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RESEARCH ARTICLE

Is newborn survival influenced by place of delivery? A comparison of home, public sector and private sector deliveries in India

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Abstract

In 2005 and again in 2011, the Government of India launched schemes to encourage institutional delivery among poor women, with the aim of improving maternal and newborn health outcomes. Partly as a result of these initiatives, the proportion of children born in a health facility rose steeply from 42% in 2000–2005 to 81% a decade later. In this context, the objective of this paper was to determine the association between place of delivery (public sector, private sector, home) and early neonatal mortality, defined as death in the first 7 days after birth. The focus was on early neonatal mortality because over half of all under-five deaths occur in his period and because the protective effect of an institutional place of birth should be strongest in those few early days. Both bivariate methods and multivariate logistic regression analysis were applied to data from the fourth round of the National Family Health Survey conducted in 2015–16. For the country as a whole, it was found that the adjusted odds of death in the early neonatal period were lower for deliveries in public health facilities than for home deliveries (OR 0.833 $p<0.01$), but no significant difference was found between deliveries in private health facilities and at home. Adjusted odds of death were higher for deliveries in private than public sector facilities (OR 1.41 $p<0.01$). On further investigation, for the poor in Bihar and Uttar Pradesh, it was found that the risks of dying in the early neonatal period were even higher for babies delivered in private health facilities than for home deliveries with adjusted odds of over 2.0. These results raise serious questions about quality of care in the private sector in India. In the context of increased emphasis on public–private partnerships in health services provision in the country, it becomes imperative to enforce better inspection, licensing and quality control of private sector facilities, especially in the states of Bihar and Uttar Pradesh.

Keywords: Early neonatal mortality; Place of delivery; Public versus private facility

Introduction

Globally 2.6 million newborn babies die every year within the first month of life (or the neonatal period), constituting about 45% of all child deaths under the age of five years (WHO, 2018). Of these neonatal deaths, 50% die within the first 24 hours itself and 75% die within the first week of life (or the early neonatal period). Furthermore, out of these 2.6 million, 0.76 million occur in India alone, constituting 30% of all neonatal deaths world-wide and the highest number for any country in the world (Zodpey & Paul, 2014). In India, significant progress has been made in reducing infant and child mortality rates, with declines of over 50% between 1992 and 2016 (Bhatia *et al.*, 2019). However, over the same period, the decline in neonatal mortality has been less impressive, with a drop of 39% according to the International Institute for Population Sciences (IIPS, 2017). Similarly, disease burden collaborators estimated the annual

percentage decline in neonatal mortality between 2000 and 2017 to be 2.8% compared with 3.9% for under-five mortality (ISDBICMC, 2020). Moreover, the early neonatal mortality rate, which accounts for more than 45% of under-five child deaths in India, has declined more slowly than the overall neonatal mortality rate (Zodpey & Paul, 2014).

For the period 2011–2015/6, the neonatal mortality rate for India is estimated at 30 deaths per 1000 live births (IIPS, 2017). This is much higher than in countries at similar levels of economic and social development such as Brazil, Russia, China and South Africa (the BRICS nations), and even countries that are behind, like Bangladesh and Sri Lanka. Additionally, wide variations are observed across states of India: the neonatal and perinatal mortality rates are as high as 45.1 and 56.4 respectively in Uttar Pradesh and as low as 4.4 and 8.4 respectively in Kerala (IIPS, 2017). Analysis of the fourth round of the National Family Health Survey (NFHS-4) documented very wide district variations in neonatal mortality, with many of the highest rates in the North–Central and Eastern regions of the country (Bora & Saikia, 2018).

In 2017, the major causes of neonatal death were prematurity, birth asphyxia and trauma, lower respiratory infections, congenital birth defects and other neonatal disorders (ISDBICMC, 2020). Information on cause of death is also available from a study of 23,602 live births in Bihar in 2016 that used verbal autopsies (Dandona *et al.*, 2019). Asphyxia and prematurity were the dominant causes of death at ages 0–2 days. For institutional deliveries, a large majority (80%) of these deaths occurred in the facility. At 3–7 days, the major causes of death were pneumonia, meningitis/sepsis and prematurity. For public sector facility deliveries, 28% of these deaths took place in the facility but this proportion rose to 91% for private sector deliveries.

With the aim to improve these health outcomes and acknowledging the targets set by Millennium Development Goals 4 and 5 of the United Nations, the Government of India initiated a number of schemes under its flagship National Rural Health Mission, now the National Health Mission (NHM). In particular, two of these schemes, the Janani Suraksha Yojana (JSY) launched in 2005 and the Janani Shishu Suraksha Karyakram (JSSK) launched in 2011, focus on reducing maternal and neonatal mortality by encouraging facility-based delivery in the presence of trained health personnel. Information about these schemes, together with advice about obstetric care and infant health, is disseminated though Mother and Child Protection (MCP) cards, which are issued to pregnant women and mothers of infants by community health workers.

The JSY is a conditional cash transfer scheme which provides financial assistance to women for delivering in all public sector and accredited private health facilities across India. As the world's largest cash incentive scheme, JSY has attracted much research attention and the evidence shows that it has had a major impact on institutional delivery, though the scale of implementation has varied widely between states (Lim *et al.*, 2010; Carvalho & Rokicki, 2019). Its least successful component concerns the reluctance of the private sector to participate because of low rates of, and delays in, reimbursement (Yadav *et al.*, 2017). The JSSK encourages institutional delivery by providing free delivery related and newborn care related services to women in all government health facilities across India. However, implementation has been patchy because of conflicting interests of health managers and frontline staff (Parashar *et al.*, 2020). The NFHS-4 revealed that, on average, families still paid more than Rupees 3000, equivalent to US$40, for a public sector delivery in the period 2010–16 (IIPS, 2017).

In the recent past, the level of institutional delivery in India has doubled, from around 40% in 2000–05 to about 80% a decade later (IIPS, 2017). Nevertheless, wide variations are recorded between states and districts, with the level of institutional delivery in Nagaland having increased over the decade from 12% to 33% compared with Karnataka, where it increased from 65% during 2000–05 to 94% during 2010–15 (IIPS, 2006, 2017). A detailed analysis of NFHS-4 data showed that underprivileged sectors of the population (the poorest, least educated and those belonging to scheduled castes and tribes) were significantly less likely than others to report facility deliveries (Mondal *et al.*, 2020). Institutional deliveries were also low among non-Hindus, those living in the Central and North East regions and for higher order births.

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This extraordinary emphasis on institutional delivery as a public health intervention is justified in part by the expectation that a newborn child's survival chances should increase substantially with a facility-based delivery in the presence of a skilled birth attendant (WHO, 2018). Globally and in India, the three major causes of neonatal deaths are preterm delivery, intrapartum related complications, particularly birth asphyxia, and infections (Lawn *et al.*, 2005). Given the fact that the former two occur mostly at the time of birth, facility-based management of complications and newborn care can reduce substantially the number of early neonatal deaths (Filippi *et al.*, 2006).

It is in this context that the aim of this paper is to advance knowledge of the association between place of delivery and early life mortality in India. Has the huge investment in promoting facility deliveries paid dividends in terms of newborn survival? A review of the international literature identified three relevant hypotheses. The first hypothesis states that babies born in institutions are less likely to die in early life than are babies born at home (Visaria, 1985; Zahid, 1996; Padhi, 2001; Darmstadt *et al.*, 2005; Filippi *et al.*, 2006; Malqvist *et al.*, 2008; Tripathy *et al.*, 2016). This is because better quality of care is available at these health facilities than at home, including factors such as the presence of skilled birth attendants, better sanitary conditions, intrapartum and postnatal care and better newborn birth preparedness. The second hypothesis states that there is no relationship between early-life mortality and institutional delivery because of the absence in health facilities of the very factors mentioned in the first hypothesis (Arokiasamy & Gautam, 2008; Titaley *et al.*, 2008; Haq, 2008; Rahman *et al.*, 2010; Shah & Dwivedi, 2011; Lohela *et al.*, 2012; Coffey, 2014). Finally, the third hypothesis states that there is a positive relationship between early-life mortality and institutional delivery, because of self-selection of high-risk women into facilities (Chowdhury *et al.*, 2005; Nathan & Mwanyangala, 2012; Pal, 2015). A few studies also examined the link between place of delivery and maternal mortality in India (Radkar & Parasuraman, 2007; Iyengar *et al.*, 2009; Prakasamma, 2009). Broadly similar hypotheses emerge from this literature as well. In this study, the problem of self-selection was adjusted by using information on women's overall health measured by body mass index and self-reported problems during pregnancy. The analysis thus provides some new data relevant to all three hypotheses, with a focus on the comparative advantage for newborn survival of public and private sector place of delivery.

This study is important for several reasons. First, the bulk of the literature focuses on understanding the factors affecting infant and child mortality, for which the determinants and interventions are very different from those for early neonatal mortality. Second, within India itself, very few studies have been conducted to investigate whether facility-based deliveries are protective to newborn children. Most of the literature is old and relates to a time when the rates of institutional delivery were low and largely confined to better educated and wealthier women who opted for private sector facilities or to those at a particularly high risk of experiencing neonatal deaths.

To the authors' knowledge, only two papers have assessed the associations between place of delivery and neonatal mortality in India, since the massive expansion in institutional deliveries of the past decade. An analysis of NFHS-4 data showed that facility deliveries were protective of neonatal survival in the East region, comprising the states of West Bengal, Assam and Odisha and in the Central region (Madya Pradesh and Chhattisgarh) but not in the North, South and West regions (Coffey, 2019). In this analysis, data for Uttar Pradesh and Bihar were analysed separately because of their high neonatal death rates and no significant differences in neonatal mortality between facility and home deliveries were found in these two states. Whereas the analysis by Coffey made no distinction between deliveries in private and public sector facilities, the second paper did make this distinction. Using data from Bihar, Dandona *et al.* (2019) found that deaths at ages 0–2 days were significantly higher for deliveries in private sector facilities and at home than for deliveries in public sector facilities, even after adjustment for proximate causes such as gestational age, entangled cord round the baby's neck and antiseptic cord care. No significant differences by place of delivery were found at ages 3–7 days.

This paper builds on these two studies with an assessment of the relationship, at national level, between place of delivery (public sector, private sector and home) and early neonatal

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mortality – that is, the probability of death in the first 7 days. This outcome was chosen since the influence of facility-based delivery on survival is most powerful during the first few days of birth. An alternative outcome is perinatal mortality but this choice was precluded by the absence of information on place of delivery of stillbirths.

Methods

Data

Data from NFHS-4 were used in this analysis (IIPS, 2017). The NFHS-4 is a national-level household survey conducted in 2015–16 in all Indian states. It provides information on population, family welfare, maternal and child health and nutrition for all India as well as for all the states and districts. Details of the methods and content of this survey are available from publications by the Indian Institute for Population Sciences. The NFHS-4 has a sample of 601,509 households, 699,686 women and 103,525 men.

The unit of analysis in this study was the mother–child dyad. The outcome relates to the child but most of the other variables pertain to the mother. Specifically, the focus was on births that occurred in the five years immediately preceding the survey to mothers who were aged 15–49 years at the time of the survey, and which were the last births that their mothers had before the survey. The restriction to the last births was imposed for two reasons: firstly, information relating to the majority of maternal and child health care variables is available only for the most recent child in the NFHS; and secondly, limiting the sample to the most recent child minimizes recall bias, under-reporting and misreporting of data (Arokiasamy & Gautam, 2008). Thus, the total sample size which forms the basis of this analysis was 18,3011 births/mothers and 2850 early neonatal deaths. Multiple births were included as separate births.

Variable description

The outcome variable of interest was early neonatal mortality. The primary independent variable was place of delivery, which had three categories: home, public health facility and private health facility. 'Home' included all deliveries that took place at the women's own home, her parents' home or other's home. Public health facilities included all government/municipal hospitals, dispensaries, community health centres, rural hospitals, block primary health centres, primary health centres, additional PHCs and sub-centres and other public health facilities. Private health facilities included hospitals, maternity homes/clinics, non-governmental organizations, trusts and other private health facilities.

A wide range of potential confounding factors of early neonatal mortality identified from the literature review was also used in the analysis. These included geographical factors (region of residence, rural–urban residence), social factors (education, caste and religion), household wealth quintile (derived from ownership of consumer durables, dwelling construction and water and sanitation) as well as demographic factors (maternal age at birth, birth order and preceding birth interval length). The categorization of these covariates and sample distribution across categories are shown in Table 1.

Regressions factors relating to maternal health and health seeking were also included. Mothers were classified according to whether or not they had received full antenatal care for the index pregnancy, which comprised at least four antenatal visits, receipt at least one tetanus injection and consumption of iron and folic acid tablets/syrup for longer than 3 months during pregnancy. In the NFHS-4, information on postnatal care of mother and baby is also available but was excluded from analysis, because many deaths occurred before the possibility of such care. In the NFHS-4, women were asked whether they had experienced convulsions, vision difficulties and swelling of the legs or body during pregnancy. Women who reported any of these conditions

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Table 1. Percentage distribution of most recent births according to place of delivery by mothers' characteristics, birth order and birth interval (NFHS-4)

	Home (%)	Public health facility (%)	Private health facility (%)	*n*	*p*-value*
Region					
North	15	59	26	24,097	<0.001
Central	27	52	21	46,868	
East	28	54	18	46,536	
North East	29	59	12	7108	
West	9	43	48	24,072	
South	4	51	45	34,330	
Place of residence					
Urban	10	46	44	54,512	<0.001
Rural	23	55	22	128,499	
Mother's education					
None	37	51	12	50,533	<0.001
Primary	25	58	17	24,603	
Secondary	11	57	32	85,919	
Higher	3	34	63	21,956	
Religion					
Hindu	17	54	29	144,381	<0.001
Muslim	28	45	27	29,433	
Other	17	49	34	9197	
Caste/tribe					
Scheduled caste	20	61	19	38,675	<0.001
Scheduled tribe	30	57	13	18,787	
Other	17	49	34	125,548	
Wealth Index					
Poorest	39	53	8	42,677	<0.001
Poorer	23	62	15	38,674	
Middle	13	60	27	36,395	
Richer	8	51	41	34,855	
Richest	4	34	62	30,410	
Age of mother at birth					
15–19	16	60	24	20,355	<0.001
20–34	18	52	30	154,351	
35–49	36	41	23	8305	
Birth order					
1–2	12	54	34	125,134	<0.001
3–4	29	52	19	44,044	
5–6	43	46	11	10,412	
7+	54	37	9	3421	

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(*Continued*)

Table 1. (*Continued*)

	Home (%)	Public health facility (%)	Private health facility (%)	*n*	*p*-value*
Birth interval					
First birth	9	54	37	61,973	<0.001
≤2 years	25	53	21	34,346	
2–4 years	25	53	22	56,966	
4–6 years	21	50	29	18,981	
7+	17	50	33	10,744	
N	34,573	96,228	52,210	183,011	

All percentages have been weighed using appropriate sampling weights.
*Based on the chi-squared test of independence; 5% level of significance.

were classified as having experienced problems during pregnancy. Similarly, women were asked about problems during delivery (breech presentation, prolonged labour and excessive bleeding). Women were classified according to whether or not they had experienced any of these three problems. The final health related factor included in the analysis was the woman's body mass index (BMI). The sample distribution for these covariates is shown in the upper four panels of Table 2.

Subjective estimates of babies' size at birth were also available but excluded from analyses because of the risks of reverse causality; babies who die soon after birth may be wrongly classified as 'small' or 'very small'. Birth weights are available from cards or mothers' recall for most facility deliveries but for only a minority of home deliveries. Moreover, a recent analysis using NFHS-4 data showed a very small difference between public and private sector deliveries in the proportion of babies classified as low birth weight (17.6% public, 16.8% private) and this variable was also excluded from analysis (Zaveri *et al.*, 2020). Information is also available on self-reported type of person who assisted with delivery (doctor, nurse/midwife or no skilled attendance) but the overlap with place of delivery precluded inclusion of this variable.

Statistical analysis

After introductory descriptive analyses, a multivariate analysis was conducted, whereby a baseline logistic regression model of the following type was fitted on the entire sample:

$$\log_e(p/1-p) = \beta_0 + \alpha P + \beta_1 X_1 + \cdots + \beta_k X_k$$

where p is the probability of early neonatal death, P is place of delivery, $X_1 \ldots X_k$ are confounding factors and α and $\beta_0 \ldots \beta_k$ are coefficients to be estimated. Next, separate logistic regression models were fitted on the sample stratified by state, since states in West and South India have much lower early-life mortality rates and relatively higher institutional delivery rates than in the rest of the country, particularly in the states of Bihar, Uttar Pradesh, Uttarakhand, Madhya Pradesh, Chhattisgarh, Rajasthan, Orissa, West Bengal and Assam. Furthermore, in an analysis of data from Bihar and Uttar Pradesh, the sample was stratified by household wealth index into low (poorest 40% population), medium (the middle 20% population) and high wealth (the richest 40% population). This was done because it was found that an interaction of the wealth index variable with the place of delivery variable was statistically significant, suggesting that the association between place of delivery and early neonatal mortality was conditioned by wealth.

Finally, although the issue of endogeneity of the place of delivery variable is minor in this context (since only 20% of total deliveries in India are home-based), a sub-analysis was conducted, whereby

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Table 2. Maternal health and delivery related indicators of most recent birth by place of delivery

	Home (%)	Public health facility (%)	Private health facility (%)	*n*	*p*-value*
Received full antenatal care					
No	94	79	67	143,869	<0.001
Yes	6	21	33	39,142	
BMI					
<18.5	30	25	16	43,170	<0.001
18.5–24.9	61	60	55	107,644	
≥25	8	13	26	28,780	
Missing	1	2	3	3416	
Faced any problems during pregnancy					
No	63	61	59	111,408	<0.001
Yes	37	39	41	71,603	
Faced any delivery related problems					
No	53	44	47	85,205	<0.001
Yes	47	56	53	97,805	
Delivery assistance by type of attendant					
Doctor	11	62	84	107,342	<0.001
Midwife/nurse	11	36	14	45,200	
No skilled attendance	78	2	2	37,409	
Cost of delivery (average, in Rs)	NA	3198	16,522	43,046	<0.001
Received financial assistance for delivery care					
No	NA	40	93	87,002	<0.001
Yes		60	7	61,436	
Received financial assistance for delivery care under JSY					
No	NA	46	95	94,178	<0.001
Yes		54	5	54,260	
Received Mother and Child Protection (MCP) card					
No	17	7	14	16,740	<0.001
Yes	83	93	86	139,394	
Length of stay in the health facility					
<2 days	NA	41	28	54,343	<0.001
≥2 days		59	72	93,823	
Size of the baby at birth					
Very large	4	7	7	11,693	
Larger than average	11	14	15	24,429	

(*Continued*)

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Table 2. (*Continued*)

	Home (%)	Public health facility (%)	Private health facility (%)	*n*	*p*-value*
Average	66	68	67	122,622	<0.001
Smaller than average	10	9	8	16,217	
Very small	4	3	3	5402	
Total	100	100	100		
N	34573	96228	52210	183,011	

All percentages have been weighed using appropriate sampling weights.
*Based on the chi-squared test of independence.

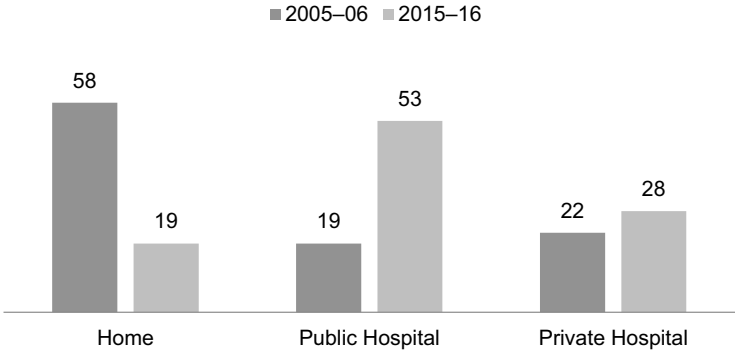

Figure 1. Births by place of delivery (in %) in India, 2005–06 and 2015–16.

the sample was restricted to deliveries occurring only in public and private health facilities. As earlier, logistic regressions stratified by state and wealth were performed for this analysis as well.

Statistical analysis was performed using STATA 14 and used appropriate weights to account for the sampling design and make the analysis representative of the entire population. Standard errors took account of sample clustering.

Results

Figure 1 shows the change in the distribution of births by place of delivery between 2000–05 and 2010–15. While home deliveries have declined drastically, the major component of the increase in institutional deliveries has been in the public health facilities. In the earlier period, births in private facilities slightly outnumbered those in the public sector. In the more recent period, 53% of births took place in public sector facilities and 28% in the private sector. Over the same decade, early neonatal mortality and neonatal mortality rates have declined for deliveries in both public and private health facilities but they have either increased or remained constant for home-based deliveries (Figures 2 and 3). In 2010–15, both neonatal and early neonatal death rates in public and private facilities were almost identical.

Associations between place of delivery and geographical, social, economic and demographic factors are shown in Table 1. Home deliveries were most common among poor, ill-educated, high-parity women and among Muslims, scheduled tribes and those living in the Central, East and North East regions. Deliveries in private health facilities were most common for wealthy, highly educated, urban women and for those living in the South and West regions of the country.

Over half (55%) of the total child deaths under the age of five occurred in the early neonatal period (Table 3). Furthermore, 61% of all child deaths in private hospitals took place in the first 7 days and

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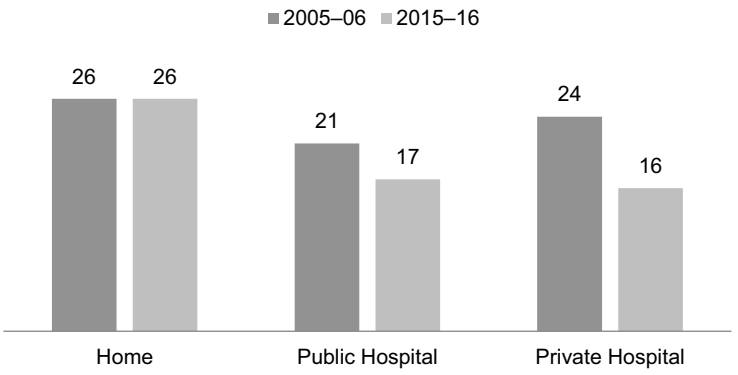

Figure 2. Trends in neonatal mortality (in %) by place of delivery in India.

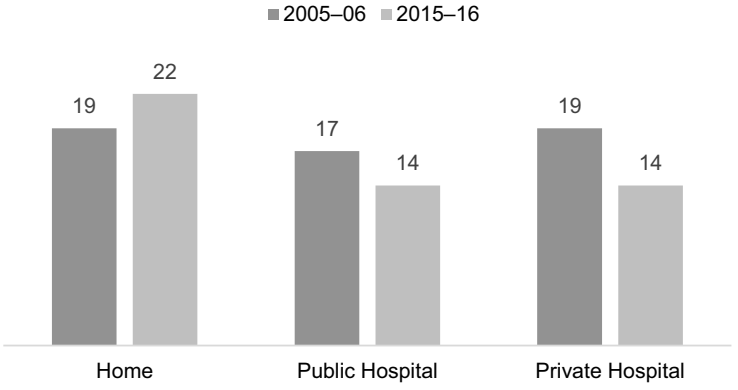

Figure 3. Trends in neonatal mortality (in %) by place of delivery in India.

approximately half of them took place on the day of birth itself. In comparison, 54% of all child deaths in public hospitals and 50% of all child deaths at home occurred in the early neonatal period.

As mentioned above, the main concern in an observational study on this topic is the possible self-selection of women at high risk of suffering an infant death into delivery at a private or public sector facility. The NFHS-4 collected a range of relevant information including self-reported problems during pregnancy and delivery. Table 2 presents the maternal characteristics and health-seeking behaviour of women in the sample. Of the women who delivered at home, just 6% had received full antenatal care compared with 21% and 33% in public and private health facilities, respectively. Nearly one-third of the women who delivered at home had a BMI of less than 18.5 (i.e. underweight) compared with a quarter in the public sector and one-sixth in the private sector. Conversely, women who used a private facility were twice as likely to be overweight (BMI 25+) than those who used a public facility and three times more likely than those who delivered at home. As expected, women who delivered in a facility were marginally more likely to have reported pregnancy and delivery related problems than those who delivered at home, but differences between public and private sector deliveries were very small. Of the women who delivered at home, 78% of them received no skilled attendance. According to women's reports, doctors assisted with 84% deliveries in the private sector, 62% in the public sector and 11% at home. About two-thirds of mothers judged the baby to be of average size with little variation by place of delivery. The proportion classified as small or very small was slightly higher for home deliveries than for facility births but there was no difference between private and public sectors. Self-reported costs of

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Table 3. Percentage distribution of child deaths by age at death (NFHS-4)*

Age at death	Home (%)	Public health facility (%)	Private health facility (%)	Total (%)
Day of birth	22	24	30	25
Day 2–Day 7	28	30	31	30
Day 8–Day 30	11	10	11	11
Day 31–Year 1	34	31	26	31
Year 1–Year 5	5	5	2	4
N	100	100	100	100

*Based on the most recent births to women in the last 5 years prior to NFHS-4 (2015–16).

delivery were over five times higher for private than public sector deliveries, which is partly a reflection of the longer time spent in private than in public facilities. Whereas 60% of mothers who delivered in a public sector facility reported reimbursement of costs (mainly from JSY), only 7% of those delivering in a private facility received any reimbursement.

Table 4 shows the results of the baseline logistic regressions of early neonatal mortality on place of delivery (base category=home), with successive controls for socioeconomic, demographic and maternal health related covariates with a final introduction for state fixed effects. In the first unadjusted model, the odds ratios (ORs) of death in the early neonatal period were significantly lower and very similar for public or private health sector deliveries than for home deliveries. In the second model, as socioeconomic variables (rural–urban residence, education and caste excluding wealth) are controlled for, the adjusted odds ratio (AOR) of death associated with public sector deliveries remained significantly lower with a modest change from 0.64 to 0.77, but they become insignificant for private health facilities (AOR 0.97). Further controls for household wealth, demographic factors (mother's age, birth order and birth interval), mother's health and health seeking (all the factors shown in the upper four panels of Table 2) and state fixed effects made little further difference to the results. In model 6 with the full range of controls, the AOR of early neonatal death for a birth in a public sector facility compared with a home delivery was 0.83. Consideration of standard errors in this model shows that the odds of early neonatal death were significantly higher for private than public sector deliveries and sub-analysis omitting home deliveries confirmed this result (see Table 7). The AOR of early neonatal death for private versus public sector deliveries was 1.41 ($p<0.01$)

Both the prevalence of institutional delivery and the rate of early neonatal mortality vary widely by state. Accordingly, separate regressions for 28 states or union territories were fitted after excluding Andaman and Nicobar Islands, Chandigarh, Dadar and Nagar Haveli, Daman and Diu, Lakshadweep, Puducherry and Sikkim because of very small sample sizes. After adjustment for the factors included in Table 4, the statistically significant results are summarized in Table 5. Because of the small number of deaths per state, few significant effects were found. The AORs of dying in the early neonatal period were significantly lower for public health facility versus home deliveries in the states of Chhattisgarh, Jharkhand, Madhya Pradesh, Jammu & Kashmir, Kerala, Tamil Nadu and Telangana. The odds of death were also significantly lower for private health facilities versus home for the southern states of Kerala, Tamil Nadu and Telangana as well as Gujarat in the west. Note, however, that home deliveries were very rare in the southern region and likely to be highly selected of risk factors for early neonatal death. Conversely, for the states of Bihar and Uttar Pradesh, the AORs of death in the early neonatal period were significantly higher for births in the private health facility than for home deliveries.

Further investigation of the situation in Bihar and Uttar Pradesh showed an interaction between place of delivery and household wealth. A large majority (79%) of mothers in Bihar and over half of mothers (54%) in Uttar Pradesh were classified as coming from the lowest two national wealth quintiles. Specifically, it was found that the probabilities of dying in the early

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Table 4. Regression of place of delivery on early neonatal mortality

	(1)	(2)	(3)	(4)	(5)	(6)
Variable	OR	OR	OR	OR	OR	OR
Place of delivery						
Home (Ref.)						
Public health facility	0.639***	0.767***	0.800***	0.800***	0.800***	0.833***
	(0.036)	(0.044)	(0.047)	(0.048)	(0.048)	(0.050)
Private health facility	0.627***	0.973	1.133	1.102	1.107	1.130
	(0.041)	(0.072)	(0.088)	(0.087)	(0.088)	(0.092)
Control variables						
Socioeconomic		✓	✓	✓	✓	✓
Wealth Index			✓	✓	✓	✓
Demographic				✓	✓	✓
Maternal health					✓	✓
State fixed effects						✓
Constant	0.022***	0.022***	0.028***	0.047***	0.039***	0.025***
	(0.001)	(0.002)	(0.003)	(0.023)	(0.019)	(0.026)
N	189,068	189,068	189,068	189,068	189,068	189,068

Robust standard errors in parentheses.
Ref., reference category; ***$p<0.01$; **$p<0.05$; *$p<0.1$.

Table 5. States where early neonatal mortality for public and private sector deliveries differs significantly from that for home delivery

	OR<1 and significant	OR> 1 and significant
Public health facility	Chhattisgarh, Jharkhand, Madhya Pradesh, Jammu & Kashmir,	
Private health facility	Gujarat	Bihar, Uttar Pradesh
Both public and private	Kerala, Tamil Nadu, Telangana	

All socio-demographic, economic, maternal and child health variables have been controlled for in the stratified regressions. All union territories (except Delhi), Sikkim and Goa were excluded from the analysis due to low sample size.

neonatal period were significantly higher in both states for private sector than for home deliveries only for infants born to women belonging to these poorer segments of the population (AOR Bihar 2.2; Uttar Pradesh 2.0) but there were no significant differences between home and public sector deliveries (Table 6). A direct comparison of the private and public sectors is shown in Table 7, where home deliveries are omitted. The AORs of death were higher for private versus public sector deliveries across all three wealth strata in both states but they were highest (AOR>2.0) for the poorer stratum and only statistically significant for this stratum (and for the richer stratum in Uttar Pradesh).

Discussion

In this paper, the relationship between place of delivery and early neonatal mortality in India was assessed. It was found that the odds of early neonatal death were lower for public health facility

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Table 6. Effect of place of delivery on early neonatal mortality in Bihar and Uttar Pradesh, stratified by low, medium and high household wealth

	Bihar			Uttar Pradesh		
Variable	Low OR	Medium OR	High OR	Low OR	Medium OR	High OR
Home (Ref.)						
Public health facility	0.974	0.339**	0.346	0.952	1.084	0.855
	(0.144)	(0.156)	(0.316)	(0.115)	(0.330)	(0.271)
Private health facility	2.204***	0.573	0.529	2.028***	1.420	1.468
	(0.404)	(0.299)	(0.467)	(0.293)	(0.461)	(0.455)
Constant	0.075**	60.028	0.003	0.050**	0.331	0.016*
	(0.095)	(247.164)	(0.016)	(0.058)	(0.767)	(0.039)
N	13,064	1941	1546	15,202	5093	8030

The ORs have been adjusted for all socioeconomic, demographic and maternal health factors.
Robust standard errors in parentheses; Ref., reference category; ***$p<0.01$; **$p<0.05$; *$p<0.1$.

Table 7. Effect of type of institutional delivery on early neonatal mortality in Bihar and Uttar Pradesh stratified by low, medium and high household wealth

	All India	Bihar			Uttar Pradesh		
Variable	OR	Low OR	Medium OR	High OR	Low OR	Medium OR	High OR
Public health facility (Ref.)							
Private health facility	1.406***	2.297***	1.862	1.863	2.171***	1.335	1.713**
	(0.098)	(0.400)	(0.936)	(1.374)	(0.291)	(0.326)	(0.449)
Constant	0.016***	0.015***	0.4381*	0.000*	0.132	0.244	0.020
	(0.018)	(0.021)	(0.022)	(0.000)	(0.190)	(0.681)	(0.058)
N	146,756	8329	1583	1372	9609	3647	6541

The ORs have been adjusted for all socioeconomic, demographic and maternal health factors.
Robust standard errors in parentheses; Ref., reference category; ***$p<0.01$; **$p<0.05$; *$p<0.1$.

deliveries than for home deliveries. This difference persisted after controls for a battery of socioeconomic and health factors and amounted to an approximate 20% reduction in risk of death. The apparent advantage for the newborn of delivery in a public sector facility was particularly pronounced in some southern states but home delivery is rare in this region, which diminishes its substantive significance. More importantly, this difference held for the economically disadvantaged states of Chhattisgarh, Madhya Pradesh and Jharkhand. This result accords with the hypothesis that institutional deliveries are protective to newborn children. Furthermore, it is consistent with recent studies on quality of public health facilities which have shown notable improvements in physical infrastructure, supplies of essential equipment, easy accessibility, increased staff appointments, particularly of auxiliary nurse midwives, and strengthening of service delivery enabled by the increased funding under the NHM (Bajpai *et al.*, 2005; Bhattacharya *et al.*, 2012; Goel & Khera, 2015).

The key contribution of this paper concerns the results with regard to private sector deliveries, which were very different from those for the public sector. Before adjustment for covariates, early neonatal mortality was much lower for private sector births than home births. After adjustment for covariates, the risk of death in the first 7 days was no different from the risk to home deliveries at the national level and significantly higher than for public sector deliveries. It thus appears that

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many families are paying large sums for private obstetric care when better outcomes, at much lower cost, for the newborn would have been obtained in public sector facilities. Investigation at state level revealed that the risks of early neonatal death were greatly and significantly higher for private sector than for home deliveries among the poor in Bihar and Uttar Pradesh. In contrast, no difference in newborn survival between public sector and home deliveries were found for the poor in these two states. In the study's classification, the poor comprised 79% of mothers in Bihar and 54% in Uttar Pradesh. These two states comprise nearly one-quarter of India's total population and an even higher proportion of all births because of higher-than-average fertility – considerations that underscore the substantive importance of the finding that the private sector is associated with particularly high newborn mortality.

These results are contrary to the popular perception that the quality of care is better in private than public health facilities in India (Griffiths & Stephenson, 2001). Private health facilities in India are diverse, ranging from huge hospitals catering to the affluent urban population, to small, rundown facilities in rural areas, owned by semi-qualified or unqualified persons. The latter facilities are unlikely to have the necessary infrastructure, equipment and skilled staff to provide an adequate level of care required for childbirth, leading to adverse maternal and child health outcomes. A recent study conducted in three districts of Uttar Pradesh showed that, although obstetric care in the private sector was more likely to be offered by qualified staff, the quality was no different from that provided by unqualified personnel (Sharma *et al.*, 2017). Moreover, the quality of care in small private hospitals in other regions of India has also been found to be sub-standard (Bhate-Deosthali *et al.*, 2011). In economics, this situation is termed adverse selection; women have erroneous expectations about the quality of care that they will receive from different facilities and thus choose facilities that offer a lower-than-average quality.

The findings of this study are important for two reasons. Firstly, the emphasis of policymakers should now be on improving the quality of obstetric care across all facilities but with special emphasis on those in the private sector, particularly in the Central and East region of the country. Even though public health facilities are improving in terms of infrastructure and services, they are still marred by problems of under-staffing, absenteeism, poor emergency care and referral services and overload. Secondly, with the National Health Mission and National Health Policy, 2017 recommending collaboration with the private sector to provide services in areas where the public sector has been deficient, an urgent priority is to introduce better inspection, licensing and quality control of private sector facilities, especially in Uttar Pradesh and Bihar. This may increase accountability and bring about improvement in the quality of health services in small private facilities.

Observational studies, such as this, cannot prove causality, despite the wide range of controls used in this analysis. It remains possible that unmeasured or poorly measured factors, such as self-reported intra-partum problems, could have distorted the associations that are found between place of delivery and early death. Under-reporting of early neonatal deaths and confusion with stillbirths are further concerns. Yet the key results presented in this study are both compelling and plausible and certainly sufficient to provoke programmatic attention and further more focused research.

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