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RESEARCH ARTICLE

New evidence on the impact of the quality of prenatal care on neonatal and infant mortality in India

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Abstract

Evidence on the impact of the quality of prenatal care on childhood mortality is limited in developing countries, including India. Therefore, using nationally representative data from the latest round of the National Family Health Survey (2015–16), this study examined the impact of the quality of prenatal care on neonatal and infant mortality in India using a multivariable binary logistic regression model. The effect of the essential components of prenatal care services on neonatal and infant mortality were also investigated. The results indicate that improvement in the quality of prenatal care is associated with a decrease in neonatal (OR: 0.93, 95% CI: 0.91–0.97) and infant (OR: 0.94, 95% CI: 0.92–0.96) mortality in India. Tetanus toxoid vaccination, consumption of iron–folic acid tablets during pregnancy and having been weighed during pregnancy were statistically associated with a lower risk of neonatal and infant mortality. Educating women on pregnancy complications was also associated with a lower risk of neonatal mortality. No effect of blood pressure examination, blood test and examination of the abdomen during pregnancy were found on either of the two indicators of childhood mortality. Although the coverage of prenatal care has increased dramatically in India, the quality of prenatal care is still an area of concern. There is therefore a need to ensure high-quality prenatal care in India.

Keywords: Quality of prenatal care; Neonatal mortality; Infant mortality

Introduction

Prenatal care services, including antenatal care (ANC) visits, iron folic acid (IFA) supplementation, tetanus toxoid injection, blood test, urine test, other diagnostic tests, health education, advice and counselling, have been recommended for a long time and have been adopted by most countries in the world (WHO, 2016). Many countries have adopted several of these interventions despite the absence of credible evidence on their impact on maternal, neonatal and child health outcomes. A study carried out by Carroli *et al.* (2001) showed a lack of strong evidence on the effectiveness of the content, frequency and timing of visits in standard ANC programmes on maternal and child health. A comprehensive review of the literature shows that routine antenatal care procedures have very little influence on maternal mortality and morbidity (Rooney, 1992; McDonagh, 1996; Carroli *et al.*, 2001; Bergsjø, 2001). Studies that examined the impact of different components of prenatal care have produced mixed results. For example, a recent systematic review from developed countries found insufficient evidence of adequate quality to recommend implementation of any of the ANC interventions as a means of reducing childhood mortality among disadvantaged/vulnerable women (Hollowell *et al.*, 2011). While there are studies that found significant effects of IFA supplementation on neonatal mortality (Zeng *et al.*, 2008, Titaley *et al.*, 2010; Titaley & Dibley, 2012), others have found no such effects (Singh *et al.*, 2014). Some studies that have also raised concerns over the

effectiveness of prenatal care in preventing low birth weight in developing countries, including India (Maitra, 2004; Celik & Younis, 2007; Mwabu, 2009; Awiti, 2014).

World Health Organization (WHO) and Government of India guidelines suggest that every pregnant woman must have at least four antenatal care visits, with the first visit preferably in the first trimester. During these visits, women must receive at least two tetanus injections, consume IFA supplements for a minimum of 90 days, undergo clinical investigations such as blood and urine tests, get their weight and height measured and receive counselling (WHO, 2016). Although these guidelines have been in place for decades, there have been only a few systematic attempts to examine the effectiveness of prenatal interventions on maternal and child health in India.

Previous studies have mostly examined the association between specific components of prenatal care services and neonatal, infant and child mortality in developing countries (Shah *et al.*, 2000; Raatikainen *et al.*, 2007; Ibrahim *et al.*, 2012; Singh *et al.*, 2014; Arunda *et al.*, 2017; Kuhnt & Vollmer, 2017). Maitra (2004), using data from the second round of the Indian National Family Health Survey (1998–99), reported that the use of prenatal care during pregnancy reduced the hazard of child mortality in rural India. Another study by Singh *et al.* (2014) reported that children whose mothers received two or more tetanus injections during pregnancy were statistically less likely to die during the neonatal period compared with children whose mothers who did not receive tetanus injections. Another study using data from 57 low- and middle-income countries suggested that antenatal check-ups, along with other effective interventions, can improve child survival in these countries (Doku & Neupane, 2017). A study from Zimbabwe reported that essential components of prenatal care, such as information on pregnancy-related complications, blood pressure examination and tetanus injections, were significantly associated with a lower risk of infant and under-five mortality (Makate & Makate, 2017). Recent systematic reviews have emphasized tetanus vaccination, detection of pre-eclampsia, treatment of malaria, physical examination and asymptotic bacteria as health interventions that make it possible to reduce the neonatal mortality rate by 10–30% (Darmstadt *et al.*, 2005). Similar findings have been reported by several other studies conducted in low- and middle-income countries (Ibrahim *et al.*, 2012).

Most previous studies defined the quality of prenatal care in terms of the number of prenatal care visits and the timing of the first visit (Shah *et al.*, 2000; Raatikainen *et al.*, 2007; Ibrahim *et al.*, 2012; Doku & Neupane, 2017). A recent study from Zimbabwe included all eight essential components of prenatal care services, giving them equal weights, and created an index of quality of prenatal care (Makate & Makate, 2017). They reported that a unit increase in the quality of prenatal care services significantly decreased the risk of neonatal, infant and under-five mortality. However, there is a lack of such evidence from other developing countries, including India. A clear understanding of the association between the quality of prenatal care and childhood mortality is of particular importance to India because India contributes the highest number of child deaths globally (Hug *et al.*, 2017). Recent estimates from the UN Inter-Agency Group for Child Mortality Estimation suggest that worldwide, about 2.5 million neonatal deaths and 4.1 million infant deaths occurred in 2017. Of these deaths, India accounted for about 24% of neonatal deaths (605,000) and 20% of infant deaths (802,000). Between 1990 and 2016, neonatal mortality in India declined from 57 deaths per 1000 live births to 25 deaths per 1000 live births (Hug *et al.*, 2017). During the same period, infant mortality declined from 88 infant deaths per 1000 live births to 35 deaths per 1000 live births. However, with the current pace of reduction in mortality in India, especially neonatal mortality, it is difficult to achieve the United Nations Sustainable Development Goal 3, which aims to reduce neonatal and under-five mortality to 12 and 25 deaths per 1000 live births, respectively, by 2030.

Studies have identified several pathways through which prenatal care interventions influence mortality during childhood. First, behavioural education received by women during antenatal visits helps in discouraging unhealthy lifestyle behaviours such as smoking and alcohol consumption during pregnancy (WHO, 2016). Second, advice on consumption of nutritious food during

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pregnancy contributes by improving the health of women, thereby reducing poor child health outcomes. Third, women who seek prenatal care are less likely to give birth to low-birth-weight babies (Habibov & Fan, 2011). The strong correlation between low birth weight and higher childhood mortality is well documented in the literature (McCormick, 1985; Yasmin *et al.*, 2001; Lawn *et al.*, 2005). Finally, during prenatal care visits, women benefit from advice on birth preparedness, which helps them to better prepare for motherhood (Moran *et al.*, 2006). Prenatal care also screens women for high-risk pregnancies that may require specialized care (WHO, 2016).

Although a few studies have taken into account the different components of prenatal care while analysing maternal health in India (Bloom *et al.*, 1999; Ram and Singh, 2006), no study has analysed the effect of prenatal care on neonatal and infant mortality. Given this context, the present study examines the impact of the quality of prenatal care on neonatal and infant mortality in India using the recently released National Family Health Survey (NFHS-4) 2015–16.

Methods

Data

The study used data from the fourth round of the NFHS (NFHS-4) conducted in 29 states and six Union Territories (UTs) of India in 2015–16. NFHS-4 is a nationally representative, large-scale, repeated cross-sectional household survey. The principal objective of the NFHS-4 was to provide district-, state- and national-level estimates of fertility, mortality and family planning. The previous three rounds of the NFHS were conducted during 1992–93, 1998–99 and 2005–06. NFHS-4 adopted a two-stage stratified sampling design. In the first stage, villages and census enumeration blocks were selected from rural and urban areas using the Probability Proportional to Size (PPS) sampling scheme. In the second stage, 22 households were selected with systematic sampling. NFHS-4 collected information from 601,509 households comprising 699,686 women aged 15–49 years. Details of the survey design and implementation are given in the NFHS 20015–16 report (IIPS & ICF, 2017).

The present analysis was based on the most recent singleton births to women during the five years preceding the survey. The most recent births were considered for the analysis because the survey collected information on prenatal care only for the most recent birth during the five years preceding the survey. The analytical sample consists of 141,818 most recently born children for whom complete information on the essential components of prenatal care services, childhood mortality and other socioeconomic characteristics were available.

Outcome variables

The outcomes of interests were neonatal and infant deaths. Neonatal death was coded as '1' if the child died within 28 days of birth and as '0' otherwise. Infant death was coded as '1' if the child died before reaching the age of one year and as '0' otherwise. For the neonatal mortality analysis, children born during the one month preceding NFHS-4 were excluded. Likewise, for the infant mortality analysis, children born during the 11 months preceding NFHS-4 were excluded to account for censoring.

Key explanatory variables

The key explanatory variable of interest was 'quality of prenatal care'. A prenatal care quality index was created using the following questions posed to women:

1. As part of your antenatal care during this pregnancy, were any of the following done at least once? a) Were you weighed? (Yes, No); b) Was your blood pressure measured? (Yes, No);

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c) Did you give a urine sample? (Yes, No); d) Was a sample of your blood taken for testing? (Yes, No); e) Was your abdomen examined? (Yes, No).
2. Were you told where to go if you had any pregnancy complications? (Yes, No).
3. During this pregnancy, did you consume iron–folic acid tablets or syrup? (Yes, No, Don't Know).
4. During this pregnancy, were you given an injection in the arm to prevent the baby from getting tetanus, that is, convulsions after birth? (Yes, No).

The response to each question/item was coded as '1' if a particular service was received and as '0' otherwise. Following Deb and Sosa-Rubi (2005), an index of prenatal care quality was created by adding all the 'yes' responses for each woman. The index ranged between 0 (if a woman did not receive any of the aforementioned services) and 8 (if a woman received all of the aforementioned services).

Other variables

Mosley and Chen (1984) provided a framework for studying the determinants of child survival. Based on their framework, studies in the past have included a number of socioeconomic and residence-related variables while analysing the determinants of mortality during childhood (Singh *et al.*, 2012a). Accordingly, this study included sex of the child (male, female), birth size (below average, average and above average), birth order and birth interval (birth order 1; birth order 2/3, and birth interval <24 months; birth order 2/3 and birth interval ≥24 months; birth order 4 or higher and birth interval <24 months; birth order 4 or higher and birth interval ≥24 months), pregnancy intention (intended, unintended), mother's age at birth of the index child (<18, 18–24, 25–29, 30 and above), mother's schooling (non-literate, primary, secondary, higher secondary or above), mother's height (in cm), caste (scheduled caste, scheduled tribe, other backward class, other), religion (Hindu, Muslim, other), wealth index (poorest, poorer, middle, richer, richest) and place of residence (rural, urban).

Statistical analysis

Univariate analysis was done to examine the average number of prenatal visits, quality of prenatal care, neonatal and infant deaths and other socioeconomic and residence-related variables in NFHS-4 (2015–16). Multivariable binary logistic regression models were used to examine the association between the quality of prenatal care and neonatal and infant mortality. The average neonatal and infant mortality was also predicted by keeping other variables constant at their mean level.

For detecting collinearity, the concept of condition number was used. A condition number of more than 30 indicates the presence of severe collinearity among the predictor variables (Dormann *et al.*, 2013). Given that the study intended to examine the independent effects of eight essential components of prenatal care services on neonatal and infant mortality, there was a chance of collinearity. For example, a woman receiving one service is more likely to receive other services as well.

Since NFHS-4 used a multistage sampling design, sampling weights were required to make the estimates representative in this study. Appropriate sampling weights were used for estimating the bivariate and multivariate results. The details of the sampling weights are given in the NFHS-4 report (IIPS & ICF, 2017). The sampling design of the NFHS-4 also accounted for the estimations. All the variables were tested for multicollinearity before being included in the regression models. All the analysis was done in STATA 13.0.

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Results

The descriptive statistics of the survey women are presented in Table 1. Neonatal mortality was 16 neonatal deaths per 1000 live births, and infant mortality was 30 infant deaths per 1000 live births. The average number of ANC visits received by women during pregnancy was 5.7. Of the eight essential components, on average about 6.8 services were received by women during the prenatal care visits. About 95% of the women received a tetanus vaccination during pregnancy, 84% consumed IFA tablets and 89% had their blood pressure and abdomen examined. Urine and blood samples were taken for 87% of the women; 90% of the women were weighed during pregnancy. Only 64% of the women received information about pregnancy-related complications during prenatal care.

The results of the multivariable logistic regression analysis are shown in Table 2. The quality of prenatal care was found to be associated with a lower risk of neonatal and infant mortality in India. A unit increase in the quality of prenatal care was associated with a 0.93 times (95% CI: 0.91, 0.96) lower risk of neonatal mortality and 0.94 times (95% CI: 0.92, 0.97) lower risk of infant mortality. A number of other factors were also found to be associated with neonatal and infant mortality. Children who were of average or above-average size at birth were 0.44 times (95% CI: 0.39, 0.50) as likely as children who were of below-average size at birth to die during the neonatal period. Likewise, children who were of average or above-average size at birth were 0.45 times (95% CI: 0.40, 0.50) as likely as children who were of below-average size at birth to die during the infancy. Birth orders 2 and 3 were associated with a lower risk of infant mortality compared with birth order 1. Birth order 4 or higher and birth interval less than 24 months was associated with a higher risk of neonatal and infant mortality (OR: 1.26 and 1.35, respectively) compared with birth order 1. Mother's schooling, mother's height and better wealth status of the household were statistically associated with a lower risk of neonatal and infant mortality.

The average neonatal and infant mortality rates according to the number of prenatal care services were predicted by keeping the other variables at their average value. Figure 1 shows the average neonatal and infant deaths per 1000 live births by the quality of prenatal care in India. The figure shows a negative association between the quality of prenatal care and neonatal and infant mortality. Neonatal and infant deaths were the highest in children whose mothers received no prenatal care (25 deaths per 1000 live births and 44 deaths per 1000 live births respectively) and the lowest in children whose mothers received all the eight prenatal care services (15 deaths per 1000 live births and 28 deaths per 1000 live births respectively).

The individual effects of each component of prenatal care services on neonatal and infant mortality in India were also examined. Before proceeding with the analysis, whether or not the eight components of prenatal care services were correlated was examined. For this purpose, the condition number was estimated. The estimated condition number was 13.4. The number being low implies that the eight components of prenatal care services were not essentially correlated. The results of the effects of the eight components of prenatal care on neonatal and infant mortality are shown in Table 3. Tetanus vaccination and the consumption of IFA tablets/syrup during pregnancy were associated with a lower risk of neonatal and infant mortality. Being weighed during pregnancy was also associated with a lower risk of neonatal and infant mortality. Receiving counselling on pregnancy-related complications during prenatal visits was associated with a lower risk of neonatal mortality. Having given a urine sample for laboratory testing was associated with a lower risk of infant mortality.

Discussion

Prenatal care is one of the most popular public health interventions intended to improve child health outcomes. The effects of the quality of prenatal care on child health outcomes have been extensively studied in developed countries (Rosenzweig & Schultz, 1983; Joyce & Grossman, 1990;

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Table 1. Descriptive statistics of sample women aged 15–49 for their most recent birth, NFHS-4 (2015–6)

Variable	Definition	Mean or %	SD
Neonatal mortality	1 if child died within first 28 days of life; 0 otherwise	1.6	12.7
Infant mortality	1 if child died within first year of life; 0 otherwise	3.0	17.1
Number of ANC visits	Average number of ANC visit	5.7	4.8
Quality of prenatal care	Prenatal care quality index	6.8	1.6
Tetanus vaccination	1 if woman received tetanus vaccination during pregnancy; 0 otherwise	94.9	22.1
IFA tablets	1 if woman received IFA tablets during pregnancy; 0 otherwise	83.7	36.9
Blood pressure check	1 if woman had blood pressure checked during pregnancy; 0 otherwise	89.0	31.3
Urine sample check	1 if woman had urine sample test during pregnancy; 0 otherwise	87.6	32.9
Blood sample test	1 if woman had blood sample test during pregnancy; 0 otherwise	87.0	33.7
Abdomen examined	1 if woman's abdomen was examined during pregnancy; 0 otherwise	88.6	31.7
Weighed during pregnancy	1 if woman's weight was measured during pregnancy; 0 otherwise	90.2	29.8
Pregnancy complication	1 if woman received information on pregnancy complications during pregnancy; 0 otherwise	63.9	48.0
Birth size	1 if child had average or above-average birth size; 0 otherwise	88.6	31.8
Child is female	1 if child is female; 0 otherwise	45.4	49.8
Age at birth of child	Mother's mean age at birth of child	24.6	4.7
Height (cm)	Mother's height (cm)	151.9	6.1
Scheduled caste	1 if household belongs to scheduled caste; 0 otherwise	22.0	41.4
Schedule tribes	1 if household belongs to scheduled tribes; 0 otherwise	10.3	30.3
Other backward class	1 if household belongs to other backward caste; 0 otherwise	45.3	49.8
Other caste	1 if household belongs to other caste; 0 otherwise	22.4	41.7
Hindu	1 if household's religion is Hindu; 0 otherwise	81.2	39.1
Muslim	1 if household's religion is Muslim; 0 otherwise	13.2	33.9
Other religion	1 if household belongs to another religion; 0 otherwise	5.6	22.9
Unintended pregnancy	1 if birth was unwanted/mistimed; 0 otherwise	8.0	27.1
Birth order	Average birth order of children	2.1	1.3
Previous birth interval	1 if birth interval was $\geq$24 months; 0 otherwise	75.0	43.3
Mother's schooling	Mean years of mother's schooling	7.4	5.1
Wealth index	Average wealth index score	3.0	1.4
Urban residence	1 if woman lives in urban area; 0 otherwise	31.5	46.5

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Table 2. Results of logistic regression analysis examining the effect of quality of prenatal care on neonatal and infant mortality in India, NFHS-4 (2015–16)

	Neonatal mortality	Infant mortality
	OR (95% CI)	OR (95% CI)
Prenatal care quality index	0.93* (0.91, 0.96)	0.94* (0.92, 0.97)
Sex of child		
Male (Ref.)		
Female	0.91 (0.82, 1.01)	1.02 (0.93, 1.12)
Birth size		
Below average (Ref.)		
Average and above	0.44* (0.39, 0.50)	0.45* (0.40, 0.50)
Birth order × birth interval		
Birth order 1 (Ref.)		
Birth order 2/3 and birth interval <24 months	0.85 (0.72, 1.02)	0.83* (0.71, 0.96)
Birth order 2/3 and birth interval ≥24 months	0.57* (0.50, 0.66)	0.57* (0.51, 0.65)
Birth order 4 or higher and birth interval <24 months	1.26* (1.01, 1.59)	1.35* (1.10, 1.65)
Birth order 4 or higher and birth interval ≥24 months	0.73* (0.59, 0.89)	0.74* (0.62, 0.89)
Pregnancy intention		
Intended (Ref.)		
Unintended	0.98 (0.82, 1.16)	1.08 (0.93, 1.25)
Mother's age at birth of child		
<18 (Ref.)		
18–24	1.03 (0.73, 1.44)	1.23 (0.92, 1.65)
25–29	1.09 (0.76, 1.55)	1.30 (0.96, 1.77)
30+	1.40 (0.97, 2.03)	1.61* (1.17, 2.21)
Mother's schooling		
Non-literate (Ref.)		
Primary	0.99 (0.85, 1.16)	0.90 (0.79, 1.03)
Secondary	0.77* (0.67, 0.89)	0.76* (0.67, 0.86)
Higher secondary or above	0.68* (0.53, 0.87)	0.66* (0.53, 0.82)
Mother's height (cm)	0.98* (0.98, 0.99)	0.98* (0.98, 0.99)
Caste		
Schedule caste (Ref.)		
Schedule tribes	0.80* (0.67, 0.96)	0.91 (0.78, 1.06)
Other backward class	0.90 (0.80, 1.03)	0.97 (0.87, 1.09)
Other	0.86 (0.71, 1.02)	0.91 (0.78, 1.06)
Religion		
Hindu (Ref.)		
Muslim	1.15 (0.97, 1.35)	1.11 (0.97, 1.28)
Other	0.85 (0.66, 1.08)	1.06 (0.86, 1.32)

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Table 2. (*Continued*)

	Neonatal mortality	Infant mortality
Wealth index		
Poorest (Ref.)		
Poorer	0.94 (0.82, 1.08)	0.96 (0.84, 1.08)
Middle	0.91 (0.77, 1.07)	0.92 (0.80, 1.06)
Richer	0.67* (0.54, 0.83)	0.65* (0.54, 0.78)
Richest	0.65* (0.50, 0.84)	0.59* (0.47, 0.74)
Place of residence		
Urban (Ref.)		
Rural	1.11 (0.95, 1.30)	1.16* (1.02, 1.34)

*Significant at $p < 0.05$. Standard errors are robust. OR: Odds Ratio.

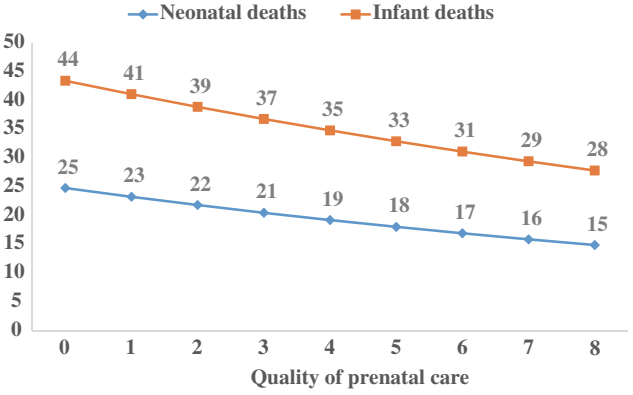

Figure 1. Neonatal and infant deaths per 1000 live births according to quality of prenatal care, India, NFHS 2015–16.

Table 3. Results of logit model examining the independent effect of specific components of prenatal care services on neonatal and infant mortality in India, NFHS-4 (2015–16)

	Neonatal mortality	Infant mortality
	OR (95% CI)	OR (95% CI)
Tetanus vaccination	0.80* (0.65, 0.99)	0.78* (0.65, 0.93)
IFA tablets	0.80* (0.70, 0.91)	0.78* (0.70, 0.87)
Blood pressure check	1.06 (0.87, 1.29)	1.05 (0.88, 1.26)
Blood sample test	1.16 (0.94, 1.44)	1.19 (0.99, 1.42)
Urine sample check	0.95 (0.78, 1.16)	0.84* (0.71, 0.99)
Pregnancy complications	0.87* (0.78, 0.98)	0.91 (0.83, 1.01)
Weighed	0.78* (0.65, 0.95)	0.83* (0.71, 0.98)
Abdomen examined	0.91 (0.78, 1.07)	0.95 (0.83, 1.08)

*Significant at $p < 0.05$. Standard errors are robust. Control variables: birth size, sex of child, pregnancy intention, birth order and birth interval, mother's schooling, mother's age at birth of child, mother's height, religion, caste, wealth and place of residence. OR: Odds Ratio.

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Behrman & Rosenzweig, 2004; Conway & Kutinova, 2006; Reichman *et al*., 2009). However, little is known about the effects of the quality of prenatal care on childhood mortality in developing countries, including India. Using nationally representative data from the latest round of India's National Family Health Survey (2015–16), the present study examined the effects of the quality of prenatal care services on neonatal and infant mortality in India. The findings indicate that a unit increase in the quality of prenatal care services reduces the risk of neonatal and infant mortality in India. Using data from the Zimbabwe Demographic and Health Survey, Makate and Makate (2017) also reported that a unit increase in the quality of prenatal care services significantly decreased the neonatal, infant and under-five deaths. To the authors' knowledge, this is the first study from India that has examined the effects of the quality of prenatal care on neonatal and infant mortality.

A key issue is measuring the quality of prenatal care services. The existing literature suggests that there are two ways of measuring the quality of prenatal care using data from the Demographic and Health Surveys. One way, like a few studies from India have done, is to assign weights to each component of prenatal care services according to their relative roles in improving maternal health (Bloom *et al*., 1999; Ram & Singh, 2006). However, those studies failed to provide sound reasoning behind the use of different weights for each component. The other way, used by a few studies in other developing countries, is to assign an equal weight to each component of prenatal care services (Deb & Sosa-Rubi, 2005; Makate & Makate, 2017) and assuming that the use of the accumulated coverage of effective interventions reduces childhood deaths more than single interventions provided in a vertical way (Darmstadt *et al*., 2005). The present study opted for the second approach to compute the quality of prenatal care. Note that even with equal weights, the study found a significant effect of the quality of prenatal care services on neonatal and infant mortality. If different weights had been given to different components based on their effectiveness, as done in some small-scale studies in India, the effect of the quality of prenatal care services on neonatal and infant mortality would have been stronger. So, the present study argues that this is less problematic than it may appear if the estimates can be thought of as a lower bound on the effect of the quality of prenatal care services in India. Further, the present study could not include a few dimensions of prenatal care, such as the relationship between a pregnant woman and the health provider, density of doctors, child services and distance to the health facility in the quality of prenatal care index as these were not available in the NFHS-4. However, it must be noted that the World Health Organization and the Government of India guidelines for prenatal care suggest including only these eight essential components, which were included in the present study, in prenatal care (Maternal Health Division, 2005; WHO, 2006).

In addition to the quality of prenatal care services, the present study also examined the independent effect of each of the eight components of prenatal care services on neonatal and infant mortality in India. Children whose mothers received the tetanus vaccination during pregnancy were less likely to die during the neonatal period and infancy compared with those whose mothers did not receive this vaccination. This finding is consistent with the findings of the previous studies conducted in developing countries, including India (Singh *et al*., 2012a; Arunda *et al*., 2017). In contrast to the findings of Singh *et al*. (2014), this study found an association between consumption of IFA tablets/syrup and lower risk of neonatal and infant mortality. Titaley and Dibley (2012) and Titaley *et al*. (2010) also reported a protective effect of IFA tablets/syrup on the risk of neonatal mortality in Indonesia.

Interestingly, children whose mothers received information on pregnancy-related complications during pregnancy were less likely to die during the neonatal period compared with those whose mothers did not receive information on pregnancy-related complications. Notably, only 62% of the mothers who delivered a baby during the five years preceding the NFHS-4 reported that they had received information on pregnancy-related complications. Moreover, only 71% of the mothers who had availed at least four prenatal visits during their most recent pregnancy

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received information on pregnancy-related complications. These findings show the apparent bias during antenatal visits towards medical interventions as opposed to counselling. Other studies from India have also reported such a bias during antenatal visits (Pallikadavath *et al.*, 2004; Singh *et al.*, 2012b). These findings call for motivating the health service providers in India to counsel and educate women on potential risks that might arise during pregnancy.

Another key finding of this study is that measurement of women's weight during pregnancy significantly decreased the risk of neonatal and infant mortality in India. Routine measurement of weight during pregnancy is an essential component of prenatal care visits since a high weight gain during pregnancy may have adverse consequences for mothers and their unborn children. For example, women who gain extreme weight during pregnancy are at a higher risk of developing pre-eclampsia and gestational diabetes mellitus (Hedderson *et al.*, 2010; Macdonald-Wallis *et al.*, 2013). This in turn is found to influence neonatal outcomes such as perinatal mortality, macrosomia and congenital anomalies (Wahabi *et al.*, 2012). Although the percentage of women who were weighed during prenatal visits increased dramatically in India between NFHS-3 (2005–06) and NFHS-4 (2015–16), more than 10% of women were not weighed during the prenatal care in NFHS-4.

The findings of this study also indicate that getting a urine test done during pregnancy is associated with a lower risk of infant mortality in India. The results of a urine test during pregnancy provide important information on the level of sugar, protein, ketones and bacteria in the body. An excess of these in a woman's body may cause gestational diabetes, pre-eclampsia, reduced levels of carbohydrate and urinary tract infections (WHO, 2016). These may cause poor fetal growth and low birth weight and, hence, may elevate mortality risk during childhood (Ashworth, 1998). About 12% of the women in the NFHS-4 reported that a urine sample was not taken during any of their prenatal care visits. These findings call for a greater adherence to the recommended guidelines on care during prenatal visits.

A few interventions – like blood test, blood pressure check and abdomen examination – did not show any association with neonatal or infant mortality. This could be because some of these – such as blood pressure and abdomen examination – require regular monitoring to detect high-risk pregnancies. For example, abdomen examination is likely to provide the best results if conducted in the third trimester or near the end of the pregnancy. Abdomen examination may indicate malposition of the baby and may potentially reduce the risk of death from obstructed labour or morbidity associated with prolonged labour (McDonagh, 1996). On the other hand, the measurement of blood pressure as a screening tool for eclampsia is flawed (Rosenberg & Twaddle, 1990). There is also the problem of defining cut-offs (Redman, 1982; Cuckle & Wood, 1984). Moreover, there are intrinsic systematic and random errors in recording blood pressure (Redman 1982). Studies also suggest that screening before 32 weeks of gestation is not cost-effective (Hall, 1990). Unfortunately, NFHS-4 does not provide any information on the trimester in which a particular service was obtained.

It is pertinent here to note the limitations of the study. NFHS-4 collected information on prenatal care services retrospectively from the mothers and, thus, was subject to recall bias. However, this bias was likely to be minimal as the information was collected in respect of the most recent births during the five years preceding the survey. The questions used to collect information on prenatal care services in the NFHS-4 have been used in all the previous three rounds of the survey and in other Demographic and Health Surveys (DHS) across low- and middle-income countries. Moreover, validation studies have found small-to-moderate levels of bias in self-reported coverage of maternal health indicators; more invasive interventions such as blood and urine tests appear to be more accurately reported (Bryce *et al.*, 2013; Liu *et al.*, 2013). In addition, the interviewers were thoroughly trained to collect such information from mothers, and standard protocols were in place to ensure high quality of the collected data.

The second limitation relates to the time/trimester when different prenatal care services were provided. The DHS surveys in general, and NFHS surveys in particular, do not collect information

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about the trimester in which a particular service was provided. Future research must focus on the time/trimester when different prenatal care services were provided. The final limitation is that the study could not account for the degree of quality with which the services (essential components) were provided as that information was not available in the NFHS-4. Future studies, therefore, must attempt to measure the degree of quality with which the eight essential services are provided.

The findings of this study provide compelling evidence on the effect of the quality of prenatal care on neonatal and infant mortality in India – a country that contributes to the highest proportion of under-five deaths (20%) globally. The study indicates that improvements in the quality of prenatal care have the potential to lower the risk of neonatal and infant mortality in India. Even though a number of prenatal care interventions showed positive effects, the present study shows that not all women receive all the essential components of prenatal care during their most recent pregnancy. Just focusing on the number of prenatal visits or the trimester in which the first prenatal visit was made is not sufficient. The time has come when India should focus more on ensuring that every pregnant woman receives the recommended care at the recommended time. This study also underscores the need to sensitize the health care providers on the importance of counselling and birth preparedness.

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Ethical Approval. The study was based on a secondary dataset with no identifiable information on the survey participants. This dataset is available in the public domain for research use and, hence, no approval was required from any institutional review board. The data can be downloaded from the website of the Demographic and Health Surveys (DHS) Program at: https://dhsprogram.com/data. The data for the current study were downloaded from the aforementioned website after receiving permission.

References

Arunda M, Emmelin A and Asamoah BO (2017) Effectiveness of antenatal care services in reducing neonatal mortality in Kenya: analysis of national survey data. *Global Health Action* **10**, 1328796.

Ashworth A (1998) Effects of intrauterine growth retardation on mortality and morbidity in infants and young children. *European Journal of Clinical Nutrition* **52** (Supplement 1), S34–41; discussion S41–42.

Awiti JO (2014) A multilevel analysis of prenatal care and birth weight in Kenya. *Health Economics Review* **4**, 33.

Behrman JR and Rosenzweig MR (2004) Returns to birthweight. *Review of Economics and Statistics* **86**, 586–601.

Bergsjø P (2001) *What is the Evidence for the Role of Antenatal Care Strategies in the Reduction of Maternal Mortality and Morbidity? Safe Motherhood Strategies: A Review Of The Evidence*. Studies in Health Services Organisation and Policy, Institute of Tropical Medicine Press, Antwerp, pp. 35–54.

Bloom SS, Lippeveld T and Wypij D (1999) Does antenatal care make a difference to safe delivery? A study in urban Uttar Pradesh, India. *Health Policy and Planning* **14**, 38–48.

Bryce J, Arnold F, Blanc A, Hancioglu A, Newby H, Requejo J *et al.* (2013) Measuring coverage in MNCH: new findings, new strategies, and recommendations for action. *PLoS Medicine* **10**, e1001423.

Carroli G, Villar J, Piaggio G, Khan-Neelofur D, Gülmezoglu M, Mugford M *et al.* (2001) WHO systematic review of randomised controlled trials of routine antenatal care. *The Lancet* **357**, 1565–1570.

Celik Y and Younis MZ (2007) Effects of antenatal care services on birthweight: importance of model specification and empirical procedure used in estimating the marginal productivity of health inputs. *Journal of Medical Systems* **31**, 197–204.

Conway KS and Kutinova A (2006) Maternal health: does prenatal care make a difference? *Health Economics* **15**, 461–488.

Cuckle H and Wood J (1984) Principles of screening. In Wood N (ed.) *Antenatal and Neonatal Screening*. Oxford University Press, Oxford.

Darmstadt GL, Bhutta ZA, Cousens S, Adam T, Walker N, De Bernis L *et al.* (2005) Evidence-based, cost-effective interventions: how many newborn babies can we save? *The Lancet* **365**, 977–988.

Deb P and Sosa-Rubi SG (2005) Does onset or quality of prenatal care matter more for infant health. *Health Econometrics and Data Group Working Paper* **5**(11).

Doku DT and Neupane S (2017) Survival analysis of the association between antenatal care attendance and neonatal mortality in 57 low- and middle-income countries. *International Journal of Epidemiology* **46**, 1668–1677.

Dormann CF, Elith J, Bacher S, Buchmann C, Carl G, Carré G *et al.* (2013) Collinearity: a review of methods to deal with it and a simulation study evaluating their performance. *Ecography* **36**, 27–46.

https://doi.org/10.1017/S0021932019000543 Published online by Cambridge University Press

Habibov NN and Fan L (2011) Does prenatal healthcare improve child birthweight outcomes in Azerbaijan? Results of the national Demographic and Health Survey. *Economics and Human Biology* **9**, 56–65.

Hall MH (1990) 4 Identification of high risk and low risk. *Baillieres Clinical Obstetrics Gynaecology* **4**, 65–76.

Hedderson MM, Gunderson EP and Ferrara A (2010) Gestational weight gain and risk of gestational diabetes mellitus. *Obstetrics and Gynecology* **115**, 597–604.

Hollowell J, Oakley L, Kurinczuk JJ, Brocklehurst P and Gray R (2011) The effectiveness of antenatal care programmes to reduce infant mortality and preterm birth in socially disadvantaged and vulnerable women in high-income countries: a systematic review. *BMC Pregnancy and Childbirth* **11**, 13.

Hug L, Sharrow D and You D (2017) *Levels and Trends in Child Mortality: Report (2017)*. Estimates developed by the UN Inter-agency Group for Child Mortality Estimation, United Nations Children's Fund, New York, 2017.

Ibrahim J, Yorifuji T, Tsuda T, Kashima S and Doi H (2012) Frequency of antenatal care visits and neonatal mortality in Indonesia. *Journal of Tropical Pediatrics* **58**, 184–188.

IIPS and ICF (2017) *National Family Health Survey (NFHS-4), 2015-16: India*. IIPS, Mumbai.

Joyce TJ and Grossman M (1990) Pregnancy wantedness and the early initiation of prenatal care. *Demography* **27**, 1–17.

Kuhnt J and Vollmer S (2017) Antenatal care services and its implications for vital and health outcomes of children: evidence from 193 surveys in 69 low-income and middle-income countries. *BMJ Open* **7**(11).

Lawn JE, Cousens S and Zupan J (2005) 4 million neonatal deaths: when? Where? Why? *Lancet* **365**, 891–900.

Liu L, Li M, Yang L, Ju L, Tan B, Walker N *et al.* (2013) Measuring coverage in MNCH: a validation study linking population survey derived coverage to maternal, newborn, and child health care records in rural China. *PLoS One* **8**, e60762.

McCormick MC (1985) The contribution of low birth weight to infant mortality and childhood morbidity. *New England Journal of Medicine* **312**, 82–90.

McDonagh M (1996) Is antenatal care effective in reducing maternal morbidity and mortality? *Health Policy and Planning* **11**, 1–15.

Macdonald-Wallis C, Tilling K, Fraser A, Nelson SM and Lawlor DA (2013) Gestational weight gain as a risk factor for hypertensive disorders of pregnancy. *American Journal of Obstetrics and Gynecology* **209**, e1–327.

Maitra P (2004) Parental bargaining, health inputs and child mortality in India. *Journal of Health Economics* **23**, 259–291.

Makate M and Makate C (2017) The impact of prenatal care quality on neonatal, infant and child mortality in Zimbabwe: evidence from the demographic and health surveys. *Health Policy and Planning* **32**, 395–404.

Maternal Health Division (2005) *Guidelines for Ante-Natal Care and Skilled Attendance at Birth by ANMs and LHVs*. Maternal Health Division, Department of Family Welfare, Ministry of Health and Family Welfare, Government of India.

Moran AC, Sangli G, Dineen R, Rawlins B, Yaméogo M and Baya B (2006) Birth-preparedness for maternal health: findings from Koupéla District, Burkina Faso. *Journal of Health, Population and Nutrition* **24**, 489–497.

Mosley WH and Chen LC (1984) An analytical framework for the study of child survival in developing countries. *Population and Development Review* **10**, 25–45.

Mwabu G (2009) The production of child health in Kenya: a structural model of birth weight. *Journal of African Economies* **18**, 212–260.

Pallikadavath S, Foss M and Stones RW (2004) Antenatal care: provision and inequality in rural north India. *Social Science & Medicine* **59**, 1147–1158.

Raatikainen K, Heiskanen N and Heinonen S (2007) Under-attending free antenatal care is associated with adverse pregnancy outcomes. *BMC Public Health* **7**, 268.

Ram F and Singh A (2006) Is antenatal care effective in improving maternal health in rural uttar pradesh? Evidence from a district level household survey. *Journal of Biosocial Science* **38**, 433–448.

Redman C (1982) Screening for pre-eclampsia. In Enkin M & Chalmers I (eds) *Effectiveness and Satisfaction in Antenatal Care*. Spastics International Medical Publications, London.

Reichman NE, Corman H, Noonan K and Dave D (2009) Infant health production functions: what a difference the data make. *Health Economics* **18**, 761–782.

Rooney C (1992) *Antenatal Care and Maternal Health: How Effective Is It?* Maternal Health and Safe Motherhood Programme, Division of Family Health, World Health Organisation, Geneva.

Rosenberg K and Twaddle S (1990) Screening and surveillance of pregnancy hypertension – an economic approach to the use of daycare. *Baillieres Clinical Obstetrics Gynaecology* **4**, 89–107.

Rosenzweig MR and Schultz TP (1983) Estimating a household production function: heterogeneity, the demand for health inputs, and their effects on birth weight. *Journal of Political Economy* **91**, 723–746.

Shah D, Shroff S and Ganla K (2000) Factors affecting perinatal mortality in India. *International Journal of Gynaecology and Obstetrics* **71**, 209–210.

Singh A, Chalasani S, Koenig MA and Mahapatra B (2012a) The consequences of unintended births for maternal and child health in India. *Population Studies* **66**, 223–239.

Singh A, Pallikadavath S, Ram F and Alagarajan M (2014) Do antenatal care interventions improve neonatal survival in India? *Health Policy and Planning* **29**, 842–848.

Singh A, Pallikadavath S, Ram F and Ogollah R (2012b) Inequalities in advice provided by public health workers to women during antenatal sessions in rural India. *PLoS One* **7**, e44931.

Titaley CR and Dibley MJ (2012) Antenatal iron/folic acid supplements, but not postnatal care, prevents neonatal deaths in Indonesia: analysis of Indonesia Demographic and Health Surveys 2002/2003–2007 (a retrospective cohort study). *BMJ Open* **2**, e001399.

Titaley CR, Dibley MJ, Roberts CL, Hall J and Agho K (2010) Iron and folic acid supplements and reduced early neonatal deaths in Indonesia. *Bulletin of the World Health Organization* **88**, 500–508.

Wahabi HA, Esmaeil SA, Fayed A, Al-Shaikh G and Alzeidan RA (2012) Pre-existing diabetes mellitus and adverse pregnancy outcomes. *BMC Research Notes* **5**, 496.

WHO (2006) *Provision of Effective Antenatal Care: Integrated Management of Pregnancy and Child Birth (IMPAC). Standards for Maternal and Neonatal Care (1.6).* Department of Making Pregnancy Safer, World Health Organization, Geneva.

WHO (2016) *WHO Recommendations on Antenatal Care for a Positive Pregnancy Experience.* World Health Organization, Geneva.

Yasmin S, Osrin D, Paul E and Costello A (2001) Neonatal mortality of low-birth-weight infants in Bangladesh. *Bulletin of the World Health Organization* **79**, 608–614.

Zeng L, Cheng Y, Dang S, Yan H, Dibley MJ, Chang S *et al.* (2008) Impact of micronutrient supplementation during pregnancy on birth weight, duration of gestation, and perinatal mortality in rural western China: double blind cluster randomised controlled trial. *BMJ* **337**, a2001.

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