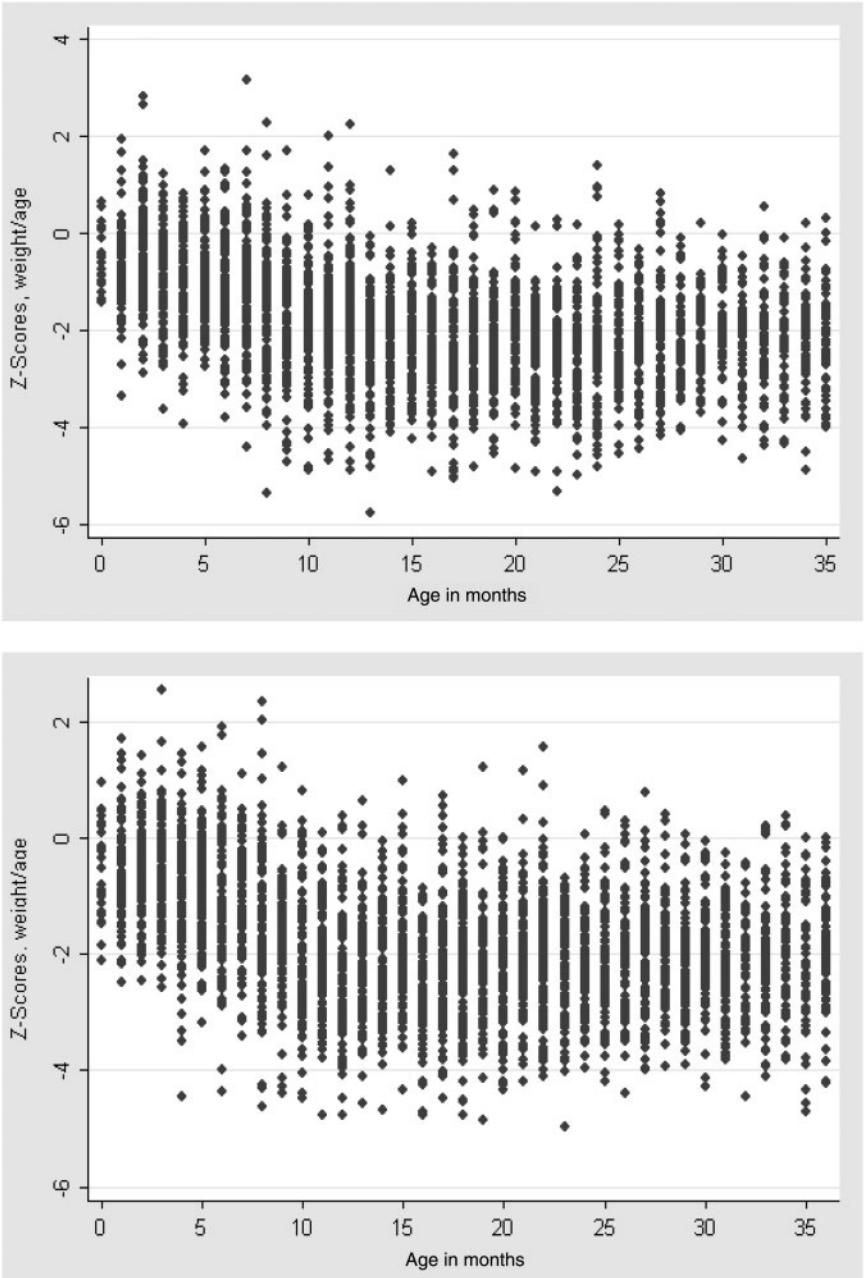

Figure 1 Distributions of child nutritional status by months, 1996 and 2001

Explanatory variables

Table 2 describes the variables in this study. We create dummy variables for respondents with primary (grades 1–5), secondary (grades 6–10) or higher (grades 11 and above) education; respondents with no education are the reference category. Educational attainment is low in Nepal: 85% of women and 38% of men interviewed in 1996 and 2001 had not progressed beyond basic education. Preliminary analysis further suggests

Table 2 Descriptive statistics

Variables and descriptions of the variables	1996			2001		
	N	Mean/ proportion	SD	*N*	Mean/ proportion	SD
Variables related to child:						
Age of child (months)	3642	15.9	9.7	3482	16.58	10.17
Gender of child (male = 1)	3642	0.51	0.50	3482	0.49	0.50
Birth order	3642	3.45	2.25	3482	3.26	2.15
Was child ill in last 2 weeks? (yes = 1)	3640	0.42	0.49	3482	0.37	0.48
Has child ever been vaccinated? (yes = 1)	2781	0.63	0.48	2666	0.92	0.27
Variables related to utilization of antenatal care:						
Did mother utilize professional antenatal care? (yes = 1)	3573	0.39	0.49	3482	0.39	0.49
Number of antenatal visits for pregnancy	3562	1.25	2.05	3480	1.57	2.12
Variables related to mother:						
Age	3642	27.01	6.48	3482	26.83	6.33
Age at first marriage	3642	16.23	2.91	3482	16.68	2.69
Log of mother's weight in kg	3592	3.81	0.13	3476	3.81	0.13
Log of mother's height in cm	3585	5.01	0.04	3475	5.01	0.04
Education level:						
Primary = 1	3642	0.11	0.31	3482	0.14	0.35
Secondary = 1	3642	0.08	0.28	3482	0.12	0.33
Above secondary = 1	3642	0.01	0.11	3482	0.01	0.12
Currently works? (yes = 1)	3635	0.78	0.41	3482	0.83	0.38
Watches television at least once a week	3635	0.09	0.28	3482	0.18	0.38
Household has radio? (yes = 1)	3634	0.39	0.49	3482	0.41	0.49
Variables related to father's education:						
Primary = 1	3636	0.25	0.43	3411	0.26	0.44
Secondary = 1	3636	0.27	0.44	3411	0.34	0.47
Above secondary = 1	3636	0.09	0.29	3411	0.06	0.24
Variables related to households:						
Floor made of earth, mud or dung? (yes = 1)	3637	0.92	0.26	3479	0.84	0.36
Water from tap? (yes = 1)	3631	0.32	0.47	3481	0.32	0.47
Water from well? (yes = 1)	3631	0.36	0.48	3246	0.39	0.48
Flush toilet (yes = 1)	3637	0.02	0.13	3247	0.08	0.27
Pit toilet (yes = 1)	3637	0.18	0.38	3247	0.16	0.37
Variables related to family:						
Number of children under 5	3642	1.97	1.10	3482	1.89	0.98
Hindu (yes = 1)	3638	0.86	0.34	3482	0.95	0.76
Brahmin/Chhetri/Newar (yes = 1)	3642	0.37	0.48	3482	0.34	0.47
Gurung/Magar/Tamang/Rai Limbu (yes = 1)	3642	0.20	0.40	3482	0.17	0.38
Variables related to region:						
Urban (yes = 1)	3642	0.09	0.29	3482	0.09	0.29
Terai (yes = 1)	3642	0.44	0.50	3482	0.49	0.49
Eastern (yes = 1)	3642	0.19	0.39	3482	0.22	0.42
Central (yes = 1)	3642	0.29	0.46	3482	0.28	0.45
Western (yes = 1)	3642	0.19	0.39	3482	0.16	0.37
Midwestern (yes = 1)	3642	0.18	0.38	3482	0.14	0.34

that educated women have educated spouses, as prior studies indicate (Basu 1994; Desai and Alva 1999), and the association is statistically significant ($\chi^2 = 1017.01$, $P < 0.0001$). In 1996, for example, 55% of women with no education married partners who had completed primary education; 84% of women with some primary education married partners who had completed at least primary education; 90% of women with secondary education married partners who had completed at least secondary education; and 85% of women with higher education married partners with equal or higher educational attainment. A similar pattern holds in 2001. Nearly 2% of mothers watch television at least once a week, and 40% have a radio at home.

We control for the mother's age, number of children aged 5 and under, place of residence, religion and caste. Prior studies find family, household and regional attributes to be significant predictors of the use of professional antenatal care and have thus influenced our choice of control variables. A mother is less enthusiastic about antenatal care if she is older, has experience with giving birth and is currently pregnant with a high-order birth (Obermeyer and Potter 1991; Chandrashekar *et al*. 1998; Magadi *et al*. 2000; Neilson *et al*. 2001). We create dummy variables if the family is Hindu or a member of one of the relatively superior castes (i.e. Brahmin/Chhetri/Newar or Gurung/Magar/Tamang/Rai Limbu). Religion and caste are important control variables, for they prescribe pregnancy values and norms in Nepal. Finally, we include a dummy for urban residence since health services are more difficult to reach in rural Nepal.

Estimation strategy

The principal obstacle to the consistent estimation of antenatal care's effect on child health is the absence of information on prior health endowments. Neither the prior health of the mother nor the prior health of the child(ren) is observable from the NDHS, and it is therefore difficult to distinguish a true causal effect from the possibility of self-selection or sample-selection (or perhaps both). We therefore employ two-stage least squares (2SLS) and Heckman sample selection models and present the most robust estimates of the correlates and consequences of antenatal care possible within the limits of the NDHS data.[10] In particular, we estimate: (a) a logit for the binary response of antenatal care use or non-use, (b) a negative binomial for the counts of antenatal visits, (c) ordinary least squares for the standardized child health measures by utilizing the *predicted* values of the use and the frequency of antenatal visits as predictors of child health, and finally (d) complement the 2SLS estimates with those from the Heckman sample selection model.

The 2SLS approach is the most common correction for endogeneity and/or selectivity (induced by the correlation between antenatal care use and the error term) in applied health research (Deaton 1995: 1834) and is therefore our preferred strategy. Self-selection is possible if a portion of the mothers in Nepal who used antenatal care in 1996 and 2001 did so because of their own health status and/or health preferences. A mother in a superior (inferior) health condition might 'favourably' ('adversely') self-select into (out of) antenatal care use and ensure a safe (unsafe) pregnancy and childbirth; that is, she may (self) select into antenatal care based on unobservable as well as observable characteristics and thereby predispose the children of respondents who receive antenatal care in particular health directions.[11] The pooling of *self-selected* health-care users with their non-user counterparts in the same analysis can mislead ordinary least squares (OLS) but not necessarily the 2SLS estimates which distinguish the selection process from the effects of the variable of interest (i.e. antenatal care utilization).

Therefore, we use parental education to identify the *consistent* (endogenous) effects of antenatal care on child health for the following reasons.[12] First, paternal education is closely correlated with antenatal care use via the mechanisms reviewed in the previous sections, yet is uncorrelated with child health as children of uneducated fathers are as healthy as those of educated fathers when maternal education is accounted for in the equation. Second, at the observable and empirical level, maternal education is more directly correlated with health care utilization than with child health in that the strong relationship between maternal education and child health is often diminished by a substantial margin when health care utilization is taken into account (Caldwell and Caldwell 1993; Maitra 2004). In the absence of NDHS data on the alternative mechanisms linking maternal education and child health, we control their correlates as well as the data allow and restrict the link between education and child health via health care utilization only.[13] After controlling for health care correlates, in other words, education becomes a more valid instrument than the alternatives used in prior studies.[14]

We put our arguments to an empirical test by examining whether (a) health care utilization is indeed a mediator variable, and (b) 2SLS consistently estimates its effect on child health as a result (results available from authors upon request). We register, first, the baseline magnitude and/or statistical significance of the OLS coefficients estimating education's effect on child health, and, second, their changes when the actual and predicted antenatal care utilization and visits enter into the 1996 and 2001 specifications, singly or jointly with controls. Results show that coefficients/*P*-values shrink/grow from the baseline magnitudes in 1996 and 2001. For example, in 1996 (2001), primary, secondary and higher paternal education effects shrink by up to 70% (80%) from 0.25 (0.37), 0.46 (0.56) and 0.57 (0.80), respectively, with the *P*-values consistently lower than 0.05–0.07 (0.08), 0.19 (0.20) and 0.24 (0.15) with sporadically significant *P*-values when antenatal care utilization (visits) enters specifications with controls. And, in 1996 (2001) primary, secondary and higher maternal education effects shrink by up to 72% (77%) from 0.42 (0.40), 0.74 (0.82) and 1.38 (1.36), respectively, with the *P*-values consistently lower than 0.05–0.18 (0.10), 0.27 (0.29) and 0.38 (0.31) with sporadically significant *P*-values when antenatal care utilization (visits) enters specifications with controls. Shrinkage also occurs—though at a lower rate by up to 7% (25%) in 1996 (2001)—when antenatal care utilization (visits) enters specifications without controls. And, education effects on child health not only shrink in size but also fail to significantly affect child health when (education-)predicted antenatal care utilization and visits enter specifications with controls. This suggests that the independent education effect on

child health evaporates when antenatal care utilization captures much of its effect.

Finally, using the Hausman specification test, we reject the null hypothesis of no systematic difference between 2SLS and alternative parameter estimates, and find that 2SLS consistently estimates (education-predicted) antenatal care utilization's and visit's effects on child health ($\chi^2 = 57.45/48.72$ with P-value = 0.00 in 1996/2001). In sum, we have rectified many but not necessarily all sources of endogeneity in antenatal care utilization, and its effects on child health are as consistent as possible given constraints in the data from NDHS or similar surveys as a result.

Self-selection is not the only source of bias, however, for sample construction is no less threatening (Heckman 1979: 153). We run the Heckman selection model in order to guard against the possibility that the NDHS might (over-)represent respondents with attributes that push health outcomes in particular directions, e.g. otherwise healthy mothers who have used antenatal care because of their older child(ren)'s health conditions.[15] As such, a mother with an existing ill (healthy) child(ren) may seek antenatal care to prevent (ensure) the ill (good) health of her forthcoming child and thus confound the effects of antenatal care with the effects of prior (child) health conditions. Unfortunately, the selection model allows us neither to check nor correct for such sample selection with confidence, for the NDHS does not provide information on mothers' or children's unique health conditions. Difficulty in interpreting ρ (the sample selection bias statistic, which is extremely sensitive to model specification) and violation of the normality assumption (heteroskedastic antenatal care use violates assumptions in the selection equation) make robust selection model estimates improbable in the current analysis and the subject of considerable debate more generally (Deaton 1997). We therefore prefer the 2SLS approach and caution against an overly credulous interpretation of the Heckman selection estimates in Table 5.

To reiterate, we estimate cross-sectional models using the 1996 and 2001 NDHS data and test for sample and temporal variation with specifications and estimation techniques that correct for potential biases. We are therefore unable to estimate panel models since the 1996 and 2001 NDHS do not interview the same households. Further details on estimation follow.

Determinants of antenatal care use

Our measures of antenatal care include the type of antenatal care and the frequency of antenatal visits. A mother's observed use of professional antenatal care demonstrates her *latent* propensity to seek professional care. We estimate the following equation:

$$Y_i^* = \beta' Z_i + \mu_i \tag{1}$$

Here Y^* is the log-odds of the use of professional antenatal care compared with traditional or no care. Y_i is 1 if the log-odds of choosing professional antenatal care $Y_1^* > 0$, 0 elsewhere. And,

$$\beta' Z_i = \beta_0 + \sum_{k=1}^{K} \beta_{Mk} M_{ki} + \beta_F F_i + \beta_c C_i + \beta_U U_i \tag{2}$$

where M comprises the variables related to the mother, i.e. her education, exposure to information, age, number of co-resident children under 5 years, and employment; F is the father's education; C comprises religious and cultural attributes; and U is urban residence. We hypothesize that the effects of maternal education, exposure to mass media and paternal education are significantly greater than zero. As such,

Hypothesis 1 $\beta_{M1} > 0$, maternal education affects the use of professional antenatal care

Hypothesis 2 $\beta_{M2} > 0$, exposure to media affects the use of professional antenatal care

Hypothesis 3 $\beta_F > 0$, paternal education affects the use of professional antenatal care

We further hypothesize that the frequency—and not simply occurrence—of professional antenatal visits will vary with education and exposure to the media (Hypotheses 4–6). We test these hypotheses with negative binomial models. The negative binomial estimation technique is appropriate because the standard deviation (2.05 in 1996; 2.12 in 2001) of the frequency of antenatal visits is greater than the mean (1.25 in 1996; 1.57 in 2001). Antenatal visits, Y, are assumed to follow the negative binomial distribution:

$$\Pr(Y_i = y) = \frac{\Gamma(\theta + y)}{y\Gamma(\theta)} \frac{\mu_i^{y_i} \theta^{\theta}}{(\mu_i + \theta)^{\theta + y_i}}$$

where θ is a random parameter that follows the gamma distribution. The mean of the dependent variable is associated with the explanatory variables through the link function, $\mu_i = e^{\beta' Z_i}$, where,

$$\beta' Z_i = \beta_0 + \sum_{k=1}^{K} \beta_{kM} M_{ki} + \beta_F F_i + \beta_c C_i + \beta_U U_i \tag{3}$$

M comprises the variables related to mothers, F is paternal education, C comprises religion and cultural attributes, and U is urban residence. As such,

Hypothesis 4 $\beta_{M1} > 0$, maternal education affects the frequency of antenatal visits

Hypothesis 5 $\beta_{M2} > 0$, exposure to media affects the frequency of antenatal visits

Hypothesis 6 $\beta_F > 0$, paternal education affects the frequency of antenatal visits

Determinants of child health

We estimate the following equation using 1996 and 2001 data to test the claim that routine professional antenatal care improves the health of infants and toddlers in Nepal.

$$CHILDHEALTH_i = \beta_0 + \sum_{m=1}^{M} \beta_{Cm} C_{mi} + \sum_{k=1}^{K} \beta_{Mk} M_{ki} + \sum_{l=1}^{L} \beta_{Hl} H_{li} + \beta_u U_i + \varepsilon_i \tag{4}$$

C is children's attributes (gender, age, birth order, whether vaccinated against tuberculosis, diphtheria, pertussis/whooping cough and tetanus, polio and measles, and whether suffered from fever, cough or diarrhoea in the 2 weeks prior to the date of interview); M is the mother's attributes (the use of professional antenatal care, antenatal visits, height, weight, current age, age at marriage, number of dependent children,

religion, caste); H is family (religion and caste) as well as household attributes (sources of water supply, toilet facilities, whether the floor of the household is made of mud) and U captures urban residence.

Hypothesis 7 posits that routine professional antenatal care benefits child health ($\beta_{M1} > 0$). We tackle the issue of endogeneity in our tests of Hypothesis 7 by (a) obtaining the predicted values of antenatal care and visits per mother conditional on education, exposure to information and other control variables from the first-stage regression as specified in Equation 3, and (b) using predicted antenatal care and visits to obtain the estimates of child health parameters as specified in Equation 4. We have thus adopted the 2SLS approach in keeping with previous retrospective studies dealing with endogenous explanatory variables in child health equations (Rosenzweig and Schultz 1983).[16]

Regression results

Determinants of antenatal care use

Table 3 reports regression results. Column 1 shows that educational attainment and access to the media, in addition to cultural, geographic and demographic controls, influence the use of antenatal care. Results remain intact when we add regional dummies in Column 2. Column 3 includes estimates of the determinants of the *frequency* of antenatal visits in 1996 and reveals broadly consistent results. Similarly, Column 4 includes the estimated effects of education and access to the media when we control for cultural, geographic and demographic variations in 2001. We account for additional regional variation in 2001 in Column 5 and present the determinants of the number of antenatal visits in 2001 in Column 6.

Logistic regression coefficients indicate that lack of education discourages the use of routine professional antenatal care, and that socio-cultural, geographic or demographic differences do not decrease the educational effects. Even a few years of schooling increase the likelihood that a mother uses professional, skilled antenatal care regularly throughout her pregnancy. Our findings based on 1996 sample data indicate that the odds that a mother with primary education uses professional antenatal care over traditional or no care are nearly twice ($\exp^{\beta} = 1.84$) the odds that an uneducated mother does so. Additionally, the odds that a mother with secondary and at least high school education will use professional antenatal care are five ($\exp^{\beta} = 4.87$) and 35 times ($\exp^{\beta} = 34.5$) higher than the odds for a mother with no schooling (Column 1). In other words, in 1996, on average, a mother who has completed 5, 10 or at least 12 years of schooling was, respectively, 15%, 34% and 57% more likely to use professional antenatal care than a mother with no schooling. A similar pattern is evident in 2001; on average, a mother is 19%, 29% and 48% more likely to use professional antenatal care if she is a primary, secondary or at least high school graduate compared with her uneducated counterpart.

Furthermore, incident rate ratios using the negative binomial coefficients suggest that a mother who is a secondary or high school graduate is expected to make, on average, 1.24 (1.19) and 1.42 (1.34) times more antenatal visits than a mother with no formal schooling in 1996 (2001) (Columns 3 and 6). Although uneducated mothers make fewer trips to antenatal professionals than primary school graduates, the difference is not statistically significant. In sum, although even a little schooling encourages the use of professional antenatal care, a mother requires at least 6 years of schooling to seek regular maternal care in Nepal. The evidence therefore provides support for Hypotheses 1 and 4 that the use and frequency of professional antenatal care increase with educational attainment. Furthermore, the educational effect is robust to sample and temporal variation.

While maternal education is important in and of itself, an educated father has an independent effect on maternal care. The paternal educational effect is consistent, though modest, and appears to be an essential control variable in models of the determinants of maternal care in Nepal. A mother uses professional antenatal care and makes frequent antenatal visits if she has an educated partner (Hypotheses 3 and 6). The 1996 results indicate that a mother is 7%, 17% and 12% more likely to use professional antenatal care if her husband has primary, secondary and at least high school education, respectively (Column 1). The 2001 results indicate, however, that a father must have at least 11 years of education to affect the use of professional antenatal care (Columns 4 and 5). As such, when a father has at least 11 years of formal schooling, his wife is 18% more likely to use professional antenatal care compared with a wife whose husband has no formal education (Column 4). Additionally, incident rate ratios from the negative binomial coefficients suggest that a mother is expected to make 1.15 and 1.24 times more antenatal visits when her husband has secondary and higher level education in 2001, respectively.

Efforts to disseminate health knowledge and practices via the mass media appear helpful (Hypotheses 2 and 5). Access to media messages influences the use of professional antenatal care and antenatal visits. The use of antenatal care increases by nearly 9% (19%), and antenatal visits by nearly 1.3 (1.2) times if a mother watches television at least once a week in 1996 (2001). Access to radio increases the probability of the use of antenatal care by nearly 5% and antenatal visits by nearly 1.2 times in 1996.

Among the controls, we find that relatively younger mothers and mothers with fewer children aged 5 and under at home (and presumably little or no experience with pregnancy) have a higher propensity to seek routine professional antenatal care (Columns 1–6). The likelihood of the use of professional antenatal care and frequent antenatal visits are higher in urban communities in the plains compared with rural communities in mountains or hills. Our findings further indicate that (a) Hindus were more likely to use professional antenatal care than non-Hindus in 2001, (b) the Brahmin/Chhetri/Newar were more likely to use routine professional antenatal care when we controlled for additional regional variations, (c) the Gurung/Magar/Tamang/Rai Limbu were more likely than the relatively inferior caste members to use professional antenatal care but make as many antenatal visits as the relatively inferior caste members seeking professional antenatal care, and (d) the use of professional antenatal care is expected to be greater among residents in eastern, central and western Nepal than those in the far-western regions of Nepal.

Table 3 Determinants of professional antenatal care utilization, 1996 and 2001

	1996			2001		
	(1) Binomial logit	(2) Binomial logit	(3) Negative binomial	(4) Binomial logit	(5) Binomial logit	(6) Negative binomial
Variables related to mothers:						
Primary education	0.60***	0.45***	0.09*	0.75***	0.70***	0.05
	(0.12)	(0.13)	(0.05)	(0.12)	(0.12)	(0.05)
Secondary education	1.43***	1.30***	0.22***	1.20***	1.07***	0.17***
	(0.18)	(0.18)	(0.06)	(0.16)	(0.16)	(0.05)
Higher education	3.54***	3.57***	0.35***	2.34***	2.13***	0.29***
	(1.03)	(1.02)	(0.10)	(0.69)	(0.68)	(0.09)
Watches television at least once a week	0.38**	0.16	0.27***	0.79***	0.65***	0.16***
	(0.17)	(0.17)	(0.07)	(0.12)	(0.12)	(0.03)
Has radio at home	0.23***	0.28***	0.14***	0.05	0.12	0.04
	(0.08)	(0.09)	(0.03)	(0.08)	(0.09)	(0.03)
Currently working	−0.09	0.10	0.01	−0.38***	−0.21*	−0.09**
	(0.10)	(0.11)	(0.04)	(0.11)	(0.13)	(0.03)
Age	−0.02**	−0.02**	−0.00	−0.03***	−0.02***	0.00
	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)	(0.00)
Number of children aged 5 and under at home	−0.14***	−0.14***	−0.02***	−0.11**	−0.12***	−0.03*
	(0.04)	(0.04)	(0.02)	(0.05)	(0.05)	(0.01)
Variables related to fathers:						
Primary education	0.28***	0.32***	0.09*	0.01	0.06	0.02
	(0.11)	(0.10)	(0.05)	(0.11)	(0.11)	(0.04)
Secondary education	0.71***	0.71***	0.09*	0.11	0.14	0.13***
	(0.11)	(0.11)	(0.04)	(0.11)	(0.12)	(0.05)
Higher education	0.48***	0.42***	0.16***	0.72***	0.74***	0.21**
	(0.16)	(0.16)	(0.06)	(0.23)	(0.24)	(0.08)
Variables related to family:						
Hindu	0.05	0.16	0.00	0.17***	0.23***	−0.03
	(0.13)	(0.13)	(0.05)	(0.05)	(0.05)	(0.02)
Brahmin/Chhetri/Newar	−0.14	0.31***	0.12***	−0.08	0.41***	0.08**
	(0.09)	(0.12)	(0.04)	(0.10)	(0.12)	(0.03)
Gurung/Magar/Tamang/Rai Limbu	−0.85***	−0.61***	−0.01	−0.55***	−0.22*	0.01
	(0.12)	(0.14)	(0.06)	(0.12)	(0.13)	(0.05)
Variables related to region:						
Urban	0.62***	0.73***	0.18**	0.79***	0.90***	0.16***
	(0.15)	(0.16)	(0.07)	(0.17)	(0.18)	(0.04)
Terai		0.60***			0.69***	
		(0.10)			(0.11)	
Eastern		0.66***			0.19	
		(0.15)			(.14)	
Central		0.85***			0.61***	
		(0.14)			(0.12)	
Western		0.99***			0.73***	
		(0.13)			(0.14)	
Midwestern		0.16			0.12	
		(0.14)			(0.14)	
Constant	−0.19	−1.56	0.78***	0.27	−0.90***	0.95***
	(0.25)	(0.30)	(0.11)	(0.24)	(0.29)	(0.12)
N	3549	3549	1362	3411	3411	1334
Pseudo-R^2	0.12	0.14	–	0.14	0.16	–
Log-likelihood ratio	−2098.10	−2043.83	−2594.84	−1969.19	−1924.20	−2562.52

***$P < 0.01$, **$P < 0.05$, *$P < 0.10$.

Robust standard errors are in parentheses. The likelihood ratio test values for $\alpha = 0$ are in parentheses [] in Models 3 and 6 values.

All in all, education appears to be a robust predictor of the routine use of professional antenatal care.[17] Consistent with retrospective studies we find that, *ceteris paribus,* maternal education fosters key changes in health-seeking behaviour. However, educated fathers have a more important role to play in the use of routine professional antenatal care than previous studies suggest. We further find that media messages play an independent role in inducing the use of routine professional antenatal care. Our findings further suggest that the mother's age, number of children and residence play an important part in the demand for professional antenatal care on a regular basis.

Determinants of child health

Table 4 presents OLS and 2SLS parameter estimates of the effect of use of professional care and antenatal visits on child health. The use of professional antenatal care and antenatal visits are behavioral inputs to child health and change systematically with variation in educational attainment and exposure to media messages, among others (Table 3). Given such endogeneity, we utilize estimates of the use of professional antenatal care and antenatal visits from the first-stage analysis to obtain the second stage estimates of the child health production parameters. We report OLS estimates in addition to 2SLS estimates for comparative purposes.

Decisions that a mother makes about the type of antenatal care to use during pregnancy and the regularity of antenatal visits matter for health in the infant and toddler years in Nepal (Hypothesis 7). Children, on average, are less malnourished relative to the US reference population when a mother uses professional antenatal care. The effects are sizable; z-scores for a child's weight-for-age increase by nearly 0.1 in 1996 and 2001 (Columns 2 and 6). Furthermore, an additional professional antenatal visit increases the z-score for children's weight-for-age by 0.78 in 1996 and 0.84 in 2001 (Columns 4 and 8). This suggests that when a mother pays at least three visits to a professional during pregnancy, as recommended by Nepal's Ministry of Health, a child is expected to maintain a healthy weight in his or her infant or toddler years, *ceteris paribus*. Results are robust to variations in sample, time and estimation techniques, and support our hypothesis that the use of routine antenatal care matters for child health.

Age matters for child health but gender does not. The negative coefficient on age indicates that, in Nepal, as a child ages, his or her health deteriorates. Child health meets the international standard for months after birth, but begins to fall below the median of the US population in 1996 and 2001 as children age beyond a threshold level. Male and female children are equally likely to face health threats in their infant and toddler years in Nepal, indicating that parents rear female children as well as they do male children as young as 36 months.

Healthy mothers have healthy children. We find an increase in maternal weight increases weight-for-age *z*-scores for children, and the effect is sizeable. Height and weight carry genetic effects, however, and the available NDHS data prevent us from distinguishing between social and biological effects. That mother's weight positively correlates with children's weight-for-age demands further inquiry, and can potentially be an important area of policy intervention to improve child health in Nepal considering that an average mother in Nepal weighs 45.4 kg for her height of 150.5 cm, and is underweight. Height and weight pick up some unobserved household heterogeneity. A mother's height is likely to be a product of a combination of genetic inheritance and the nature of her upbringing by her parents. We therefore attempt to control for some aspects of unobserved household heterogeneity by including height and weight, and note that maternal care and antenatal visits remain robust predictors as a result.

Among the remaining controls, we fail to establish any systematic differences in health between children born into Hindu *vs* non-Hindu families. Compared with children born to relatively 'inferior' caste members, children born into Brahmin, Chhetri or Newar families are well nourished, as are children born into Gurung, Magar, Tamang or Rai Limbu families. Differences in sanitation seem to matter more than differences in water supply for child health. Children are better nourished when households have access to pit latrine services than when they lack any interior sanitation facilities at all.

Heckman sample selection estimates

We also estimate the prenatal care utilization and child heath equations with Heckman's sample selection bias model. The Heckman selection model (a) estimates the selection model—the prenatal care utilization equation, (b) calculates the expected error for each observation and (c) treats the estimated error as an explanatory variable in estimating the child health equation. The model, therefore, allows the unobservable attributes affecting the demand for prenatal care to be correlated with the unobservable attributes affecting child health, and thereby subjects the estimates to another demanding test.

Table 5 shows that our original estimates are robust to the alternative and restrictive estimation techniques, in that the prenatal care utilization and child health determinants in the binomial logit or 2SLS model and the Heckman selection bias model are broadly consistent in size and direction despite the fact that the hypothesis of no sample selection bias is rejected ($\chi^2 = 24.72$; $P < 0.01$ for the 1996 sample, and $\chi^2 = 4.12$; $P < 0.05$ for the 2001 sample).[18] As such, education and exposure to media messages increase the use of routine professional antenatal care, and maternal health care during pregnancy is good for the health of infants and toddlers in Nepal.

Conclusions and policy implications

Years of Safe Motherhood interventions have failed to deliver expected gains in maternal and child health in Nepal. Low use of antenatal services, high maternal mortality and chronic malnutrition are common (UNICEF 1996).

We set out to understand the 'patterns' and 'consequences' of antenatal care utilization in Nepal. Our study has not only confirmed prior findings but also furthered our understanding of antenatal care use in Nepal and in South Asia at large. Our analysis of NDHS data collected in 1996 and 2001 suggests that (a) maternal education encourages the routine utilization of

Table 4 Determinants of child health, 1996 and 2001

	1996				2001			
	(1) OLS	(2) 2SLS Fitted binomial logit	(3) OLS	(4) 2SLS Fitted negative binomial	(5) OLS	(6) 2SLS Fitted binomial logit	(7) OLS	(8) 2SLS Fitted negative binomial
Variables related to mothers:								
Professional antenatal care	0.08*	0.13***	–	–	0.11**	0.13***	–	–
	(0.04)	(0.02)			(0.04)	(0.03)		
Antenatal visits	–	–	0.03**	0.78***	–	–	0.04**	0.84***
			(0.01)	(0.20)			(0.02)	(0.25)
Log of height	1.77**	1.59**	0.88	0.50	2.91***	2.63***	3.79***	3.77***
	(0.70)	(0.69)	(1.19)	(1.17)	(0.67)	(0.67)	(1.10)	(1.14)
Log of weight	1.86***	1.87***	1.71***	1.73***	1.31***	1.34***	1.48***	1.31***
	(0.20)	(0.20)	(0.31)	(0.30)	(0.21)	(0.21)	(0.31)	(0.33)
Age	0.00	0.01	0.01	0.02**	0.00	0.01*	0.01	0.00
	(0.00)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Age at marriage	0.01**	0.01*	0.02	0.01	−0.00	−0.00	0.00	−0.00
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.02)	(0.01)
Variables related to child:								
Sex	0.06*	0.08**	0.04	0.04	0.02	0.02	0.01	0.00
	(0.03)	(0.03)	(0.06)	(0.06)	(0.03)	(0.03)	(0.06)	(0.07)
Age	−0.16***	−0.16***	−0.15***	−0.16***	−0.15***	−0.16***	−0.13***	−0.13***
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Age^2	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***	0.00***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Birth order	−0.02	−0.02	−0.05*	−.05*	−0.04**	−0.03**	−0.05	−0.04
	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	(0.01)	(0.03)	(0.03)
Was ill?	−0.15***	−0.15***	−0.06	−0.06	−0.06	−0.06	−0.11*	−0.10
	(0.04)	(0.04)	(0.07)	(0.07)	(0.04)	(0.04)	(0.06)	(0.07)
Vaccinated?	0.11**	0.09**	0.14	0.15	−0.00	0.01	−0.13	−0.14
	(0.04)	(0.04)	(0.09)	(0.10)	(0.09)	(0.09)	(0.22)	(0.23)
Variables related to family:								
Hindu	−0.01	−0.05	0.03	0.01	−0.02	−0.04	−0.04	−0.01
	(0.07)	(0.07)	(0.11)	(0.11)	(0.02)	(0.03)	(0.04)	(0.04)
Brahmin/Chhetri/Newar	0.17***	0.11**	0.16**	−0.01	0.19***	0.15**	0.20**	0.06
	(0.05)	(0.05)	(0.08)	(0.09)	(0.05)	(0.05)	(0.09)	(0.10)
Gurung/Magar/Tamang/Rai Limbu	0.46***	0.49***	0.52***	0.47***	0.54***	0.55***	0.53***	0.47***
	(0.06)	(0.06)	(0.12)	(0.11)	(0.06)	(0.06)	(0.12)	(0.12)
Variables related to households:								
Water from tap	0.09*	0.07	0.07	0.05	−0.06	−0.07	−0.01	−0.04
	(0.05)	(0.05)	(0.08)	(0.09)	(0.05)	(0.05)	(0.10)	(0.11)
Water from well	0.18***	0.10*	0.04	0.01	0.08	0.04	−0.02	−0.10
	(0.05)	(0.05)	(0.09)	(0.09)	(0.06)	(0.06)	(0.11)	(0.10)
Flush toilet	0.08	−0.01	−0.04	−0.17	0.25**	0.12	0.03	−0.05
	(0.18)	(0.17)	(0.19)	(0.20)	(0.11)	(0.11)	(0.14)	(0.15)
Pit toilet	0.16**	0.11*	0.11	0.02	0.14**	0.09*	−0.10	−0.16*
	(0.06)	(0.06)	(0.08)	(0.09)	(0.06)	(0.05)	(0.09)	(0.08)
Floor	−0.28***	−0.25**	−0.17	−0.13	−0.29***	−0.22**	−0.27**	−0.19
	(0.10)	(0.10)	(0.13)	(0.13)	(0.10)	(0.10)	(0.13)	(0.13)
Urban	0.16**	0.04	0.33***	0.12	0.04	−0.07	−0.02	−0.18
	(0.09)	(0.09)	(0.11)	(0.12)	(0.09)	(0.10)	(0.11)	(0.12)
Constant	−16.80***	−15.88***	−12.19***	−10.97**	−19.95***	−18.76***	−24.97***	−25.02***
	(3.18)	(3.15)	(5.36)	(5.30)	(2.99)	(3.01)	(5.02)	(5.11)
N	2427	2460	830	828	2380	2333	824	806
R^2/Pseudo-R^2	0.35	0.36	0.38	0.39	0.32	0.33	0.32	0.32

***$P < 0.01$, **$P < 0.05$, *$P < 0.10$.

Robust standard errors are in parentheses.

Table 5 Heckman sample selection model estimates, 1996 and 2001

	1996	2001
Outcome variable model: child health		
Child's sex	0.046 (0.060)	0.015 (0.062)
Child's age	−0.160 (0.013)***	−0.135 (0.015)***
Child's age^2	0.003 (0.000)***	0.002 (0.000)***
Child's birth order	−0.064 (0.028)**	−0.045 (0.032)
Was the child ill?	−0.090 (0.062)	−0.085 (0.068)
Was the child vaccinated?	0.146 (0.091)	−0.151 (0.221)
Mother's (log of) height	0.452 (1.102)	3.791 (1.020)***
Mother's (log of) weight	1.797 (0.281)***	1.293 (0.295)***
Mother's age	0.027 (0.009)***	0.009 (0.012)
Mother's age at marriage	0.011 (0.013)	0.010 (0.015)
Hindu	0.033 (0.112)	−0.065 (0.040)*
Brahmin/Chhetri/Newar	0.051 (0.077)	0.140 (0.092)
Gurung/Magar/Tamang/Rai Limbu	0.628 (0.115)***	0.538 (0.115)***
Water from tap	0.027 (0.088)	−0.020 (0.092)
Water from well	−0.044 (0.088)	−0.109 (0.104)
Flush toilet	−0.130 (0.182)	0.071 (0.130)
Pit toilet	0.048 (0.087)	−0.132 (0.080)*
Floor	−0.103 (0.125)	−0.194 (0.124)
Urban	0.316 (0.112)***	−0.188 (0.109)*
Constant	−9.834 (5.035)**	−24.018 (4.604)***
Selection variable model: antenatal care		
Mother's primary education	0.336 (0.077)***	0.477 (0.076)***
Mother's secondary education	0.836 (0.100)***	0.646 (0.096)***
Mother's higher education	2.029 (0.447)***	1.149 (0.323)***
Mother watches television	0.125 (0.103)	0.327 (0.077)***
Mother has a radio at home	0.129 (0.052)**	0.126 (0.054)**
Mother currently working	0.014 (0.065)	−0.073 (0.077)
Mother's age	−0.004 (0.004)	−0.008 (0.004)**
Number of children at home	−0.093 (0.023)***	−0.007 (0.027)
Father's primary education	0.161 (0.066)**	0.142 (0.068)**
Father's secondary education	0.469 (.068)***	0.172 (0.072)**
Father's higher education	0.235 (0.102)**	0.537 (0.135)***
Hindu	0.034 (0.086)	0.093 (0.040)**
Brahmin/Chhetri/Newar	0.220 (0.070)***	0.257 (0.073)***
Gurung/Magar/Tamang/Rai Limbu	−0.360 (0.086)***	−0.224 (0.084)***
Urban	0.262 (0.099)***	0.555 (0.095)***
Terai	0.437 (0.063)***	0.399 (0.064)***
Eastern	0.420 (0.092)***	0.161 (0.092)*
Central	0.509 (0.084)***	0.450 (0.081)***
Western	0.535 (0.088)***	0.409 (0.092)***
Midwestern	0.201 (0.090)***	0.196 (0.087)**
Constant	−1.304 (0.186)***	−1.295 (0.176)***
N	3007	2881
Log-pseudo likelihood ratio	−2558.709	−2475.837
λ	−0.466	−0.275
$(\rho = 0)$: χ^2	24.72***	4.12**

***$P < 0.01$, **$P < 0.05$, *$P < 0.10$.

Robust standard errors are in parentheses.

professional antenatal care, (b) women married to educated men are significantly more likely to use antenatal care than women married to men with little or no schooling and finally (c) children are more likely to be healthy when their mothers maintain good health and seek antenatal care.

Thus, we found that education increases routine antenatal care utilization and that child health improves as a result. However, we must raise a note of caution. First, we have rectified many but not necessarily all sources of endogeneity in antenatal care utilization and, following Maitra (2004), we suggest careful health policy designs in Nepal, among other South Asian countries. Second, maternal education may not bring *contemporaneous* attitudinal or behavioural changes towards maternal health care in patriarchal Nepal; a similar concern is raised by Basu (1994), Jeffery and Jeffery (1996) and Mumtaz and Salway (2007). Education of the father is critical. We show that educated fathers are more central to maternal demand for antenatal care than implied by conventional wisdom. In the face of strict gender norms, religious and cultural health practices in Nepal, we emphasize that in addition to focusing on female education and women's status, efforts should be made to involve fathers in maternal care, maternal health and child health. Mass dissemination of health information and health practices via the media or other sources complements formal education by increasing enthusiasm and awareness of maternal health care. Mothers and children benefit in the process.

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Endnotes

[1] The Safe Motherhood Initiative is a worldwide effort to ensure that women experience safe and healthy pregnancy and childbirth. The key components of the Safe Motherhood (SM) programme in Nepal include: 'a) provision of around the clock emergency obstetric care services, b) ensuring the presence of skilled attendants at birth, and c) enhancing public awareness on SM issues through community mobilization, empowering of community, family and women' (WHO/SEARO 2003).

[2] RECPHEC (1997) estimates ~850–1000 maternal deaths per 100 000 live births.

[3] Nepalese mothers thus make fewer antenatal visits than recommended by either the Nepalese Ministry of Health or WHO. The Ministry of Health and WHO recommend three and four antenatal visits, respectively, during pregnancy, and WHO suggests more than four antenatal visits if a mother is at risk and needs special care (Ministry of Health 1996; UNICEF-WHO 2003).

[4] See McDonagh (1996), Rooney (1992), Villar and Bergsjo (1997) and Bergsjo and Villar (1997) for reviews on (a) considerable variations in what constitutes antenatal care, and/or (b) the effectiveness of antenatal care to improve maternal and child mortality and morbidity. The authors argue that screening for poor maternity history is effective in reducing maternal mortality and morbidity, and that the effectiveness of many routine procedures is questionable.

[5] Maternal health services have more recent origins than modern health services in Nepal. Whereas the latter have been available since the 1960s, the Ministry of Health in Nepal did not create maternal health posts staffed by female maternal and child health workers until 1991 (Acharya and Cleland 2000).

[6] Other determinants include women's age, ethnicity, religion, culture, clinical need for care, decision-making power, costs, location and quality of health services. See Say and Raine (2007) for a comprehensive review of the determinants of maternal health care in developing countries. Low use of antenatal care prevails in India (Pallikadavath *et al*. 2004), Pakistan (Mumtaz and Salway 2007) and Bangladesh (Koenig *et al*. 2007).

[7] Demographic surveys do not include the full list of household or community variables needed to readily establish a causal link between maternal education and child health in developing countries like Nepal (Desai and Alva 1999). When schooling is not universally accessible, mandatory and/or encouraged through in-kind or cash incentives, for example, educated women are commonly: (i) the offspring of educated parents or a non-randomly selected set of uneducated parents with exceptional respect for formal education; (ii) married to educated, often economically better-off husbands; and/or (iii) living in urban communities with relatively better access to professional health services. Maternal education is thus strongly correlated with parental and spousal socio-economic status.

[8] Alterative indicators of antenatal care utilization include the timing of the first antenatal visit (Magadi *et al*. 2000), the place of delivery (Futura and Salway 2006) and the content of care, such as tetanus toxoid immunizations, blood tests for anaemia screening, etc. Routine antenatal visits are an important determinant of having a trained attendant at birth (Bloom *et al*. 1999), and higher antenatal visits are correlated with earlier demand for professional antenatal care (-0.46, $P < 0.0001$). Not surprisingly, studies use either the number of antenatal visits or the timing of the first antenatal visit to measure antenatal care utilization (Bloom *et al*. 1999), and socio-economic and demographic factors—the interest of our study—equally affect the timing and frequency of antenatal visits (Obermeyer and Potter 1991; Bhatia and Cleland 1995; Magadi *et al*. 2000). Nonetheless, we have conducted a survival analysis of time (in months) to the first antenatal visit (we thank one of the reviewers for this suggestion). Data on time to the first antenatal visits are available only for those mothers who used professional antenatal care in their previous pregnancy. Following Allison (1995), the OLS estimates of the log of times to first antenatal visit are the same as survival estimates considering (a) that there are no censored observations (all mothers in this sub-analysis have experienced the 'event'), and (b) that the distribution of the timing of the first antenatal care visit is fairly normal, ranging from the first to the ninth month, with a mean of ~5 months (4.8 in 1996, and 4.5 in 2001). Maternal education, father's higher education and access to the media are significant and of the expected sign. Results are available upon request.

[9] We thank one of the reviewers for suggesting this bivariate relationship between age and child health and the policy recommendation.

[10] We thank one of the reviewers for suggesting the Heckman sample selection model (Table 5). We report the 2SLS as well as the OLS estimates in Tables 3 and 4.

[11] One cannot assume that superior health outcomes among the offspring of antenatal care users are due to antenatal care; on the contrary, they may be due to unobserved correlates of antenatal care utilization.

[12] Endogeneity is an econometric problem where an explanatory variable is correlated with error terms. It arises from self-selection, measurement error and simultaneity (Wooldridge 2002: 50–51).

[13] The mechanisms linking maternal education and child health include: (a) improved socio-economic status, (b) health knowledge, (c) modern attitudes towards health care, (d) female autonomy and (e) reproductive behaviours.

[14] Prior studies commonly use the availability of health care services in the community as the instrument to identify health care's exogenous effect on child health despite a close and direct correlation between health infrastructure and child health (see

Maitra 2004; Rous *et al*. 2004, among others). Strauss and Thomas (1998) summarize the studies showing the (direct) correlation between health infrastructure and child health.

[15] The ultimate source of both biases is unobserved heterogeneity, and the econometric problem being the induced correlation between the error terms and the regressors (Deaton 1997).

[16] Alternatively, we estimate the child health equation with a 3SLS procedure. The 3SLS allows us to estimate Equations 3 and 4 simultaneously as a system of equations. 3SLS allows child health to be estimated as a function of the mother's routine professional antenatal care utilization as observed, as opposed to as predicted in the 2SLS procedure (Equation 3). Results are available upon request.

[17] In addition, we have (a) trichotomized antenatal care into professional, traditional and none, and estimated a multinomial logistic regression, and (b) rank-ordered antenatal care into modern (professional), less modern (traditional) and not modern (none), and estimated an ordered logistic regression model. We find consistent results regardless. Results are available upon request.

[18] ρ is highly sensitive to model specifications, and should be interpreted with caution.

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