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GATEKEEPERS OR EQUAL PARTNERS? AN EXAMINATION OF MALE PARTNER ATTENDANCE IN ANTENATAL CARE

A dissertation
by

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Dissertation Chair: Dr. Shanta Pandey

Abstract

A growing body of literature, particularly from low and middle-income countries, has focused on the role of male involvement in maternal care as a crucial strategy to improve maternal and neonatal health outcomes. The purpose of this three-paper dissertation is to add to this evidence base within the context of India, and to gain an in-depth understanding of one aspect of male involvement – that is, male partner attendance in antenatal care. This dissertation utilized data from the National Family Health Survey (NFHS-3, 2005-06 and NFHS-4, 2015-16) and was framed using the Social Ecological Model, Connell's Theory of Gender and Power and a Gender-Transformative lens. Paper 1 summarized the levels of male partner attendance in antenatal care and assessed changes over time. Further, multivariable logistic regression models were used to examine the factors influencing male partner attendance in antenatal care. The results show an overall increase in male partner attendance in India during the period of 2005-06 to 2015-16, with the Southern region reporting the highest level of male partner attendance in both years. Higher level of education and household wealth, increased knowledge of pregnancy-related complications, older age at marriage, and women's

autonomy were positively associated with male partner attendance in antenatal care. Paper 2 examined the association between male partner attendance in antenatal care and maternal health service utilization. Controlling for all socio-demographic variables and adjusting for report of pregnancy complications, the results showed that women who were accompanied by a male partner for antenatal care reported increased odds of maternal health service utilization (early initiation of antenatal care, frequency of antenatal care contacts and institutional delivery). While the place of residence (rural/urban) did not influence the association between male partner attendance and maternal health service utilization, region had a significant moderating effect. Paper 3 examined the association between antenatal care and infant birth weight, adjusting for gestational age. Further, the analysis also assessed whether the relationship between antenatal care and infant birth weight varied by male partner attendance. Findings indicate that early initiation of antenatal care and maternal immunization was associated with reduced odds of low birth weight among infants. The results showed that male partner attendance in antenatal care did not have a moderating influence. Taken together, the findings of the three papers have implications for policy and practice; further, they provide support for interventions that aim for a more inclusive and gender-transformative approach to maternal and neonatal health.

DEDICATION

To my ever-supportive and loving family.

To all those who identify as women and are negotiating inequitable gender norms and battling injustice within their community, workplace, household and intimate relationships; and, to all the men brave enough to challenge the status quo.

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zones. Thanks to all my friends, whose constant support and motivation has enabled me to cross the many highs and lows of this process. Most importantly, I would like to thank my husband, Shourjya, for his never-ending patience, steady support, and for teaching me so much of what I know.

When I began my doctoral education, I expected an uneventful start and finish in Boston; however, it is four cities, three countries, a wedding, and a pandemic later that I have finally completed drafting my dissertation. Thus, more than anything, this Ph.D. journey has taught me to transform, update, adapt, and question when required. As I move forward, I hope to extend this learning to my understanding of the social world, my perspectives on social justice, and my work as a social work researcher.

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Chapter I. Introduction

Statement of the problem

Maternal and neonatal mortality rates are considered a key indicator of disparities between developed and developing countries (Singh, Pallikadavath, Ram, & Alagarajan, 2014). According to global estimates, in 2017, Sub-Saharan Africa and South Asia accounted for about 86% of estimated global maternal deaths; further, India and Nigeria accounted for over one-third of this number (World Health Organization, 2019). Within India as well there are wide disparities in maternal mortality rates on the basis of region (Munshi, Yamey, & Verguet, 2016), socio-economic status and caste-based inequalities (Horwood, Opondo, Choudhury, Rani, & Nair, 2020). Reproductive, maternal and newborn health are inseparably linked (Bhutta, Lassi, Blanc, & Donnay, 2010); and, in addition to the burden of maternal mortality, India also has the highest number of neonatal mortalities worldwide (UNICEF, 2015). Despite a considerable decline in neonatal mortality over the past two decades, India still accounts for approximately 28% of global neonatal deaths (Altman, Sidney, De Costa, Vora, & Salazar, 2017). Further, estimates reveal that 18% of infants in India are born with Low Birth Weight (LBW) (IIPS, 2018), one of the key predictors of neonatal mortality in India (Apte et al., 2019).

According to research, utilization of maternal health services (institutional delivery[1], antenatal care, postnatal care) is crucial to reducing maternal morbidity, mortality, and neonatal death (Campbell & Graham, 2006; Joe et al., 2018; Kesterton et al., 2010b). Studies from developing countries, including India, have shown that medical

[1] Refers to birth of child in a health facility, supervised by a medical professional.

attention at birth and during pregnancy significantly improves maternal and child health outcomes (Feng et al., 2011; Goldie, Sweet, Carvalho, Natchu, & Hu, 2010). Over the past decade, maternal healthcare utilization in India has increased rapidly; for instance, receipt of full antenatal care[2] increased from 12% in 2005–06 to 20% in 2015–16, and Skilled Attendance at Birth (SBA) increased from 47% to 81% over the same period (Ali et al., 2019). However, despite national efforts to improve levels of maternal health service utilization (Lim et al., 2010), progress has been slow in India, with widespread regional inequities (Ali, Dhillon, & Mohanty, 2019). Apart from low levels of maternal health service utilization nationally, there also exist wide disparities within states and across income levels. For example, the wealthiest group in Northern and North-Eastern states such as Bihar, Jharkhand, Uttar Pradesh, Chhattisgarh, and Madhya Pradesh had almost identical levels of maternal health service utilization as compared with the poorest groups in Southern states like Kerala and Tamil Nadu (Pathak, Singh, & Subramanian, 2010; Singh, Rai, & Kumar, 2013). Socio-economic inequalities often intersect with caste and religious identities to further compound the gaps in maternal health service utilization. Within this context, understanding the multiple influences that impact maternal health service utilization is a crucial step to reducing inequalities in access and improving maternal and neonatal health.

Factors influencing maternal health service utilization and infant birth weight

Several studies have documented the social, economic, regional, and cultural factors influencing maternal health service utilization (Dehingia, Singh, Raj, & McDougal, 2019; Ogbo et al., 2019; Singh et al., 2012; Sunil et al., 2006). Among socio-

[2] Woman having four or more visits for ANC, having at least two tetanus injections and consuming 100 IFA (Iron and Folic Acid) tablets/syrup for their last birth.

economic factors, higher education, better standard of living, ownership of a bank account, exposure to mass media, belonging to the majority religion (Hindu), belonging to upper castes, residing in an urban area, older age and age at marriage above 18 years were positively associated with higher levels of maternal health service utilization in India (Jat, Ng, & San Sebastian, 2011; Ogbo et al., 2019; Pallikadavath, Foss, & Stones, 2004; Paul & Chouhan, 2019; Sunil et al., 2006). At the family and household level, studies found that supportive role of family and female social networks (Raman et al., 2014), male partner attendance in antenatal care (Chattopadhyay, 2012), and greater decision making autonomy (Mistry et al., 2009) were associated with increased odds of maternal health service utilization. In addition to these, studies also found that resources within the community could affect women's maternal health service utilization. For instance, women who participated in microcredit programs within the community (Dehingia et al., 2019), those who were visited by a community health worker during pregnancy, and women who lived in communities which had a Mahila Mandal and Anganwadi[3] had increased odds of maternal health service utilization (Sunil et al., 2006). In contrast, increased distance to health facilities was associated with decreased odds of maternal health service utilization among women (Sunil, Rajaram, & Zottarelli, 2006). Some research also documented that improved access to antenatal care services was associated with increased utilization of other maternal health services such as facility birth and postpartum care (Dixit, Khan, Dwivedi, & Gupta, 2017; Ram & Singh, 2006).

Studies show that adequate access to antenatal care is also a crucial determinant of infant birth weight (da Fonseca, Strufaldi, de Carvalho, & Puccini, 2014; Hueston,

[3] Informal social service clubs are known as Mahila Mandals; Anganwadi is a rural health center, this was launched in 1974 under the Integrated Child Development Services (ICDS) Scheme.

Gilbert, Davis, & Sturgill, 2003; Khanal, Zhao, & Sauer, 2014; Pinzón-Rondón et al., 2015; Servan-Mori, Sosa-Rubí, Najera-Leon, & Darney, 2016; Zhou et al., 2019). For example, evidence both globally and in India shows that adjusting for gestational age, women with access to adequate antenatal care and those who had four or more antenatal care contacts were significantly less likely to deliver a low birth weight infant (Kader & Perera, 2014; Servan-Mori et al., 2016; Zhou et al., 2019; Apte et al., 2019; Khan, Mozumdar, & Kaur, 2019). In contrast, the absence of prenatal care is associated with increased odds of low infant birth weight (less than 2500 gms, as defined by the WHO) (Khanal et al., 2014; Pinzón-Rondón et al., 2015). Apart from antenatal care, research also documents that mother's age, occupation, higher household income and education, rural place of residence have been associated with decreased odds of low infant birth weight; in contrast, biological factors such as health problems during pregnancy, high body mass index (BMI), and inter-pregnancy interval of less than two years were associated with increased odds of low birth weight among infants (Bhowmik et al., 2019; Demelash, Motbainor, Nigatu, Gashaw, & Melese, 2015; Gebremedhin, Ambaw, Admassu, & Berhane, 2015; Manyeh et al., 2016; Singh, Ueranantasun, & Kuning, 2017). Environment factors such as exposure to tobacco smoke (Salmasi, Grady, Jones, & McDonald, 2010) and cooking with highly polluting cooking fuels (U. Singh et al., 2017) were also associated with higher odds of low birth weight among infants. More specifically, in India, female gender and lower birth order were significant predictors of low birth weight (Apte et al., 2019). Additionally, one study from India that used infant birth weight as a continuous measure in grams found that maternal social capital was positively associated with higher infant birth weight. In particular, membership in a

women's group or religious groups was associated with higher infant birth weight (Lee, Oh, Perkins, Heo, & Subramanian, 2019).

Overall, while a number of studies in India have examined individual and policy level factors influencing both maternal health service utilization and infant birth weight, the role of the partner and family has not been well-documented. This creates an important gap in research, particularly in the Indian context, wherein women's reproductive decision-making is heavily influenced and controlled by their partner and family members (Mondal, Karmakar, & Banerjee, 2020; Paul et al., 2017). In the following section, I discuss existing literature in the area of male involvement in maternal care, both globally and in India.

Male involvement in maternal care

Since the *1994 International Conference on Population and Development (ICPD*), there has been increased recognition of the need for male involvement in the advancement of gender equality and global public health (Peacock & Barker, 2014; Peacock, Stemple, Sawires, & Coates, 2009). A key strategy recommended by the *World Health Organization (WHO)* concerning health promotion for maternal and newborn health is male involvement in pregnancy, childbirth, and the post-birth period (WHO, 2015). This may include men's role in decision making, male attendance at antenatal care, knowledge and attitudes towards maternal healthcare, and informational or social support during pregnancy (Gibore, Bali, & Kibusi, 2019; Jungari & Paswan, 2019a; Rahman et al., 2018; Singh & Ram, 2009; Story et al., 2012; Teklesilasie & Deressa,

2018; Yargawa & Leonardi-Bee, 2015). Research shows that male involvement[4] in maternal care is associated with a range of positive outcomes such as increased odds of antenatal care attendance, facility birth, skill birth attendance, postpartum care, breastfeeding initiation, and decreased odds of maternal depression (Tokhi et al., 2018; Yargawa & Leonardi-Bee, 2015). Further, research focusing specifically on male partner attendance in antenatal care found that it was associated with increased odds of skilled birth attendance, institutional delivery, and post-partum visits, while it had no significant impact on the number of antenatal visits (Suandi, Williams, & Bhattacharya, 2019). While most studies show a positive association between male involvement and maternal health service utilization, the level of male involvement varies across different contexts (Chattopadhyay, 2012; Mohammed et al., 2019; Rahman et al., 2018; Sapkota, Kobayashi, Kakehashi, Baral, & Yoshida, 2012). Within India, studies document considerable variation in male involvement and awareness regarding pregnancy-related complications (Awasthi et al., 2008; Chattopadhyay, 2012; Jungari & Paswan, 2019b, 2019a; Singh & Ram, 2009). Furthermore, there are observed differences in male involvement based on religion, caste, and educational levels (Singh & Ram, 2009).

Based on cultural and social context, male involvement in maternal care may be operationalized in varying forms such as attendance in antenatal care and at delivery, financial assistance, birth preparedness and provision of information (Suandi et al., 2019; Yargawa & Leonardi-Bee, 2015). In this dissertation, however, I focus on a specific aspect of male partner involvement – that is, male partner attendance in antenatal care.

[4] Within this context, male involvement in maternal care is used as an umbrella term and includes male partner attendance in antenatal care, arrangement of transportation, assistance in household activities, presence during delivery and postpartum care.

Cultural context

Within the South-Asian context, the social construction of gender has a strong influence on maternal health and pregnancy-related outcomes (Mandal, Muralidharan, & Pappa, 2017; Mumtaz, Salway, Shanner, Zaman, & Laing, 2012; Paudel, Javanparast, Dasvarma, & Newman, 2018). More specifically, in the Indian context, gendered division of reproductive labor often shapes women's access to maternal care and support during pregnancy. Studies show that men are typically not involved in reproductive health as this is seen as a woman's domain (Barua, Pande, MacQuarrie, & Walia, 2004; Jungari & Paswan, 2019a). In contrast, men are also the designated gate-keepers and primary decision-makers in relation to women's health service utilization. For instance, results from the *National Family Health Survey (NFHS-4)* document that 18% of women did not use institutional delivery because their husbands did not allow them to access services, and 26% of husbands whose wives did go for any antenatal care check-ups felt that it was unnecessary and did not allow their wives to go for any antenatal care (NFHS, 2015). Within this cultural context, male partner attendance during antenatal care contacts can be viewed as a strong motivating factor to increase overall awareness and knowledge of men about maternal care, and to increase maternal health service utilization. Understanding the factors that influence male partner attendance in antenatal care and how male partner attendance can impact maternal health service utilization and infant birth weight can play a crucial role in improving maternal and child health outcomes in India.

Dissertation purpose and aims

Although some studies within India have researched male partner attendance in antenatal care (Barua, Pande, MacQuarrie, & Walia, 2004; Jungari & Paswan, 2019b; Singh & Ram, 2009), none of the studies provide an understanding of the overall extent of male partner attendance, how this has changed over time, and the factors influencing male partner attendance in antenatal care. Furthermore, despite evidence from low and middle-income countries demonstrating the positive effect of educating and engaging with male partners in antenatal care (antenatal care, delivery, and postnatal care) (Tokhi et al., 2018), within India, the effect of male partner attendance on maternal health service utilization has not been systematically examined. Further, only one prior study has used nationally representative data from three Indian states (Uttar Pradesh, Maharashtra, West Bengal) to examine male partner attendance in antenatal care. Additionally, despite the documented association between paternal involvement and infant birth weight, none of the studies from India have controlled for the effect of male partner attendance.

Thus, this three-paper dissertation aims to add to the existing literature on male partner attendance in antenatal care. It seeks to provide a holistic understanding of male partner attendance in India by assessing the current levels of male partner attendance, examining its effect on maternal health service utilization and infant birth weight, and exploring the determinants of male partner attendance in antenatal care. The data for this three-paper dissertation came from two rounds of the National Family Health Survey (NFHS-3 and NFHS-4) to examine the following questions:

Paper 1. What is the extent of male partner attendance in antenatal care? What factors affect male partner attendance in antenatal care within the Indian context?

a. What is the level of male partner attendance in antenatal care in India? Does male partner attendance in antenatal care vary regionally and over time?
b. What are the factors influencing male partner attendance in antenatal care? In particular, how does women's autonomy affect male partner attendance in antenatal care? (only the latest round of the *National Family Health Survey, NFHS-4, 2015-16,* was used for this analysis)

Paper 2: How important is male partner attendance in antenatal care in improving women's use of maternal health services in India? The sub-questions are:

a. Is there an association between male partner attendance in antenatal care and timing and number of antenatal care contacts after controlling for socio-demographic factors?
b. Is there an association between male partner attendance in antenatal care and women's utilization of institutional delivery, after controlling for socio-demographic factors?
c. Does the association between male partner attendance in antenatal care and women's utilization of maternal health services vary by place of residence and region?

Paper 3. Is male partner attendance in antenatal care associated with improved birth outcomes (infant birth weight)? The sub-questions are:

a. What is the association between antenatal care and infant birth weight, controlling for gestational age and male partner attendance?
b. Does male partner attendance in antenatal care influence the association between antenatal care and the risk for low infant birth weight, controlling for gestational age?

Theoretical Frameworks

This dissertation utilizes the Social Ecological Model, Connell's Theory of Gender and Power, and a Gender-Transformative Approach as a framework to contextualize male partner attendance in antenatal care and its effect on maternal health service utilization and infant birth weight.

Social-ecological Model proposed by Bronfenbrenner (1977) has been often used as a framework within research examining maternal health service utilization (Antai & Adaji, 2012; Kaiser et al., 2019; Shahabuddin et al., 2017). The Model helps understand

the complex social behavior, determined through individual and environmental factors (Raneri & Wiemann, 2007). According to the social-ecological model (Bronfenbrenner, 1977), multiple systems influence an individual's development and behavior; these may range from systems that directly affect the individual such as family or peer relationships, to those that may have a more indirect effect, such as gender roles and cultural norms. For instance, maternal health service utilization is influenced by pre-disposing socio-demographic factors (Jat et al., 2011; Ogbo et al., 2019; Pallikadavath et al., 2004; Paul & Chouhan, 2019; Sunil et al., 2006), interactions at the mezzo-level (Mistry et al., 2009; Sunil et al., 2006), as well as broader cultural and policy factors at the macro-level (Rahman & Pallikadavath, 2018).

Further, evidence shows that there are multiple levels of influence on male involvement in maternal care. Individual-level factors include age, education, religion, caste, ethnicity, marriage type, employment, knowledge about pregnancy-related complications; while, at the mezzo-level, factors such as attitudes of health workers predicted male partner involvement in maternal care (Ampt et al., 2015; Barua et al., 2004; Bhatta, 2013; Bishwajit et al., 2017; Craymah, Oppong, & Tuoyire, 2017; Gibore et al., 2019; Gill et al., 2017; Jungari & Paswan, 2019b; Sharma, Bhuvan, & Khatri, 2018; Singh & Ram, 2009; Tweheyo, Konde-Lule, Tumwesigye, & Sekandi, 2010; Wai et al., 2015). Additionally, broader gender roles, attitudes, and social norms were important predictors of male partner involvement (Craymah et al., 2017; Dumbaugh et al., 2014; Jungari & Paswan, 2019b; Singh & Ram, 2009).

Thus, within this dissertation, I utilized the *Social Ecological Model* as a framework to examine the multiple levels of influence both on male partner attendance in

antenatal care in India and the association between male partner attendance in antenatal care and maternal health service utilization (See figures 1 & 2).

Figure 1. Theoretical framework to assess factors influencing male partner attendance in antenatal care – Social Ecological Model

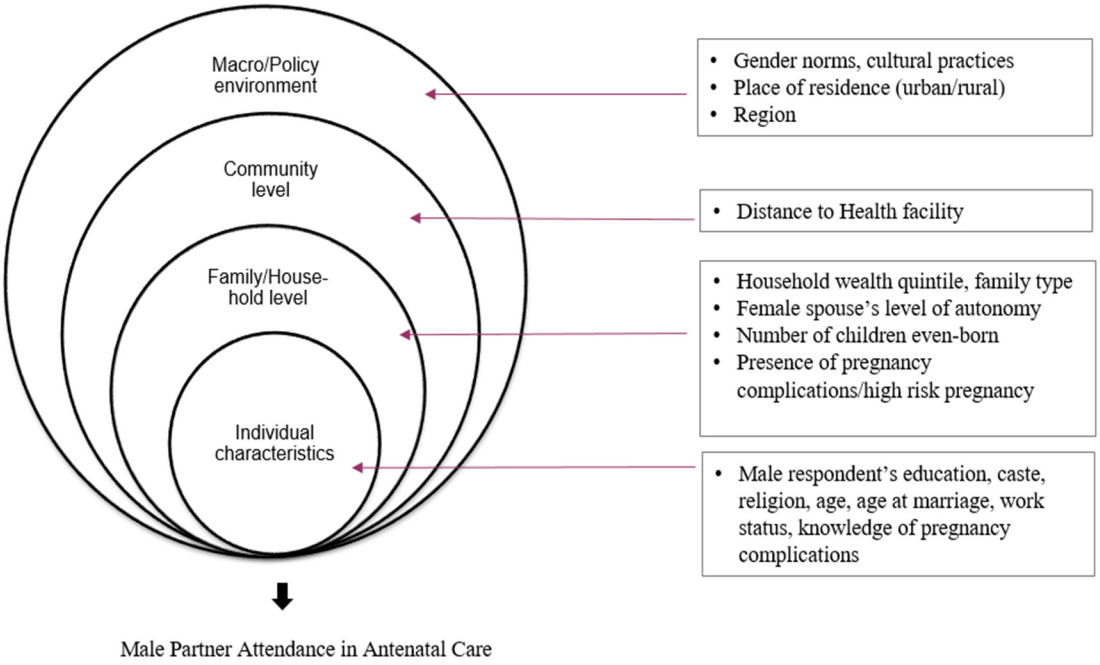
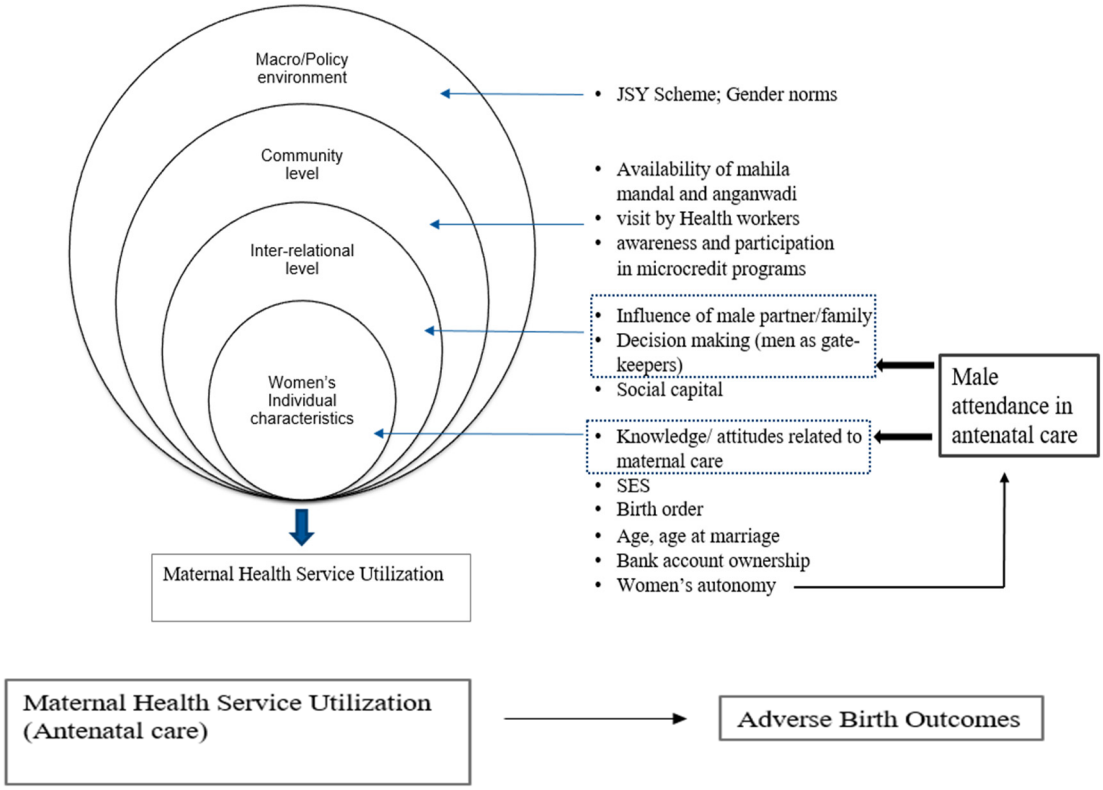


Figure 2. Theoretical framework to examine male participation – Social Ecological Model



While the *Social-Ecological Model* provides a framework to examine male partner attendance in antenatal care, it does not help understand the cultural influences and men's perceived need to be involved as husbands and fathers. Thus, in addition to the *Social-Ecological Model*, the theory of *Gender and Power* helps to frame an understanding of how gendered division of reproductive labor, unequal power relations, and cultural norms and practices shape male partner attendance. Additionally, the *Gender-Transformative Approach* underscores the need for a paradigm shift in programs and interventions aimed at improving maternal and neonatal health. A *Gender Transformative Approach* builds on the work of Kabeer (2005) and refers to working towards making structural changes that address the root causes of gender inequality and moving beyond traditional approaches that focus on interventions based on the individual

behavior of women (Kabeer 2005; Hillenbrand et al., 2015). Numerous interventions have used a *Gender Transformative Approach* lens to examine the impact of male partner involvement on health outcomes (Dworkin & Barker, 2019; Hartmann et al., 2016; Kågesten & Chandra-Mouli, 2020). In particular, this perspective is vital to acknowledging that while involvement of men in pregnancy, childbirth, and post-birth is beneficial to improving maternal and child health, this involvement needs to be grounded in women's autonomy and implemented in a manner that respects and promotes women's choices and decision-making.

Data source

To examine male partner attendance in antenatal care, data were used from two rounds of the National Family Health Survey (NFHS-3 and NFHS- 4) conducted in 2005-06 and 2015-16, respectively. The survey is a nationally representative, multi-topic survey conducted by the International Institute for Population Sciences (IIPS) and the Ministry of Health and Family Welfare (MoHFW) (IIPS, 2017). The survey's objective was to collect essential data on health and family welfare to help policymakers and program evaluators assess trends and progress in India's health indicators over time. A stratified two-stage sampling design was employed, and the 2011 census was used as the sampling frame for selecting the Primary Sampling Units (PSUs) in NFHS-4. The villages in rural areas and Census Enumeration Blocks in urban areas represented the PSUs. For each state, urban and rural samples were drawn separately and proportionate to the state. The NFHS-4 survey includes data on all twenty-nine states and seven union

territories; data on Telangana[5] was added in the fourth round of the NFHS survey (NFHS-4, 2015-16).

The women's questionnaire includes information from women aged 15-49 years on topics such as background characteristics, antenatal care, delivery care, postnatal care, delivery characteristics, and postpartum complications. A subset of households was interviewed to collect data from male partners; data from men's questionnaire covered background characteristics, marriage, employment, number of children, presence at antenatal care visits, contraceptive knowledge and use and fertility preferences. Questionnaires for each state were multilingual, with questions both in the principal language of the state/union territory and English. The questionnaire was also available in 1-2 other commonly used languages in the state/union territory. The survey was administered verbally via a trained interviewer in either English or the principal language of each Indian state, depending on household members' preference. For NFHS-4, a sample of 699,686 women with a 97% response rate and 112,122 men with a 92% response rate was generated (IIPS, 2017).

Similar to NFHS-4, NFHS-3 also utilized a stratified, multistage sampling design, with two-stage sample design in rural areas and three-stage sample design in urban areas. The 2001 census data provided the main sampling frame for the sample selection. Data were obtained for twenty-nine states and seven union territories. An overall sample of 131,596 women with a 92% response rate, and 85,373 men was generated with an 84% response rate. Table 1.1 presents the sample distribution between rural and urban areas.

[5] The state of Telangana was formed on June 2, 2014 and was previously a part of Andhra Pradesh. Following the addition of Telangana, there are now 29 states and 8 union territories in India.

Table 1.1 Sample sizes for data from NFHS – 3 and NFHS – 4

NFHS – 4 (2015-16)	N	NFHS – 3 (2005-06)	N
Women (age 15- 49 years)	699,686	**Women (age 15- 49 years)**	131,596
Urban	204,735	Urban	61,028
Rural	494,951	Rural	70,568
Men (age 15-54 years)	112,122	**Men (age 15-54 years)**	85,373
Urban	35,526	Urban	45,133
Rural	76, 596	Rural	40, 240
Households interviewed	601, 509	**Households interviewed**	73, 974
Urban	175, 946	Urban	36, 313
Rural	425, 563	Rural	37, 661

Data linking and selection

Data from the men's questionnaire was linked with data from women's questionnaire using the household identification numbers. Although data on polygamous couples have been included in the survey, male partners who indicated having more than one wife were excluded from the analysis. Further, questions about antenatal and delivery care were asked only to those women who reported having at least one birth in the past five years. If the woman had at least one antenatal care contact during pregnancy, they were asked if their spouses accompanied them during antenatal contacts. Data were selected for analysis if the women responded to the question: "Was the child's father present at any antenatal care contact for your most recent child?". Combined couples data were used for Paper I.

Defining Key Concepts

Male partner attendance: Male partner attendance in antenatal care was recoded based on the survey question: "Was the child's father present at any antenatal care contact for your most recent child?"; women who answered yes to this question were coded as 1, otherwise as 0.

Early Initiation of antenatal care: To measure *Early Initiation of antenatal care*, a dichotomous variable was used based on women's timing of first antenatal care contact. Women who had their first antenatal care contact within 12 weeks of pregnancy were coded as 1 (WHO, 2016), and women who responded that they had their first *antenatal care* contact at 12 weeks or later were coded as 0. Detailed definition is available in table 1.2.

Frequency of antenatal care contacts is based on the number of *antenatal care* contacts that a woman had during her pregnancy. This was recoded into two dichotomous variables - Frequency of antenatal care contacts (4 or more contacts) with two categories: Less than 4 contacts, 4 or more contacts; and, frequency of antenatal care contacts (8 or more contacts) with two categories: Less than 8 contacts, 8 or more contacts[6].

Receipt of tetanus toxoid (TT) injection: A dichotomous outcome variable was used to measure if a respondent has had at least one tetanus toxoid injection during their visits to the antenatal care clinic.

Antenatal care testing: A dichotomous variable was used to measure whether women received all the components of antenatal care testing. Women who responded yes to all questions on whether they had been weighed, whether their blood and urine sample had been taken, whether blood pressure had been taken and abdomen examined, were coded as 1 otherwise as 0.

Antenatal care counselling: A dichotomous variable was used to measure whether women received counselling on pregnancy complications. Women who responded that

[6] The 2016 WHO recommendation states that women should have at least 8 antenatal care contacts, with the first contact taking place in the first trimester (WHO, 2016).

they had been told about pregnancy complications and had been told about where to receive medical help for pregnancy complications were coded as 1 otherwise as 0.

Institutional delivery: A dichotomous outcome variable was used to measure Institutional Delivery, based on women's choice for place of delivery. Women who delivered at a health facility (including both public and private) were coded as 1, and women who responded that they delivered at home were coded as 0.

Infant birth weight: Infant birth weight data measured in grams was used as a continuous variable.

Low infant birth weight: Based on the WHO definition (2014), an infant was defined as having low birth weight if their birth weight was less than 2500 grams and was coded 1, otherwise as 0. (Gestational age was added as a control variable within the model).

Table 1.2 Timing and definition of antenatal care

Term	Definition	Timing
Antenatal care	Routine antenatal care is defined as the care provided by health professionals to all pregnant women to ensure the best health conditions for the women and their fetuses during pregnancy. The basic components of the antenatal care include risk identification, prevention, and management of pregnancy-specific or concomitant diseases, education and health promotion (WHO, 2016)	Based on 2016 WHO antenatal care model: *First trimester:* Contact 1: Up to 12 weeks *Second trimester:* Contact 2: Up to 20 weeks Contact 3: Up to 26 weeks *Third trimester:* Contact 4: Up to 30 weeks Contact 5: Up to 34 weeks Contact 6: Up to 36 weeks Contact 7: Up to 38 weeks Contact 8: Up to 40 weeks
Institutional delivery	Operationalized as delivery in any health facility attended by a skilled birth attendant/ medical	

	professional (Darega, Dida, Tafese, & Ololo, 2016).	

A more detailed operational definition and coding of each variable used is described in the respective chapters and also reported in Supplementary Table 14 in Appendix 1.

Overview of Papers

Paper 1, Chapter II documents the prevalence of male partner attendance in antenatal care, using data from 2005-06 and 2015-16 National Family Health Survey (NFHS) surveys. Additionally, this paper utilizes the latest NFHS data from the survey conducted in 2015-16 to examine the factors influencing male partner attendance in antenatal care. For this paper, I created a couples dataset using identification numbers for the primary sampling unit (PSU), household and line number, and included household level data on household wealth index, region, place of residence and distance to health facility. The final analytic sample included couples (NFHS-4: 20,177; NFHS-3: 13,488), where the women have had at least one antenatal care contact and had information on male partner attendance. Further, to examine the determinants of male partner attendance in antenatal care, data were used from the latest round of the *National Family Health Survey (NFHS-4), 2015-16* and the final analytic sample consisted of 18,868 couples. For the analysis, weighted (probability weights) descriptive statistics were conducted to summarize the level of male partner attendance in antenatal care in India, overall, by state and by region. Additionally, these analyses were conducted separately for both rounds of the survey (NFHS-3 and NFHS-4) in 2005-06 and 2015-16, respectively. I also summarized trends in utilization of antenatal care overall, by state and by region. A visual representation of regional trends in male partner attendance in antenatal care was

provided using Tableau 2020.3. For the second part of the analysis, I used data from the the *National Family Health Survey, NFHS-4, 2015-16* and constructed multivariable logistic regression models to estimate the relationship between the predictor variables and male partner attendance. The Odds Ratio (OR) and 95% confidence interval (CI) have been reported for the results. Although this study is unable to capture all aspects of male involvement in maternal care, it contributes to literature in this area by using nationally representative data to examine the levels of male partner attendance in antenatal care, and investigate the factors that shape male partner attendance.

To add to this body of literature, ***paper 2, Chapter III.*** examined the association between male partner attendance in antenatal care and maternal health service utilization. I also assessed variations in this association by place of residence and region.

This paper aims to contribute to the growing evidence-base on the positive effect of male partner attendance in antenatal care. It seeks to provide a nuanced understanding of how this relationship varies by region and place of residence. This paper utilized data only from the women's questionnaire and from the latest round of the *National Family Health Survey*, conducted in 2015-16. The final analytic sample of 144,840 women included all those who had at least one antenatal care contact and had information on male partner attendance and maternal health service utilization (timing and frequency of antenatal care). Similarly, for examining the association between male partner attendance and institutional delivery, I included only those women who had at least one antenatal care contact, had information on male partner attendance and on institutional delivery. The final analytic sample, in this case, consisted of 146,378 women.

Furthermore, I also conducted a sensitivity analysis using a sub-sample of women (19,462) who had completed the domestic violence module. For the analysis, I conducted weighted (probability weights) descriptive statistics, bi-variate analysis, and multivariable logistic regression analysis to assess the association between male partner attendance in antenatal care and maternal health service utilization. The logistic regression models were used to examine the association between male partner attendance at antenatal care and each of the four outcome variables: early initiation of antenatal care, frequency of antenatal care contacts (4 or more contacts; and, 8 or more contacts), and institutional delivery. Additionally, I also tested the moderating effects of place of residence and region on the association between male partner attendance in antenatal care and maternal health service utilization. As a sensitivity analysis, the multivariable regression models were replicated, controlling for intimate partner violence (physical violence, emotional violence and sexual violence) among a sub-sample of women who had been interviewed for the module on domestic violence. For all models, Odds Ratio (OR) and 95% confidence interval (CI) were reported.

Finally, while some studies in India have assessed the association between antenatal care and infant birth weight (Kader & Perera, 2014; Khan et al., 2019; Zaveri et al., 2020), none of these studies have examined the effect of early initiation of care during pregnancy, nor have they examined the separate components of antenatal care (receipt of tetanus toxoid injection, testing, counselling). Further, despite the documented association between paternal involvement and infant birth weight, none of the studies from India have controlled for the effect of male partner attendance. To fill this research gap, ***in paper 3, Chapter IV***, I used the latest round of the National Family Health Survey

conducted in 2015-16 to examine the association between antenatal care and infant birth weight, and assessed how this association varied by male partner attendance. This paper aims to contribute to the existing evidence-base on understanding the positive effect of antenatal care on infant health outcomes. This paper utilized data from the latest round of the NFHS (NFHS-4, 2015-16). To avoid recall bias, the study was limited to the most recent births in the five years preceding the survey. The final analytic sample consisted of 90,680 women who had information on their child's birth weight, on antenatal care utilization and male partner attendance. For the analysis, I used weighted (probability weights) descriptive statistics and logistic regression analysis to assess the association between antenatal care and infant birth weight. Logistic regression models were run to examine the association between each predictor (Timing of first antenatal care contact, Frequency of antenatal care contacts, and components of antenatal care) with the outcomes (infant birth weight – continuous; low infant birth weight – categorical). Odds Ratio (OR) and 95% confidence interval (CI) were reported and each of the models was adjusted for gestational age. Furthermore, I controlled for male partner attendance in antenatal care within all regression models. Additionally, to understand the effect of male partner attendance in antenatal care on this association, an interaction term was added within each regression model. All regression models were run for the full sample, as well as sub-samples based on the method of reporting birth weight (medical records/recall). The results of this study add to the growing body of literature that documents the positive effect of involving male partners in maternal care on infant health outcomes.

In conclusion, this three-paper dissertation's finding can make an important contribution to the literature on male partner attendance in antenatal care. Being one of

the first studies to document the national and regional trends in male partner attendance and its effect on maternal health service utilization and infant birth weight, the results presented here will be particularly useful to inform targeted interventions aimed at improving maternal and neonatal health in India.

Chapter II. An examination of trends and factors influencing male partner attendance in antenatal care in India

Background

Post the 1994 International Conference on Population and Development (ICPD), there has been a shift in global health perspectives, from viewing women solely as objects of fertility control to a rights-based framework for sexual and reproductive health (Dworkin & Barker, 2019). As part of this shifting perspective, male involvement in the advancement of gender equality and global public health began to gain ground and led to a rapid increase in gender-transformative interventions in the area of sexual and reproductive health (Peacock & Barker, 2014; Peacock, Stemple, Sawires, & Coates, 2009). A Gender Transformative Approach refers to building structural changes that address the root causes of gender inequality, and is geared towards moving beyond traditional approaches or interventions that are focused on the individual behavior of women (Kabeer 2005; Hillenbrand et al., 2015). Many of these gender-transformative interventions have noted a positive impact of male involvement in reducing gender-based violence and HIV prevention (Dworkin & Barker, 2019). Furthermore, there is also a growing interest in engaging with male partners in maternal care, with the goal of improving maternal and child health outcomes (Yargawa & Leonardi-Bee, 2015).

Based on a gender-transformative approach, numerous studies have examined the impact of male involvement in maternal care[7]. While most studies show a positive association between male involvement and maternal health service utilization, the level of

[7] Within this context, male involvement in maternal care is used as an umbrella term and includes male partner attendance in antenatal care, arrangement of transportation, assistance in household activities, presence during delivery and postpartum care.

involvement varies across different contexts (Chattopadhyay, 2012; Mohammed, Johnston, Vackova, Hassen, & Yi, 2019; Rahman et al., 2018; Sapkota, Kobayashi, Kakehashi, Baral, & Yoshida, 2012). For instance, a study that examined indicators of male involvement in maternal and neonatal health in an urban town in Myanmar found that a majority of men accompanied their wives to antenatal care visits (82%) and for delivery (87%); additionally, a majority of men shared health-related decisions with their wives (Ampt et al., 2015). Another study that used 2011 Bangladesh Demographic and Health Survey (DHS) data to examine factors associated with male involvement in reproductive health found that 94% of men had correct knowledge about nutrition requirements and 83% of men had the necessity of check-up during pregnancy; however, only 23% of the men knew the correct timing of the first antenatal care check-up and only about one-third of the participants reported that they were present during the visit by a medical professional (Bishwajit et al., 2017). Another study from Nepal that examined involvement of men in antenatal care, birth preparedness, breastfeeding and immunization found that while about 56% of men helped in household chores, 53% arranged money for delivery, 59% encouraged their partners to exclusively breastfeed, only about 39% accompanied their partners for at least one antenatal visit.

Globally, research shows that men who are older, have higher levels of education, exposure to mass media, better knowledge of pregnancy-related complications, increased perception of risk during pregnancy (Barua et al., 2004; Bhatta, 2013; Bishwajit et al., 2017; Craymah et al., 2017; Wai et al., 2015), as well as those in monogamous marriages (Craymah, 2017) were more likely to be involved in maternal care. In contrast, men who reported being employed (Gibore et al., 2019) and those living more than 5 km away

from the health facility (Tweheyo et al., 2010) were less likely to be involved in maternal care. Further, women's autonomy, particularly movement autonomy, was associated with reduced odds of male involvement in maternal care (Thapa, 2013). Additionally, studies also found that social identities such as caste (Singh & Ram, 2009), religion, ethnicity (Gibore et al., 2019; Bhatta, 2013) were associated with male involvement in maternal care. For instance, research from India shows that non-Hindus and those belonging to SC/ST (Schedule Caste/Scheduled Tribe) castes were less likely to accompany their wives for antenatal checkups as compared to Hindus and men belonging to General castes (Singh and Ram, 2009). Evidence from India also documents that men belonging to non-nuclear families were less likely to accompany their partners to antenatal care than men belonging to nuclear households (Singh & Ram, 2009). Additionally, gender roles and norms (Sharma et al., 2018; Jungari & Paswan, 2019b), and men's perception of the attitude of health workers were important determinants of male involvement in maternal care (Awasthi et al., 2008; Barua et al., 2004; Singh & Ram, 2009).

Further, research has documented that healthcare providers' attitude toward men who accompany their partners to antenatal care visits is an important influencing factor on men's involvement in antenatal care (Craymah et al., 2017; Gibore et al., 2019). In a study by Craymah et al. (2017), participants reported that harsh treatment by healthcare providers discouraged them from attending antenatal care clinics. Similar to evidence documented by Gibore et al. (2019), a study in India by Barua et al. (2004) found that women may not want the husbands involved and that the health workers make it difficult for husbands to be involved. Gender roles, attitudes, and social norms also shape this interaction and influence the extent of male involvement (Craymah et al., 2017;

Dumbaugh et al., 2014; Jungari & Paswan, 2019b; Singh & Ram, 2009). Participants in a qualitative study in Ghana reported that they experienced pressure to embrace the dominant definitions of masculinity and that these limit how men are permitted to engage in pregnancy and childbirth (Dumbaugh et al., 2014). Similar results were found from a study in Tanzania where men reported that they considered pregnancy-related issues to be a woman's domain (Vermeulen et al., 2016).

Gaps in literature. Within India, studies show considerable regional variation in the extent of male involvement in maternal care. Most of the studies focus on a specific population using qualitative methodology and convenience sampling to understand the experiences of and barriers to male involvement in maternal care. Further, within the broader ambit of male involvement, limited studies have separately examined the effect of male partner attendance in antenatal care. None of these studies provide an understanding of the overall extent of male partner attendance in antenatal care in India, how this varies by region, and the factors influencing male partner attendance.

This study used nationally representative data from two rounds of the National Family Health Survey (NFHS) (NFHS-4, 2015-16; NFHS-3, 2005-06) to assess the extent of and changes in male partner attendance in antenatal care. Understanding both the current levels of male partner attendance and changes over time are important metrics to consider in assessing overall male partner attendance in antenatal care and its potential implications for maternal and neonatal health outcomes. Further, the paper will provide an understanding of the factors influencing male partner attendance.

Theoretical Frameworks

Social Ecological Model

According to the *Social-Ecological Model* proposed by Bronfenbrenner (1977), individual behavior is not only influenced by personal characteristics, but is also a result of the context within which an individual exists (Bronfenbrenner, 1977; McLeroy, Bibeau, Steckler, & Glanz, 1988). According to the *social-ecological model* (Bronfenbrenner, 1977), multiple systems influence an individual's development and behavior; these may be on an interpersonal, organizational, community, or policy level. Previous research shows that there are multiple levels of influence on male involvement in maternal care. Individual-level factors include age, education, religion, caste, ethnicity, marriage type, employment, knowledge about pregnancy-related complications; while, at the mezzo-level, factors such as attitudes of health workers were found to be predictors of male involvement in maternal care (Ampt et al., 2015; Barua et al., 2004; Bhatta, 2013; Bishwajit et al., 2017; Craymah, Oppong, & Tuoyire, 2017; Gibore et al., 2019; Gill et al., 2017; Jungari & Paswan, 2019b; Sharma, Bhuvan, & Khatri, 2018; Singh & Ram, 2009; Tweheyo, Konde-Lule, Tumwesigye, & Sekandi, 2010; Wai et al., 2015). Additionally, broader gender roles, attitudes and social norms were important predictors of male involvement (Craymah et al., 2017; Dumbaugh et al., 2014; Jungari & Paswan, 2019b; Singh & Ram, 2009). This paper utilizes the *Social Ecological Model* as a framework to understand the multiple levels of influence that shape and predict male partner attendance in antenatal care (See figure 3). A limitation of the *Social Ecological Model* in this scenario is that while it recognizes the broader cultural and social context, it does not provide a framework to understand how unequal division of reproductive labor

and power relations shape men's decisions and actions. To better understand the social mechanisms that inform gendered practices in India, I utilized Connell's Theory of Gender and Power.

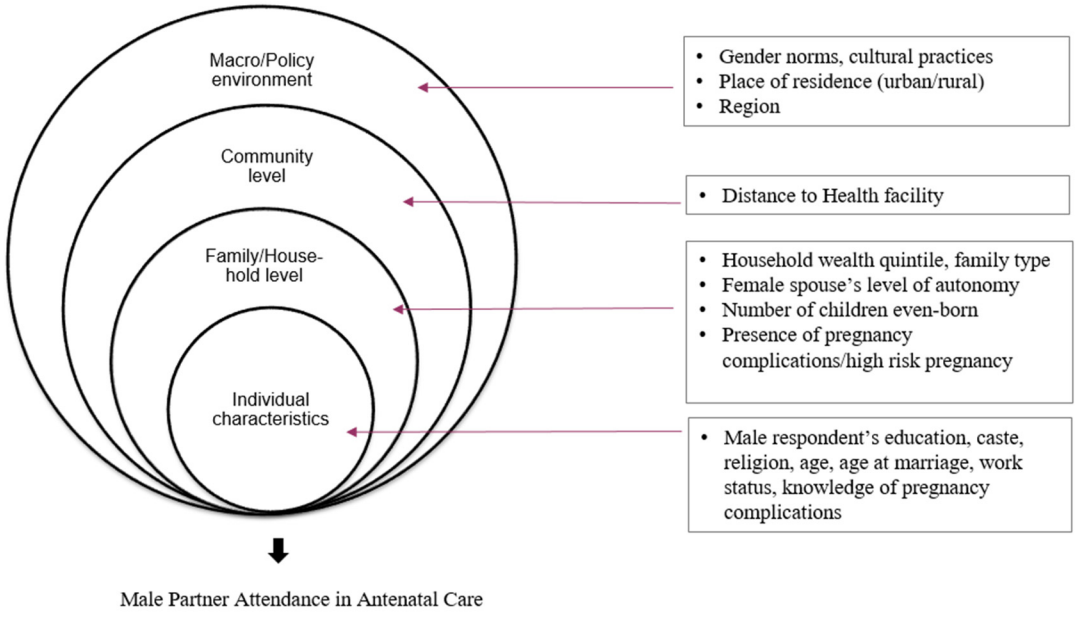
Connell's Theory of Gender and Power

Building on prior research and theorization in the area of gender and sexual inequality, Connell (1987) developed an integrative theory of gender and power. According to Connell's *Theory of Gender and Power*, the three central tenets of gendered relationships between men and women are: the sexual division of labor, the sexual division of power, and the structure of cathexis. The "sexual division of labor" essentially refers to the assignment of differing and unequal positions to women in relation to men, which then translates to fixed roles and responsibilities. For instance, child care and reproductive labor are often viewed as women's domain of work. The second tenet refers to the inequalities in power between the sexes that arise based on the sexual division of power. And finally, the structure of cathexis refers to 'affective attachments' and 'social norms,' which dictate appropriate gender practices and rules. According to the theory, the three tenets overlap with each other to explain the gendered roles taken on by men and women. Further, the theory expounded that these three tenets existed both at the society and institutional level. The institutional level referred to social institutions including families, work sites, religious institutions, the health system, and media.

The *Theory of Gender and Power* can inform our understanding of behavior as a result of an individuals' social environment and the gender-based exposures and risks (Wingood & Diclemente, 2000). Within the Indian context, the gendered division of reproductive labor shapes women's access to maternal care and support during

pregnancy. While on the one hand, men do not involve themselves in reproductive health, as this is seen as a woman's domain (Barua et al., 2004; Jungari & Paswan, 2019a); by contrast, men are also the gate-keepers and primary decision-makers in relation to women's maternal health service utilization (Chattopadhyay, 2012; NFHS, 2015). Within this cultural context, male partner attendance during antenatal care contacts could be a crucial enabling factor to increase women's maternal health service utilization. In this study, the *Theory of Gender and Power* is employed as a framework to understand how gendered division of reproductive labor, unequal power relations, and cultural norms and practices shape male participation in maternal care.

Figure 3. A conceptual framework to examine factors influencing male partner attendance in antenatal care



Informed by the *Social Ecological Model* and the *Theory of Gender and Power* this paper asks the following broad question: *What is the extent of male partner attendance in antenatal care, and what factors shape this?* The sub-questions are:

- *What is the extent of male partner attendance in antenatal care in India, overall and by region?*
- *Has the level of male partner attendance in antenatal care improved between 2005 and 2015 nationally, and by state?*
- *What socio-demographic factors influence male partner attendance in antenatal care?*

To answer these questions, this paper will rely on two waves of nationally representative, secondary data from India.

Methods

Data source

To examine the extent of male partner attendance in antenatal care and factors predicting male partner attendance, data were used from two rounds of the National Family Health Survey (NFHS- 3 and NFHS-4) conducted in 2005-06 and 2015-16 respectively. This is a nationally representative, multi-topic survey undertaken by the International Institute for Population Sciences and Macro International (IIPS, 2017). The sampling design was a stratified two-stage sample, and the 2011 census was used as the sampling frame. For each state, urban and rural samples were drawn separately and proportionate to the state. Similar to NFHS-4, NFHS-3 also utilized a stratified, multistage sampling with 2001 census data as the main sampling frame. In NFHS-3, data was included on twenty-eight states and Delhi; while, in NFHS-4, data was available for twenty-nine states and seven union territories (an additional state of Telangana was added in the fourth round of the NFHS survey, NFHS-4 2015-16). Overall, for both round of NFHS data, a subset of households was interviewed to collect information from male partners. For NFHS-4, a sample of 699,686 women with a 97% response rate and a sample of 112,122 men with a 92% response rate was generated. For NFHS-3, an overall

sample of 131,596 women was generated with a response rate of 92.4% and a sample of 85,373 men was generated with an 84% response rate.

Descriptive statistics estimating male partner attendance in antenatal care

For the analysis, data from the men's questionnaire were linked with data from women's questionnaire to create a couples dataset using identification numbers for the primary sampling unit (PSU), household and line number. Data on household wealth index, region, place of residence, and distance to health facility from the household questionnaire was also linked with the couples dataset. Within the couples datasets, of all the women who were asked about antenatal care, 20.385 women in NFHS-4 and 16,536 women in NFHS-3 had data available on antenatal care contacts. This excluded nulliparous women and those who had given birth prior to five years before the survey. Further, women who reported having zero antenatal care contacts (NFHS-4: 3,729; NFHS-3: 2,891), and those with missing data on antenatal care contacts (NFHS-4: 208; NFHS-3: 153) were excluded from the analysis. Next, women who had missing data on male partner attendance in antenatal care were excluded from the analysis (NFHS-4: 4). The final analytic sample included 13,488 women from couples data for NFHS-3 and 20,177 women from couples data for NFHS-4.

Figure 4. Flowchart depicting data selection process for NFHS-3 (2005-06) survey

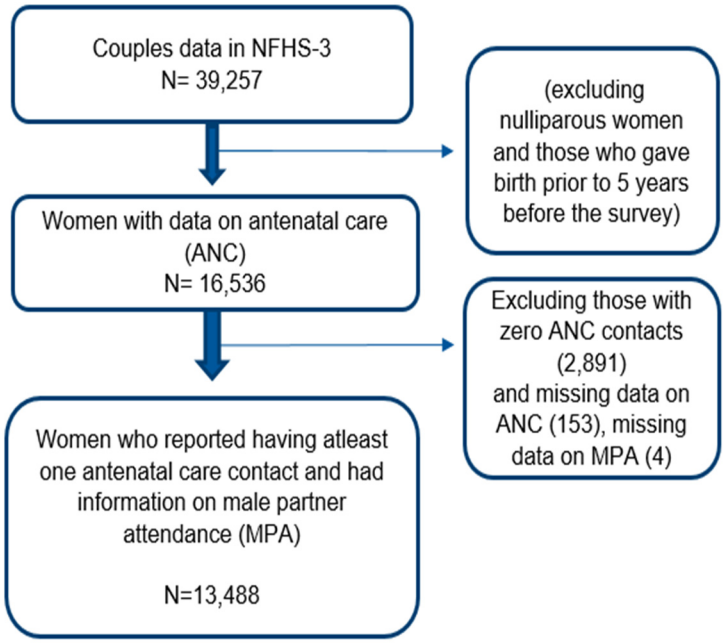
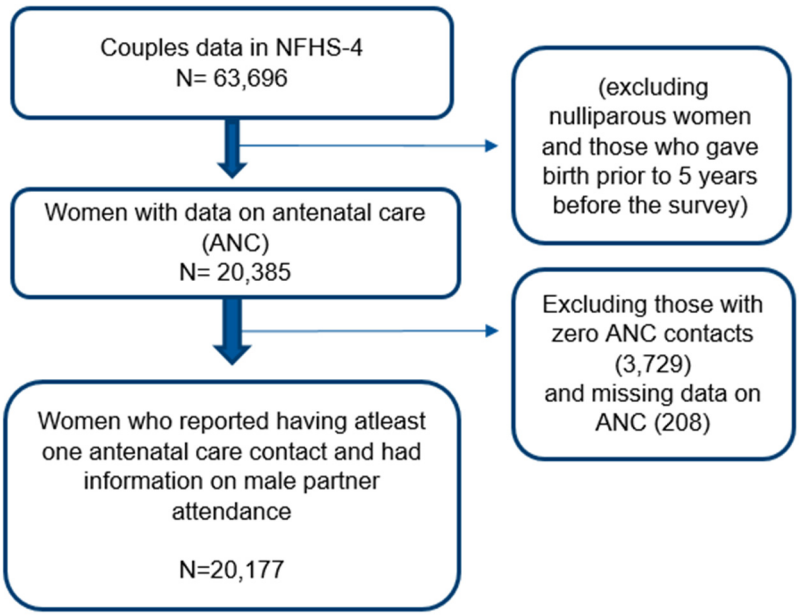


Figure 5. Flowchart depicting data selection process for NFHS-4 (2015-16) survey

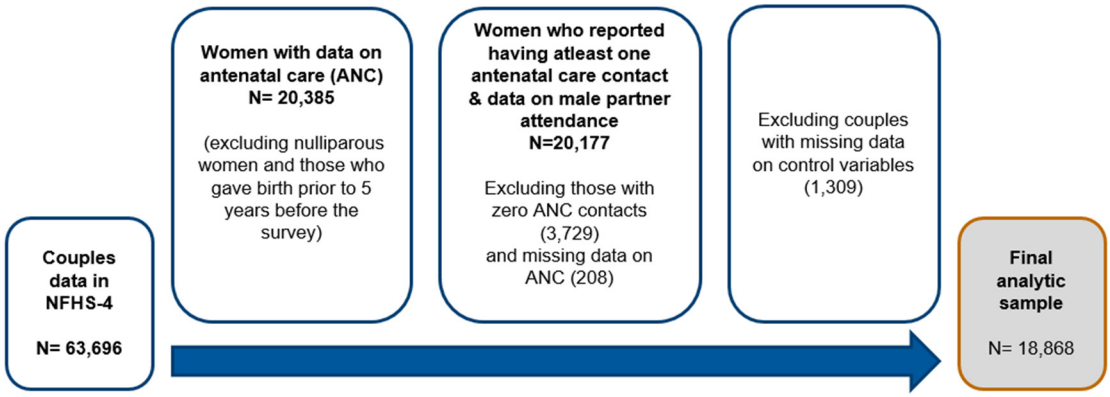


Logistic regression analysis examining the determinants of male partner attendance in antenatal care using data from NFHS-4

For the second part of the analysis that examined determinants of male partner attendance in antenatal care, data were only used from the *National Family Health Survey (NFHS-4), 2015-16*. Similar to the previous analysis, data from the men's questionnaire were linked with data from women's questionnaire to create a couples dataset; and further, data on household wealth index, region, place of residence, and distance to health facility from the household questionnaire were linked with the couples dataset.

Among the 63,696 couples in the 2015 survey, 20,177 women had data on whether their male partner was present at antenatal care contacts, excluding women with missing data on antenatal care contacts (208) and if they reported having zero antenatal care contacts (3,729). Additionally, respondents were dropped if they had missing data on caste (1,255), occupation (27), and age at marriage (5), and pregnancy complications (22). The final analytic sample consisted of 18,868 couples.

Figure 6. Flowchart depicting data selection process for analysis of determinants of male partner attendance in antenatal care, NFHS-4 (2015-16) survey



Research Ethics

In alignment with the ethical guidelines, permission was obtained from Boston College Institutional Review Board (IRB) for the study.

Measures

In this paper, the *respondent* implies a male partner and the *spouse* implies his female wife. Both male and female participants were asked whether the male partner was present during antenatal care. To maintain consistency across all papers in this dissertation, however, I have utilized the responses about male partner attendance as reported by the female participant for this paper. Among the control variables, education, caste[8], religion, age, age at marriage, family type, work status and knowledge of pregnancy-related complications were measured at the individual level from the men's questionnaire; household wealth, place of residence, region and distance to health facility were measured at the household level; and pregnancy complications, number of children ever-born and women's autonomy were measured at the individual level from the women's questionnaire.

Dependent variable

Male partner attendance: Male partner attendance in antenatal care is recoded based on the survey question: *"Was the child's father present at any antenatal care contact for your most recent child?"*; women who answered yes to this question were coded as 1, otherwise as 0.

[8] Marginalized Hindu Communities were classified as Scheduled Castes (SC), Scheduled Tribes (ST) and Other Backward Classes (OBC) based on the Constitution (Scheduled Castes) Order, 1950.

Independent variables

To examine the factors predicting male partner attendance in antenatal care, I analyzed data from the NFHS-4 (NFHS-4, 2015-16). I included male respondent's socio-demographic characteristics (education, caste, religion, age, age at marriage, family type, work status, knowledge of pregnancy-related complications), and household level characteristics (household wealth, place of residence, region and distance to health facility) in the regression model. Further, pregnancy complications, number of children ever-born and women's autonomy were included from the women's questionnaire. Predictor variables and their operational definition are detailed in supplementary table 14 in Appendix 1.

Statistical analyses

Weighted (probability weights) descriptive statistics were conducted to summarize the level of male partner attendance in antenatal care in India. I examined these trends overall, by state and by region. These analyses were conducted separately for both rounds of the survey (NFHS-3 and NFHS-4) in 2005-06 and 2015-16, respectively. Since NFHS-3 contains data only on twenty-eight states and Delhi, the analysis using both rounds of NFHS data was restricted only to these states to maintain consistency. Additionally, I also summarized trends in utilization of antenatal care overall, by state and by region. Tableau 2020.3 was used to visually represent regional trends in male partner attendance in antenatal care.

For the second part of the analysis, I used data only from the latest round of the National Family Health Survey, NFHS-4, 2015-16 and examined factors influencing

male partner attendance in antenatal care. In this case, data on all twenty-nine states[9] and seven union territories was included. Multivariable logistic regression models were employed to estimate the relationship between the predictor variables and male partner attendance, and Odds Ratio (OR) and 95% confidence interval (CI) have been reported. The following multiple regression model estimates the odds of male partner attendance in antenatal care, where X_1 is a vector of male respondent's characteristics (male respondent's education, caste, religion, age, age at marriage, family type, work status, knowledge of pregnancy related complications), X_2 is a vector of household level characteristics (household wealth, place of residence, region and distance to health facility), and X_3 is a vector of female spouse's characteristics (woman's level of autonomy, number of children ever-born and pregnancy complications) for individual i:

$$y = \begin{cases} 0 \text{ if no male partner attendance} \\ 1 \text{ if male partner attendance} \end{cases}$$

$$Logit\ p\ (y_i = 1) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3}$$

In the equation above, β_0 is the intercept and, β_1, β_2, and β_3 are the coefficients associated with each of the predictor variables.

Data analyses were conducted using the statistical package Stata SE version 14.2 (Stata Corp, College Station, TX). To account for the complex sample design, survey weights were used to obtain representative estimates.

[9] The state of Telangana was formed on June 2, 2014 and was previously a part of Andhra Pradesh. Following the addition of Telangana, there are now 29 states and 8 union territories in India.

Results

Table 2.2 presents the prevalence of male partner attendance in antenatal care using two waves of NFHS data (NFHS-3, 2005-05 and NFHS-4, 2015-16). Further, visual representation of trends in male partner attendance are provided in Figure 7 and Figure 8. Overall, in 2015 about 86% of women reported that they had attended at least one antenatal care contact during their pregnancy; of these women, about 85% reported that their male partners had accompanied them to antenatal care contacts. This increased from 65% in 2005 to 85% in 2015 (see table 2.2).

Male partner attendance in 2005-06

Overall, about 78% of women had at least one antenatal care contact during their pregnancy. The percentage of women who did not have antenatal care contacts varied considerably across states in India, ranging from 1% in Tamil Nadu to 69% in Bihar. Kerala was the only state where 100% of women reported having at least one antenatal care contact during pregnancy (see table 2.1).

Among couples where the women had at least one antenatal care contact, 66% of women reported that the male partner was present during antenatal care contacts. States with high levels of male partner attendance were Kerala (93%), Goa (86%), Tamil Nadu (84%), New Delhi (83%), and Himachal Pradesh (83%). States with low levels of male partner attendance were Mizoram (43%), Meghalaya (44%), Uttar Pradesh (50%), Manipur (55%), and Chhattisgarh (56%). Overall, in 2005, the Eastern (63%), North-Eastern (65.23%), and Central (54.83%) regions showed the lowest levels of male partner attendance as compared to other regions in India.

Male partner attendance in 2015-16

Overall in 2015-16, about 85% of women had at least one antenatal care contact during pregnancy (see table 2.2). The percentage of women who reported never having had any antenatal care contacts varied across India's states, ranging from as low as 0.64% in Kerala to 41% in Bihar. Among couples where the women had at least one antenatal care, overall in India, 85% reported that the male partner was present at least one antenatal care contact. In 2015-16 states with high levels of male partner attendance were Tripura (95%), Kerala (94%), Sikkim (93%), Tamil Nadu (92%), and West Bengal (91%). States with lower levels of male partner attendance were Mizoram (58%), Meghalaya (62%), Nagaland (66%), Arunachal Pradesh (75%), and Uttar Pradesh (76%). Overall, in 2015, the North-Eastern (82%) and Central (80%) regions showed lower levels of male partner attendance.

Next, I examined the individual characteristics and predictors of male partner attendance in antenatal care using data from the latest wave of the National Family Health Survey (NFHS-4, 2015-16).

Demographic characteristics:

The socio-demographic characteristics of the male respondents are presented in Table 2.3. In 2015, about 85% of women reported that the male partner was present during antenatal care contacts for their last child. The male respondents' age varied from 17 to 54 years, with 91% of the male respondents in the age group of 25 years and above. The majority of the male respondents reported that they were married at 18 or more years (93.3%). The male respondents had fathered two children on average, and for approximately 34% of male respondents, this was their first child ever born. The majority of male respondents (57%) had completed secondary level education (up to 10^{th} grade)

and about 13% had not attended any formal schooling. A large proportion of the male respondents were Hindu (82%), and 45% belonged to Other Backward Classes (OBC). Further, more than half of the male respondents were rural (65%) and belonged to the Central (23%) and Southern (23%) regions.

Factors influencing male partner attendance in antenatal care

Two logistic regression models examining factors influencing male partner attendance in antenatal care were run:

In Model I, male partner attendance in antenatal care was regressed on a list of individual factors (Male respondent's education, caste, religion, age, age at marriage, family type, work status, knowledge of pregnancy-related complications), household-level factors (household wealth quintile, place of residence, region, distance to health facility), number of children ever born, whether the female spouse had any pregnancy complications and women's level of autonomy. Each of these served as predictor variables in the multivariable logistic regression model (N=18, 868). Results revealed that higher education and household wealth, increased knowledge of pregnancy level complications, being married at 18 years and older and higher level of women's autonomy were significantly associated with increased odds of male partner attendance in antenatal care (see table 2.4). In contrast, compared to living in Southern region, those who lived in Northern, Central, North-East and Western regions had lower odds of accompanying their partner to antenatal care.

Men with higher secondary education were 56% more likely to attend antenatal care contacts as compared with men with no formal education (OR= 1.56, 95% CI [1.20 - 2.05]). Male partner's knowledge of complications during pregnancy was also associated

with likelihood of these partners' attendance at antenatal care, with every unit increase in knowledge of pregnancy-related complications during pregnancy being associated with 14% increased likelihood of attending antenatal care contacts (OR= 1.14, 95% CI [1.09 - 1.18]). Further, men belonging to households classified under richest wealth quintile were almost twice as likely to attend antenatal care contacts than those belonging to the poorest wealth quintile (OR= 1.88, 95% CI [1.44 - 2.44]). While respondent's age was not associated with male partner attendance, age at marriage was significantly associated such that men married at 18 years and older were found to be 38% (OR=1.38, 95% CI [1.16 - 1.64]) more likely to have present at antenatal care contacts as compared with those married below 18 years of age. Further, the region was significantly associated with male partner attendance. With reference to Southern region, North (OR=0.70, 95% CI [0.56 – 0.86]), Central (OR=0.58, 95% CI [0.48 – 0.70]), North-East (OR=0.60, 95% CI [0.47 – 0.76]) and Western region (OR=0.66, 95% CI [0.51 – 0.84]) were significantly less likely to report male partner attendance at antenatal care contacts. Although the Eastern region showed 2% increased odds of male partner attendance in comparison to the Southern region, this finding was not statistically significant.

Although household wealth was significantly associated with male partner attendance, work status had no significant association with male partner attendance. Additionally, although in bivariate analysis number of children ever-born was associated with male partner attendance, when controlling for all other variables, this did not have a significant relationship with the likelihood of male partner attendance at antenatal care contacts. Furthermore, religion, caste, family type, age, work status, pregnancy

complications and place of residence had no association with odds of male partner attendance, when controlling for all other factors.

Model II also controlled for women's autonomy within Model I. Women's autonomy was significantly associated with male partner attendance (see table 2.4). With every unit increase in score for women's autonomy, there was a 16% increased likelihood that the male partner was present during antenatal care contacts (OR= 1.16, 95% CI [1.09 - 1.24]). Moreover, although the strength and significance of other variables remained the same, pseudo R^2 improved slightly for Model II on the addition of autonomy (from 0.046 in Model I to 0.047 in Model II).

Discussion

For this paper, I have used nationally representative data to understand the extent of male partner attendance in antenatal care, and the factors influencing this involvement. Overall, the results show that more than three-fourths of men were present for at least one antenatal care contact during the pregnancy for their last child. Further, the levels of male partner attendance have increased over time (from 2005 to 2015) and show variation across regions in India. Using data from the fourth wave of the NFHS, I found that education, household wealth, knowledge of pregnancy-related complications, age at marriage, region and women's autonomy emerged as significant predictors of male partner attendance in antenatal care.

These findings contribute to the existing literature on male partner attendance in antenatal care. Programs and interventions in reproductive health have traditionally had a dominant focus on women, keeping men outside the scope of these interventions. However, evidence shows that working with male partners in addition to women can be

instrumental to improving service utilization, maternal and child health outcomes, and can also have the potential to transform existent gender roles and norms (Barker, Ricardo, Nascimento, Olukoya, & Santos, 2010; Tokhi et al., 2018). I utilized the Social Ecological Model to contextualize and organize the multiple influences that shape male partner attendance in antenatal care. Bronfenbrenner's *social-ecological model* serves as a useful tool in this study as it helps to understand that an individual's behavior is influenced both by personal characteristics, as well as the context within which they are embedded.

While bearing in mind the individual, family/household and community-level factors that influence male partner attendance in antenatal care, it is also important to reflect on the macro level or cultural context within which these decisions are made. Prior evidence in the area of male involvement in maternal care highlights the relevance of cultural practices and gender norms as crucial barriers to male involvement in maternal care (Awasthi, Nandan, Mehrotra, & Shankar, 2008; Barua et al., 2004; Lewis, Lee, & Simkhada, 2015; Sharma, Bhuvan, & Khatri, 2018; Singh & Ram, 2009). Particularly in the South Asian context, gender norms translate into rigid gender roles which specify pregnancy and maternal care as a "woman's domain" (Barua et al., 2004; Lewis et al., 2015). For instance, qualitative data from India revealed that while some male participants believed it to be their responsibility to accompany women to antenatal care visits, others felt that they need not be concerned with pregnancy-related issues when they were "busy earning for the family" (Jungari & Paswan, 2019a). Connell's *Theory of Gender and Power* (1987) provides a practical framework here by explaining that division of sexual labor and unequal power relations create and reinforce such strict

gender roles. However, the major underlying idea of Connell's work on theorizing gender is from a social constructivist perspective that views gender not as static, but rather as dynamic and relational; it posits that gender is constantly being reproduced through social relations at the individual, family, community and policy level (Connell, 2002). Within this framework and broader cultural context, it could be assumed that by accompanying the woman to antenatal care contacts men can not only be equal and responsible partners in maternal care, but also act as crucial agents of change. Involvement of men in maternal care can thus be seen as transforming power dynamics and as producing a shift in the role of men from gate-keepers/decision makers to equal partners.

With this framework in place, in the discussion that follows, I will highlight the main findings:

Firstly, male partner attendance during maternal care has increased over time. A majority of women reported that their male partner was present during antenatal care contacts; and, there has been an increase in levels of male partner attendance from 2005 to 2015. Earlier studies in India reported varying levels of male partner attendance, from 32% in a rural tribal district in Maharashtra (Jungari & Paswan, 2019a), 81% in another rural district in Maharashtra (Singh & Ram, 2009), to 18% in an urban slum settlement in Uttar Pradesh (Awasthi et al., 2008). Using nationally representative data, this study's results document levels of male partner attendance, both at the national and state level. Overall, the results show that in 2015 about 86% of women reported that they had attended at least one antenatal care contact during their pregnancy; of these women, about 85% reported that their male partners had accompanied them to antenatal care contacts. These results highlight the role of men not only as responsible partners to women in

maternal care, but also as key agents of change with the ability to transform inequitable gender relations (Greene, 2004) that adversely affect maternal and child health. This is one of the first studies to examine variations in male partner attendance nationally and by regions in India. The study findings provide a first comprehensive assessment of male partner attendance in antenatal care, and lays the groundwork for future research into understanding how varying social and regional contexts may impact attendance. While these results are encouraging, it is important to note that this study could not distinguish between the number of antenatal care contacts that the male partner was present for. Thus, it is possible that for some women, these results are not indicative of sustained male partner attendance and that their male partner was present for only one contact. Further, it is also crucial to take note that 15% of women reported that the male partner was not present during any antenatal care contact, with this number varying across states. In some states, such as Mizoram (41%) and Meghalaya (38%), approximately one in three women reported that their male partner was completely absent during antenatal care contacts. These results point to the need for context-specific and community-based strategies aimed at increasing male partner attendance in antenatal care. Social workers and community health workers can be crucial to implementing community-outreach interventions that target not only male partners of women but also other male members within the community such as community leaders, religious or village heads. Further, male community health workers/ Male Health Activists can be useful to engage with men on maternal and child health issues and bring about positive behavior change (Fotso, Higgins-Steele & Mohanty, 2015).

Study results also show that educated and wealthy men and those with better knowledge of pregnancy complications were more likely to be involved in maternal care. Consistent with previous research in South Asia (Bhatta, 2013; Bishwajit et al., 2017; Jungari & Paswan, 2019b, 2019a; Singh & Ram, 2009), the results of this study demonstrate that wealthier men and those with higher education levels and increased knowledge of pregnancy-related complications are more likely to be involved in maternal care. While most research has examined factors influencing male partner attendance within a smaller community or within a specific state, this study uses nationally representative data to demonstrate that controlling for other factors, education and household wealth emerge as significant predictors of male partner attendance in antenatal care. Perhaps, men who are more educated would be more involved in decision-making in relation to maternal care, and less concerned by cultural barriers to male partner attendance (Singh & Ram, 2009). Further, this study's results reveal that men with better knowledge of pregnancy complications are 13% more likely to participate in antenatal care. Apart from being more likely to attend antenatal care, men with better knowledge of maternal care and pregnancy complications may also be in a better position to be involved in decision making regarding antenatal care and place of delivery, and to advocate for a health facility birth; in turn, increasing maternal health service utilization among women (Jungari & Paswan, 2019b). Educating men on pregnancy issues can also be crucial to fighting cultural taboos around pregnancy, increasing joint decision-making on health issues and improving intra-spousal communication (Lewis et al., 2015). It is important to note that knowledge of pregnancy complications and pregnancy preparedness shares a reciprocal relationship with attending antenatal care contacts.

While better knowledge leads to greater odds of male partner attendance, research shows that men accompanying their partners to antenatal care reported higher levels of birth preparedness and readiness regarding pregnancy complications (Mersha, 2018). This evidence underscores the importance of both involving men in antenatal care and educating them on maternal care and pregnancy complications. Prior research in India shows that male partners often have low levels of awareness regarding pregnancy complications. For instance, a study that examined male involvement in Agra, Uttar Pradesh found that only 23% of husbands were aware of pregnancy-related complications, despite 58% of women in the sample having experienced at least one health problem during the antenatal period (Awasthi et al., 2008). A more recent study in India that examined husbands' knowledge and awareness of pregnancy complications among the tribal population in Gadchrioli district of Maharashtra found that nearly 40% of men reported not knowing any complications during pregnancy, childbirth, and postpartum (Jungari & Paswan, 2019b). Within this context, strategies aimed at ensuring that men accompany women on at least one antenatal check-up can provide a crucial opportunity for them to be counselled on maternal health issues. In addition, community-based education programs and mass media campaigns aimed at positive behavior change can be particularly useful to encourage male partner attendance (Sood, 2004).

Results indicate that male respondent's age at marriage is positively associated with male's participation in maternity care. According to the study results, of the men who were completely absent during antenatal care, 10% reported being married below the age of 18 years. In contrast to this, men married at 18 years and older were 38% more likely to be present at antenatal care contacts. These results highlight the negative social

and health consequences of child marriage as a practice that is highly prevalent in India. Child marriage, defined as a formal marriage or an informal union between a child under 18 years of age and an adult or another child, is a serious violation of human rights. Despite considerable declines worldwide over the past decade, child marriage still remains a persistent problem, particularly in South Asia which accounts for the largest number of child brides worldwide (UNICEF, 2019). Child marriage has been banned in India as early as 1929, with the law being updated in 2006 under the Prohibition of Child Marriage Act. Despite this, India remains one of the countries with the highest rate of child marriage, disproportionately affecting poorer and socially disadvantaged populations (Crivello, Roest, Vennam, Singh, & Winter, 2018; Pankhurst, Tiumelissan, & Chuta, 2016). These results support the growing body of literature that documents the social and health consequences of early and child marriage, and calls for tighter laws regarding the practice. Although child marriage as a practice among girls has been well-documented, fewer studies have examined men's contraceptive needs, fertility intentions, and health consequences based on age at marriage (Misunas, Gastón, & Cappa, 2019). The results of this study draw attention to this gap in literature and for the need to address child marriage as a practice that leads to adverse social and health outcomes among young boys and men.

According to the study findings, women's autonomy is positively correlated with male partner attendance. An unanticipated finding was a significant and positive relationship between women's autonomy and male partner attendance. In this paper, women's autonomy was measured based on a score created from variables measuring women's ability to make decisions in relation to healthcare, finances and movement (see

Table 1). In the Indian context, women's movement and access to financial resources are to a large extent controlled by male household members. According to the NFHS-4 report, only about 42% of women in India had money that they alone could decide on how to use, and about 53% of women had a bank account that they alone could use. Further, only 50% of women are allowed to go to a health facility; and only 41% of women are allowed to go to the market, health facility, or outside of their village/ community by themselves (IIPS, 2017). Thus, for most women, healthcare decisions are not individual decisions, with about 74% of women reporting that their healthcare decisions were taken jointly with their husbands. Despite the strong influence that women's autonomy could have on their health-seeking behavior and on male participation, few studies have included women's autonomy as a predictor of male partner attendance in antenatal care. Some evidence shows that women's autonomy has an inverse relationship with male partner attendance in antenatal care (Thapa & Niehof, 2013). This would imply that male partners of women who have more freedom of movement and more financial autonomy would be less likely to accompany them to antenatal care contacts; thus, in such case, the male partner's involvement would be an expression of women's lack of autonomy. Considering the control that men have on women's movement and resources in the Indian context, one would assume an inverse relationship as well. However, the study results show that every unit increase in women's level of autonomy was associated with a 16% increased likelihood that their male partners would accompany them to antenatal care contacts. These results add to the prior discussion on how women's autonomy may be associated with male involvement in maternal care. While increased financial and movement autonomy would lead to

improvements in healthcare accessibility for women, this may not necessarily suggest that this would lead to greater involvement of men in maternal care (Thapa & Niehof, 2013). However, the significant positive association found between women's autonomy and male partner attendance within the context of India, underscores the importance of women's empowerment as a key strategy to improve male partner attendance as well as maternal health service utilization. Particularly at the community level, social workers may be instrumental in the development of Mahila Mandals/Self-Help Groups (organization of women that provide micro-finance facilities to undertake entrepreneurial activities) as a strategy to enable economic independence and women's empowerment (Ramanjaneyalu, 2018; Sunil et al., 2006). Further research should be undertaken to examine whether women's autonomy can have a reinforcing influence on various aspects of male involvement.

Finally, the study results found that age, family type, work status, number of children ever-born, caste, religion, place of residence, distance to health facility, and presence of pregnancy complications did not change male partner attendance. Overall at the national level controlling for all other factors, age, family type, work status, and number of children ever-born had no association with male partner attendance in antenatal care. This outcome is contrary to that of earlier studies which show that older men (Singh & Ram, 2009), those with fewer children (Craymah, Oppong, & Tuoyire, 2017; Mersha, 2018), and those that lived in nuclear families (Jungari & Paswan, 2019b; Singh & Ram, 2009) were more likely to accompany their wives to antenatal care visits. Furthermore, my results also show that caste and religion do not influence male partner attendance when all other factors are controlled for, and when you are looking at the

national level. The presence of pregnancy complications having no significant association with male partner attendance is an important finding, as it points to the fact that men's attendance in antenatal care is not dependent on high-risk or complicated pregnancies. Further, the study also finds conflicting results regarding the place of residence (rural/urban). Prior research points to an association between place of residence and male partner attendance (Bishwajit et al., 2017; Mersha, 2018), explained by the perspective that men living in urban areas would have higher socio-economic status, better literacy and thus would be more involved in maternal care. However, the results of this study show that that controlling for all other factors, residence in rural or urban areas was not significantly associated with male partner attendance. This finding takes on added importance as none of the previous studies in India have included place of residence as a potential predictor of male partner attendance.

While place of residence does not emerge as an important factor influencing male partner attendance, it is interesting to note that region emerges as an important predictor. According to the study results, male partner attendance was significantly lower in Northern, Central, North-eastern and Western regions in comparison to the Southern region. Additionally, the Central and North-Eastern regions had the lowest levels of women who reported that their partners were present during antenatal care contacts, both in 2015 and 2005. These results could be partly explained by the lack of education (NSO, 2019), overall limited access to healthcare services, and gender inequality in these regions. According to recent estimates, central, eastern, and North-Eastern regions show some of the worst indicators in terms of maternal health service utilization (Ali, Dhillon, & Mohanty, 2019). Further research should be undertaken to understand the cultural and

social contexts in these regions that may present barriers to male partner attendance in antenatal care.

Limitations

The current paper in this dissertation has some limitations. Firstly, there has been considerable debate on the lack of standard methods to measure men's participation in maternal health (Jungari & Paswan, 2019a). This dissertation is limited to the questions regarding male partner attendance that have been asked in the NFHS survey. The variable on male attendance in antenatal care was asked in the form of a yes/no question for *at least* one antenatal care contact, and thus I will not be able to account for male partner attendance for multiple antenatal care contacts or sustained male involvement. Second, the National Family and Health Survey data included questions on male attendance in antenatal care only from the third round of the survey; thus, I was only able to assess change in male partner attendance for 2005 and 2015, and cannot understand the trends in male participation prior to that time period. Due to limitations of the data, I could not account for the influence of prevalent gender roles and norms, as well as health system level factors such as harsh treatment from health providers, which might impede male partner attendance in antenatal care. Furthermore, it is important to consider the potential for social desirability bias which could lead to an overestimation of report of male partner attendance. Finally, due to the survey's limitations, this dissertation only includes understanding health behavior among partners of a specific gender. It focuses on women as primary childbearing individuals, excluding persons of other genders who may be childbearing individuals (trans men).

Implications for theory, policy, and practice

Despite these limitations, the study findings contribute to the literature by documenting the levels of male partner attendance in antenatal care in India, and provides an understanding of the multiple influences that shape male partners' attendance in antenatal care. Currently, the majority of the RMNCH (Reproductive, Maternal, Newborn and Child Health) policies and programs in India have had an exclusive focus on women, keeping male partners outside the scope of these interventions (Barua et al., 2004; Comrie-Thomson et al., 2015; Lim et al., 2010). However, a holistic approach that includes working with individuals, families, and communities can be key to ensuring that women have access to optimum care during pregnancy, childbirth and the postpartum period (World Health Organization, 2010). Thus, the findings reported here are particularly useful for policymakers and health workers to inform interventions that engage with men, both as individuals as well as being situated within the family/household and community.

In particular, these results highlight the need for interventions that focus on education and information dissemination regarding maternal care, birth preparedness and pregnancy-related complications. Provisioning of information resources, mass-media campaigns, and workshops on counselling both men as well as couples within communities can be useful strategies in this regard. Community participation and mobilization should be acknowledged as another key aspect of interventions aimed at improving male partner attendance. For instance, having dialogue, particularly with women within communities, should be an important component of designing and implementing such interventions. Furthermore, community health workers and social

workers play an essential role in forming sustainable partnerships with community-based organizations and in engaging with men within these communities.

This dissertation's findings also bring attention to the influence of socio-cultural factors such as women's level of autonomy within the household and the practice of child marriage. These indicate the need for stricter implementation of laws regarding child marriage, and increased awareness on the negative social and health consequences of early and child marriage. Further, the study results show a positive and reinforcing effect of higher levels of women's autonomy on male partner attendance. These results suggest that policies aimed at women's empowerment are important not only to improve women's bargaining power and decision making within the household, but also could lead to increased involvement of male partners. That said, future research should be undertaken to understand how the effect of women's autonomy on male partner attendance varies across social, economic and regional contexts.

As one of the first studies that examines trends in male partner attendance in India at a national and regional level, this study also serves as a primer for similar research in India and other low- and middle-income countries. Further qualitative research can provide a more in-depth understanding of the regional variations in male partner attendance. It can explore the cultural and region-specific factors that might shape this. The study findings also show a rising trend in levels of male partner attendance in India, indicating a possible change in cultural norms and values surrounding men's involvement in maternal care. Future rounds of the NFHS data can be useful to examine the trajectory of these trends. Additionally, while I have focused on male partner attendance in antenatal care as a predictor of maternal health service utilization, this may exclude other

aspects of male involvement in maternal care. Future investigations should focus on exploring a more composite measure of male involvement, including aspects such as provisioning of financial support, arranging transportation and presence at delivery and postpartum care. Apart from the structural and socio-economic barriers to male partner attendance in antenatal care, there could be many factors that shape men’s perceived need to be involved. Thus, future research should explore male partners' perception of attendance in antenatal care, particularly their experiences of negotiating prevalent gender norms and receiving health workers' treatment.

Table 2.1 Utilization of antenatal care (ANC), NFHS-3, 2005-06 and NFHS-4, 2015-16

	2005-06 (N= 16, 383)		2015-16 (N= 23,906)	
State[a]	**Zero ANC contacts**	**At least one ANC contact**	**Zero ANC contacts**	**At least one ANC contact**
India	**21.85**	**78.15**	**14.48**	**85.52**
Andhra Pradesh	5.34	94.66	1.86	98.14
Assam	24.76	75.24	8.14	91.86
Bihar	69.83	30.17	41.92	58.08
Goa	1.98	98.02	2.66	97.34
Gujarat	11.66	88.34	13.44	86.56
Haryana	8.77	91.23	17.49	82.51
Himachal Pradesh	11.38	88.62	6.14	93.86
Jammu	16.37	83.63	7.23	92.77
Karnataka	10.04	89.96	9.43	90.57
Kerala	0.00	100.00	0.64	99.36
Madhya Pradesh	22.28	77.72	22.00	78.00
Maharashtra	7.27	92.73	6.88	93.12
Manipur	12.19	87.81	9.86	90.14
Meghalaya	31.93	68.07	11.73	88.27
Mizoram	26.17	73.83	13.24	86.76
Nagaland	43.84	56.16	57.50	42.50
Orissa	12.47	87.53	4.93	95.07
Punjab	8.66	91.34	1.83	98.17
Rajasthan	25.25	74.75	13.28	86.72
Tamil Nadu	1.18	98.82	7.64	92.36
West Bengal	6.98	93.02	7.47	92.53
Uttar Pradesh	34.83	65.17	24.70	75.30
New Delhi	8.88	91.12	3.51	96.49
Arunachal Pradesh	39.52	60.48	39.98	60.02

Tripura	19.82	80.18	7.35	92.65
Uttaranchal	24.24	75.76	16.02	83.98
Sikkim	11.10	88.90	2.56	97.44
Jharkhand	41.67	58.33	21.39	78.61
Chhattisgarh	11.82	88.18	3.80	96.20
Regions				
North	18.10	81.90	10.64	89.36
Central	29.48	70.52	21.68	78.32
East	34.58	65.42	21.67	78.33
North-East	25.16	74.84	10.58	89.42
West	8.85	91.15	9.74	90.26
South	5.09	94.91	5.41	94.59

[a]NFHS-3 only has data available for 28 states and Delhi. Thus, in order to maintain consistency, prevalence of male partner attendance is presented for these states.

Table 2.2 Trends in male partner attendance in antenatal care based on women's report, NFHS-3, 2005-06 and NFHS-4, 2015-16

	2005-06[a] (N= 13,488)		**2015-16 (N= 20, 177)**	
State	**Male partner not present**	**Male partner present**	**Male partner not present**	**Male partner present**
India	**34.4**	**65.6**	**14.65**	**85.35**
Andhra Pradesh	24.26	75.74	13.89	86.11
Assam	33.60	66.40	17.87	82.13
Bihar	28.19	71.81	18.76	81.24
Goa	13.83	86.17	9.37	90.63
Gujarat	28.77	71.23	14.62	85.38
Haryana	38.32	61.68	10.57	89.43
Himachal Pradesh	16.81	83.19	10.95	89.05
Jammu	25.08	74.92	9.28	90.72
Karnataka	27.32	72.68	16.54	83.46
Kerala	6.95	93.05	5.19	94.81
Madhya Pradesh	36.43	63.57	18.67	81.33
Maharashtra	35.43	64.57	14.68	85.32
Manipur	44.31	55.69	20.21	79.79
Meghalaya	55.76	44.24	37.76	62.24
Mizoram	56.70	43.30	41.20	58.80
Nagaland	36.26	63.74	33.82	66.18
Orissa	35.33	64.67	9.63	90.37
Punjab	30.80	69.20	10.21	89.79
Rajasthan	39.26	60.74	19.25	80.75
Tamil Nadu	15.59	84.41	7.68	92.32
West Bengal	42.47	57.53	8.02	91.98

Uttar Pradesh	49.67	50.33	23.17	76.83
New Delhi	16.68	83.32	12.81	87.19
Arunachal Pradesh	19.11	80.89	24.32	75.68
Tripura	18.02	81.98	4.37	95.63
Uttaranchal	19.79	80.21	13.79	86.21
Sikkim	43.15	56.85	6.61	93.39
Jharkhand	31.07	68.93	18.52	81.48
Chhattisgarh	43.28	56.72	9.95	90.05
Regions				
North	33.21	66.79	13.85	86.15
Central	45.17	54.83	20.18	79.82
East	37.27	62.73	12.6	87.40
North-East	34.77	65.23	18.51	81.49
West	32.85	67.15	14.52	85.48
South	20.97	79.03	11.09	88.91

[a]NFHS-3 only has data available for 28 states and Delhi. Thus, in order to maintain consistency, prevalence of male partner attendance is presented for these states.

Table 2.3. Characteristics of male respondents based on male partner attendance in antenatal care (N=18,890)

	Male partner not present (%)	Male partner present (%)	Full sample (%)
Male partner attendance in antenatal care	14.83	85.17	100
Individual level variables (Men's questionnaire)			
Male respondent's educational level			
No formal Education	17.80	11.77	12.67
Primary	17.39	13.63	14.19
Secondary	54.16	57.11	56.67
Higher	10.65	17.49	16.48
Male respondent's religion			
Hindu	82.22	82.16	82.17
Muslim	13.12	12.61	12.68
Others	4.66	5.23	5.15
Male respondent's caste			
Scheduled Castes (SC)	21.73	20.65	20.81
Scheduled Tribe (ST)	11.97	10.84	11.01
Other Backward Classes (OBC)	47.09	44.45	44.84
General	19.21	24.06	23.34
Male Respondent's age			
15-24 years	9.52	8.45	8.61
25 years and above	90.48	91.55	91.39
Male respondent's Age at marriage			
Less than 18 years	10.20	6.08	6.69
18 years and older	89.80	93.92	93.31
Family Type			
Joint	41.36	43.69	43.34
Nuclear	58.64	56.31	56.66
Work status			
Unemployed	6.00	6.72	6.62
Currently employed	94.00	93.28	93.38
Male respondent's Mean Knowledge of pregnancy complications	1.33 (1.33)	1.62 (1.35)	1.58 (1.35)
Individual level variables (Women's questionnaire)			
Number of children ever born (Women's questionnaire)			
None	29.70	35.04	34.25
At least one child	70.30	64.96	65.75
Complications during pregnancy (Women's questionnaire)			

No	58.86	57.94	58.07
Yes	41.14	42.06	41.93
Women's Autonomy (Mean, SD)	2.36 (1.08)	2.58 (1.05)	2.55 (1.06)
Household level variables			
Household Wealth Index			
Poorest	23.84	15.65	16.86
Poorer	23.03	18.59	19.25
Middle	21.62	21.66	21.65
Richer	17.74	21.76	21.17
Richest	13.77	22.34	21.07
Place of residence			
Urban	28.84	36.50	35.37
Rural	71.16	63.50	64.63
Region			
North	13.28	13.94	13.84
Central	30.88	21.23	22.66
East	17.36	20.05	19.65
North-East	4.25	3.31	3.45
West	17.49	17.61	17.59
South	16.75	23.85	22.80
Distance to health facility			
Not a problem	68.07	72.89	78.18
Big problem	31.93	27.11	27.82

Table 2.4. Multivariable logistic regression results for factors predicting male partner attendance in antenatal care: Odds Ratios (AOR) (95% Confidence Interval)

	Model I Male partner attendance N= 18,868		Model II Male partner attendance (adjusted for women's autonomy) N= 18,868	
	OR	CI	OR	CI
Individual level variables (Men's questionnaire)				
Male respondent's educational level (ref: No formal education)				
Primary	1.10	(0.90 - 1.34)	1.09	(0.90 - 1.33)
Secondary	1.27***	(1.07 - 1.50)	1.26**	(1.07 - 1.49)
Higher	1.56***	(1.19 - 2.05)	1.53**	(1.17 - 1.99)
Male respondent's religion (ref: Hindu)				
Muslim	0.99	(0.81 - 1.20)	1.01	(0.83 - 1.24)
Others	0.94	(0.68 - 1.31)	0.93	(0.67 - 1.30)
Male respondent's caste (ref: General)				
Scheduled Castes (SC)	1.14	(0.95 - 1.37)	1.13	(0.94 - 1.36)
Scheduled Tribe (ST)	0.91	(0.78 - 1.06)	0.92	(0.79 - 1.07)
Other Backward Classes (OBC)	1.08	(0.88 - 1.32)	1.09	(0.89 - 1.33)
Male Respondent's age (ref: 25 years and above)				
15-24 years	0.99	(0.81 - 1.22)	0.96	(0.78 - 1.18)
Male respondent's Age at marriage (Less than 18 years)				
18 years and older	1.37***	(1.15 - 1.63)	1.35**	(1.14 - 1.61)
Family Type (ref: Joint)				
Nuclear	1.07	(0.94 - 1.21)	1.03	(0.90 - 1.16)
Male respondent's Work status (ref: Unemployed)				
Currently employed	0.92	(0.73 - 1.16)	0.90	(0.71 - 1.13)
Male respondent's Knowledge of pregnancy complications	1.13***	(1.08 - 1.18)	1.13***	(1.08 - 1.18)
Individual level variables (Women's questionnaire)				
Number of children ever-born (ref: None)	0.95	(0.82 - 1.11)	0.95	(0.82 - 1.10)
At least one child				
Complications during pregnancy (ref: No)	1.07	(0.95 - 1.19)	1.06	(0.95 - 1.19)
Yes				
Female (Spouse) respondent's Level of autonomy			1.16***	(1.08 - 1.23)
Household level variables				
Household Wealth Index (ref: Poorest)				
Poorer	1.13	(0.97 - 1.33)	1.13	(0.96 - 1.32)
Middle	1.31**	(1.10 - 1.56)	1.29**	(1.08 - 1.54)
Richer	1.51***	(1.23 - 1.87)	1.48***	(1.20 - 1.84)

Richest	1.87***	(1.43 - 2.44)	1.79***	(1.37 - 2.34)
Place of residence (ref: Urban)				
Rural	0.96	(0.82 - 1.12)	0.97	(0.82 - 1.14)
Region (ref: South)				
North	0.69**	(0.56 - 0.86)	0.70**	(0.56 - 0.86)
Central	0.58***	(0.48 - 0.70)	0.59***	(0.49 - 0.71)
East	1.01	(0.82 - 1.26)	1.04	(0.83 - 1.29)
North-East	0.59***	(0.46 - 0.76)	0.58***	(0.45 - 0.75)
West	0.65**	(0.51 - 0.84)	0.67**	(0.52 - 0.86)
Distance to health facility (ref: Not a problem)				
Big problem	0.93	(0.81 - 1.08)	0.95	(0.82 - 1.09)
Constant	3.15***	(2.01 - 4.94)	2.36***	(1.48 - 3.77)
Pseudo R^2	0.046		0.047	

***p<0.001, ** p<0.01, * p<0.05

Figure 7. Trends in male partner attendance in India using data from National Family Health Survey (NFHS-3 2005-06)

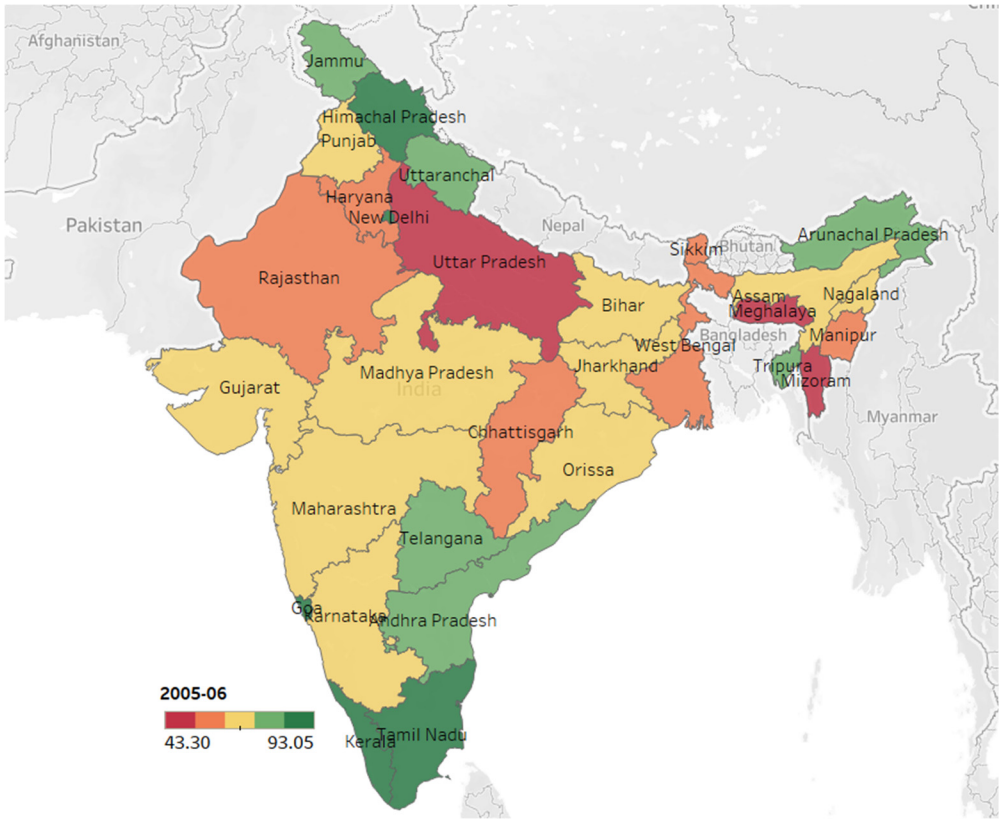
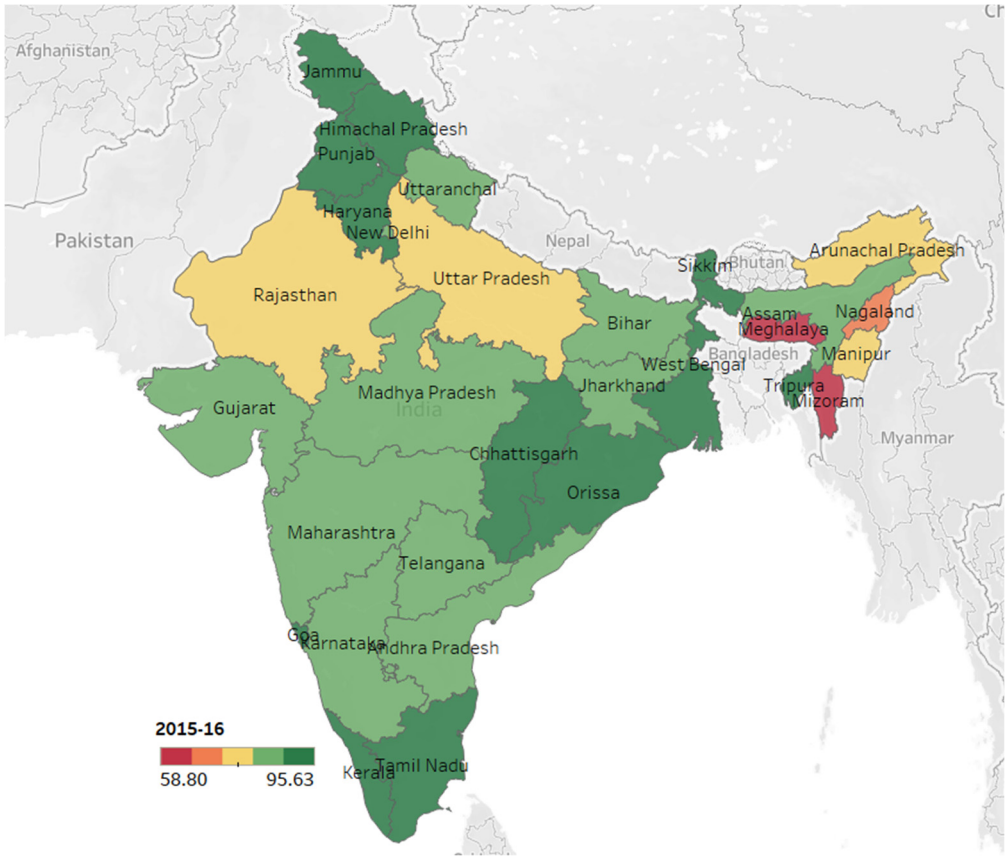


Figure 8. Trends in male partner attendance in India using data from National Family Health Survey (NFHS-4 2015-16)



Supplemental Table 1. Prevalence of male partner attendance in antenatal care based on men's report, NFHS-3, 2005-06 and NFHS-4, 2015-16

	2005-06 (N=10, 009)		2015-16 (N=16, 109)	
State	Male partner not present	Male partner present	Male partner not present	Male partner present
India	**24.6**	**75.4**	**20.13**	**79.87**
Andhra Pradesh	24.82	75.18	26.57	73.43
Assam	27.81	72.19	26.28	73.72
Bihar	23.07	76.93	31.12	68.88
Goa	12.47	87.53	3.09	96.91
Gujarat	19.91	80.09	15.8	84.2
Haryana	37.43	62.57	13.61	86.39
Himachal Pradesh	20.46	79.54	19.12	80.88
Jammu	11.84	88.16	9.1	90.9
Karnataka	21.46	78.54	12.77	87.23
Kerala	8.79	91.21	9.59	90.41
Madhya Pradesh	28.99	71.01	28.9	71.1
Maharashtra	17.95	82.05	13.09	86.91
Manipur	38.91	61.09	25.81	74.19
Meghalaya	45.22	54.78	49.51	50.49
Mizoram	50.78	49.22	56.29	43.71
Nagaland	22.26	77.74	27.65	72.35
Orissa	19.75	80.25	13.19	86.81
Punjab	25.51	74.49	13.83	86.17
Rajasthan	32.53	67.47	16.85	83.15
Tamil Nadu	19.51	80.49	9.78	90.22
West Bengal	29.19	70.81	27.24	72.76
Uttar Pradesh	32.42	67.58	29.16	70.84
New Delhi	18.57	81.43	20.26	79.74
Arunachal Pradesh	18.32	81.68	19.76	80.24

Tripura	22.19	77.81	27.89	72.11
Uttaranchal	13.64	86.36	21.26	78.74
Sikkim	28.86	71.14	6.2	93.8
Jharkhand	10.78	89.22	17.41	82.59
Chhattisgarh	30.99	69.01	15.65	84.35
Region				
North	28.09	71.91	15.46	84.54
Central	31.07	68.93	27.07	72.93
East	24.28	75.72	23.75	76.25
North-East	29.49	70.51	28.23	71.77
West	18.58	81.42	14.04	85.96
South	20.66	79.34	16.48	83.52

Supplementary Table 2 Multivariable logistic regression results for factors predicting male partner attendance in antenatal care: Odds Ratios (OR) (95% Confidence Interval) (Model I with separate components of women's autonomy, and Model II including the additional interaction term of women's autonomy with household wealth index)

	Model I Male partner attendance N = 18.868		Model II Male partner attendance N = 18.868	
	OR	CI	OR	CI
Individual level variables (Men's questionnaire)				
Male respondent's educational level (ref: No formal education)				
Primary	1.08	(0.89 - 1.32)	1.09	(0.90 - 1.33)
Secondary	1.24*	(1.05 - 1.47)	1.25**	(1.06 - 1.48)
Higher	1.49**	(1.14 - 1.95)	1.50**	(1.15 - 1.94)
Male respondent's religion (ref: Hindu)				
Muslim	1.01	(0.83 - 1.24)	1.02	(0.84 - 1.25)
Others	0.94	(0.67 - 1.31)	0.93	(0.67 - 1.30)
Male respondent's caste (ref: General)				
Scheduled Castes (SC)	1.12	(0.93 - 1.35)	1.13	(0.94 - 1.36)
Scheduled Tribe (ST)	0.92	(0.79 - 1.07)	0.92	(0.79 - 1.07)
Other Backward Classes (OBC)	1.09	(0.89 - 1.33)	1.08	(0.88 - 1.33)
Male Respondent's age (ref: 25 years and above)				
15-24 years	0.95	(0.781 - 1.175)	0.963	(0.786 - 1.180)
Male respondent's Age at marriage (Less than 18 years)				
18 years and older	1.35**	(1.13 - 1.60)	1.36***	(1.14 - 1.62)
Family Type (ref: Joint)				
Nuclear	1.02	(0.90 - 1.16)	1.02	(0.90 - 1.16)
Male respondent's Work status (ref: Unemployed)				
Currently employed	0.90	(0.71 - 1.13)	0.90	(0.71 - 1.14)
Male respondent's Knowledge of pregnancy complications	1.13***	(1.08 - 1.18)	1.13***	(1.08 - 1.18)
Individual level variables (Women's questionnaire)				
Number of children ever-born (ref: None)				
At least one child	0.96	(0.82 - 1.11)	0.95	(0.82 - 1.10)
Complications during pregnancy (ref: No)				
Yes	1.06	(0.95 - 1.19)	1.06	(0.95 - 1.19)
Female (Spouse) respondent's Level of autonomy				
			1.03	(0.93 - 1.14)
Household level variables				
Household Wealth Index (ref: Poorest)				
Poorer	1.13	(0.97 - 1.33)	1.09	(0.74 - 1.60)

Middle	1.28**	(1.08 - 1.53)	0.94	(0.63 - 1.39)
Richer	1.48***	(1.19 - 1.83)	0.88	(0.56 - 1.39)
Richest	1.77***	(1.36 - 2.32)	0.98	(0.46 - 2.06)
Interaction of household wealth with level of autonomy (ref: Poorest)				
Poorer*autonomy			1.02	(0.87 - 1.18)
Middle*autonomy			1.14	(0.99 - 1.33)
Richer*autonomy			1.24**	(1.05 - 1.47)
Richest*autonomy			1.28	(0.97 - 1.69)
Place of residence (ref: Urban)				
Rural	0.96	(0.82 - 1.13)	0.981	(0.834 - 1.153)
Region (ref: South)				
North	0.71**	(0.57 - 0.88)	0.70**	(0.57 - 0.87)
Central	0.59***	(0.49 - 0.71)	0.60***	(0.50 - 0.72)
East	1.06	(0.85 - 1.32)	1.04	(0.84 - 1.29)
North-East	0.58***	(0.45 - 0.75)	0.59***	(0.46 - 0.76)
West	0.68**	(0.53 - 0.87)	0.67**	(0.52 - 0.86)
Distance to health facility (ref: Not a problem)				
Big problem	0.95	(0.82 - 1.09)	0.95	(0.83 - 1.09)
Components of women's autonomy[a]				
Financial autonomy (ref: No)				
Yes	1.24***	(1.10 - 1.39)		
Movement autonomy (ref: Not allowed at all)				
Allowed to go out accompanied	1.08	(0.88 - 1.33)		
Allowed to go out alone	1.12	(0.90 - 1.38)		
Decision-making autonomy (ref: No)				
Yes	1.31***	(1.15 - 1.49)		
Constant	2.38***	(1.46 - 3.88)	3.03***	(1.82 - 5.02)

***p<0.001, ** p<0.01, * p<0.05

[a]Women's autonomy was constructed as a score covering the following components: financial autonomy, decision making autonomy and movement autonomy. Financial autonomy is based on questions on whether the respondent has money that they alone can use, and whether they have a bank account. Movement autonomy is based on questions on whether the respondent is allowed to go to the market, health facility or to go outside the village/community. Decision making autonomy is based on questions on whether the respondent makes decisions regarding healthcare, major household purchases and the decision to visit family or relatives.

Supplementary Table 3. Multivariable logistic regression results for factors predicting male partner attendance in antenatal care: Odds Ratios (OR) (95% Confidence Interval) (Model I including male respondent's occupation type, and Model II including categorization of formal vs. informal sector)

	Model I Male partner attendance N = 18.868		Model II Male partner attendance N = 18.868	
	OR	CI	OR	CI
Individual level variables (Men's questionnaire)				
Male respondent's educational level (ref: No formal education)				
Primary	1.11	(0.91 - 1.35)	1.11	(0.91 - 1.35)
Secondary	1.26**	(1.07 - 1.50)	1.27**	(1.08 - 1.51)
Higher	1.48**	(1.12 - 1.94)	1.53**	(1.17 - 2.00)
Male respondent's religion (ref: Hindu)				
Muslim	0.99	(0.81 - 1.20)	1.00	(0.82 - 1.22)
Others	0.96	(0.70 - 1.32)	0.96	(0.69 - 1.32)
Male respondent's caste (ref: General)				
Scheduled Castes (SC)	1.14	(0.95 - 1.36)	1.13	(0.94 - 1.36)
Scheduled Tribe (ST)	0.91	(0.78 - 1.06)	0.91	(0.78 - 1.06)
Other Backward Classes (OBC)	1.07	(0.88 - 1.31)	1.07	(0.88 - 1.31)
Male Respondent's age (ref: 25 years and above)				
15-24 years	0.99	(0.81 - 1.22)	0.99	(0.81 - 1.22)
Male respondent's Age at marriage (Less than 18 years)				
18 years and older	1.38***	(1.16 - 1.64)	1.38***	(1.16 - 1.64)
Family Type (ref: Joint)				
Nuclear	1.07	(0.94 - 1.21)	1.08	(0.95 - 1.22)
Male respondent's Work status (ref: Unemployed)				
Business	1.06	(0.81 - 1.38)		
Agriculture	0.92	(0.72 - 1.17)		
Services	0.98	(0.72 - 1.33)		
Manual	0.85	(0.66 - 1.09)		
Male respondent's Work status (ref: Formal sector work)				
Informal sector work			0.88**	(0.77 – 1.00)
Male respondent's Knowledge of pregnancy complications	1.14***	(1.09 - 1.18)	1.14***	(1.09 - 1.18)
Individual level variables (Women's questionnaire)				
Number of children ever-born (ref: None)				
At least one child	0.96	(0.82 - 1.11)	0.95	(0.82 - 1.11)
Complications during pregnancy (ref: No)				
Yes	1.07	(0.96 - 1.20)	1.07	(0.96 - 1.20)
Household level variables				

Household Wealth Index (ref: Poorest)				
Poorer	1.13	(0.97 - 1.33)	1.14	(0.98 - 1.33)
Middle	1.30**	(1.09 - 1.55)	1.32**	(1.10 - 1.57)
Richer	1.49***	(1.21 - 1.85)	1.52***	(1.23 - 1.88)
Richest	1.80***	(1.37 - 2.36)	1.85***	(1.42 - 2.41)
Place of residence (ref: Urban)				
Rural	0.96	(0.82 - 1.13)	0.94	(0.80 - 1.10)
Region (ref: South)				
North	0.70**	(0.57 - 0.87)	0.71**	(0.57 - 0.88)
Central	0.59***	(0.49 - 0.70)	0.59***	(0.49 - 0.71)
East	1.02	(0.82 - 1.26)	1.03	(0.83 - 1.28)
North-East	0.59***	(0.46 - 0.76)	0.60***	(0.47 - 0.76)
West	0.66**	(0.52 - 0.85)	0.66**	(0.52 - 0.85)
Distance to health facility (ref: Not a problem)				
Big problem	0.94	(0.82 - 1.08)	0.94	(0.81 - 1.08)
Constant	3.26***	(2.08 - 5.10)	3.13***	(2.07 - 4.73)

***p<0.001, ** p<0.01, * p<0.05

Chapter III. The role of male partners in maternal health service utilization: a secondary analysis using 2015-16 National Family Health Survey (NFHS) data

Background

According to 2017 World Health Organization estimates, approximately 810 deaths occur each day due to pregnancy and childbirth complications (World Health Organization, 2019). Developing countries bear a disproportionately high burden of maternal deaths, with about 99% of pregnancy-related deaths occurring in these countries. Despite considerable declines in India's maternal mortality rate over the past decade (RGI, 2018), data show that India and Nigeria still accounted for over one-third of estimated global maternal deaths (World Health Organization, 2017).

Prior research has shown that one of the key strategies for reducing maternal deaths is through the provisioning of quality care during pregnancy and childbirth. This includes providing comprehensive antenatal care, skilled birth attendance and access to emergency obstetric care (Campbell & Graham, 2006; Kesterton, Cleland, Sloggett, & Ronsmans, 2010a; Sunil et al., 2006; Paina et al., 2016; Sharma, Jones, Loxton, Booth, & Smith, 2018). Over the past decade, India has seen a rapid increase in skilled birth attendance and antenatal care utilization; for instance, utilization of complete antenatal care increased from 12% in 2005–06 to 20% in 2015–16, and Skilled Attendance at Birth (SBA) increased from 47% to 81% over the same period (Ali et al., 2019). Despite these increases, India is far from achieving universal antenatal coverage and access to institutional delivery for all women. There also exist considerable variations in utilization based on education levels, household wealth, and across regions (Pathak, Singh, & Subramanian, 2010; Singh, Rai, & Kumar, 2013).

The determinants of maternal health service utilization in India have been extensively examined. Studies have found that at the individual level, higher education, accumulation of wealth in the household, exposure to mass media, being upper caste and Hindu, living in an urban residence and being visited by a health worker were all associated with increased odds of maternal health service utilization. Additionally, women who were older, and those married at 18 years and older were more likely to access maternal health services (Pallikadavath et al., 2004; Sunil et al., 2006; Jat et al., 2011; Ogbo et al., 2019; Paul & Chouhan, 2019). Some studies also showed that decision making autonomy and factors indicative of financial autonomy, such as awareness and participation in microcredit programs and ownership of a bank account, were associated with higher odds of maternal health service utilization (Mistry et al., 2009; Dehingia et al., 2019; Singh et al., 2019). Further, at the household and community level, women living in nuclear households, and women who reported male involvement in maternal care were more likely to access maternal health services (Saikia & Singh, 2009; Speizer et al., 2015). Additionally, husbands' knowledge of pregnancy complications was also associated with maternal health service utilization (Jungari & Paswan, 2019; Chattopadhyay, 2012; Khan et al., 2004). Apart from these, broader structural factors such as cultural acceptability of institutional delivery (Patel, Das, & Das, 2018) and policy level factors such as the introduction of the *Janini Suraksha Yojana (JSY)* Scheme were found to impact the uptake of maternal health services (Rahman & Pallikadavath, 2018). Most research in this area has focused on the socio-economic and policy level determinants of maternal health service utilization, with limited attention to the role of partners and family. Only one Indian study used national level data from the NFHS 2005

survey to examine the association between male partner attendance and women's health service utilization (Chattopadhyay, 2012).

There is now a growing body of literature that recognizes the positive role of male involvement in maternal care. Studies have shown that male involvement in maternal care is associated with increased odds of antenatal care attendance, facility birth, skill birth attendance, postpartum care, breastfeeding initiation, and decreased odds of maternal depression (Mohammed, Johnston, Vackova, Hassen, & Yi, 2019; Tokhi et al., 2018; Yargawa & Leonardi-Bee, 2015; Teklesilasie & Deressa, 2018). A systematic review of research that focused on male partner attendance in antenatal care found that it was associated with increased odds of skilled birth attendance, institutional delivery and postpartum visits, while it had no significant impact on the number of antenatal visits (Suandi et al., 2019).

While recent research in India has delved into the factors that influence male involvement in maternal care (Jungari & Paswan, 2019a, 2019b), the effect of this involvement on maternal health service utilization has not been adequately explored. Only two studies in India examined the impact of male involvement on service utilization and health outcomes. A randomized controlled trial conducted by the Population Council in New Delhi found that following an intervention involving counselling of male partners on sexual and reproductive health issues, there was an increase in early initiation of breastfeeding and improved family planning practices (Varkey et al., 2004). Another study that used national level data found that male partner attendance in antenatal care and improved knowledge of pregnancy related complications was associated with increased odds of women having institutional delivery by 35% (Chattopadhyay, 2012).

Gap in literature:

Studies from low- and middle-income countries conclude that while there is some evidence of a positive impact of male involvement on maternal health outcomes and service utilization, there is considerable regional variation in these results and the magnitude of the association is unclear (Tokhi et al., 2018). Limited studies in India have examined male involvement in maternal care; and, only one study uses nationally representative data from NFHS survey 2005 to examine the association between male partner attendance and maternal health service utilization focusing on three states (Uttar Pradesh, Maharashtra, West Bengal) (Chattopadhyay, 2012). Moreover, none of the previous research in India that examined the association between male partner attendance and maternal health service utilization provides a nuanced understanding of how this relationship varies by region and place of residence, despite studies documenting that geographical region and place of residence both play a crucial role in determining access to maternal health service utilization (Pathak, Singh, & Subramanian, 2010; Singh, Rai, & Kumar, 2013). Informed by the *social-ecological model*, the current study attempts to understand the effect of male partner attendance on maternal health service utilization using the latest round of the National Family Health Survey (NFHS-4) 2015-16.

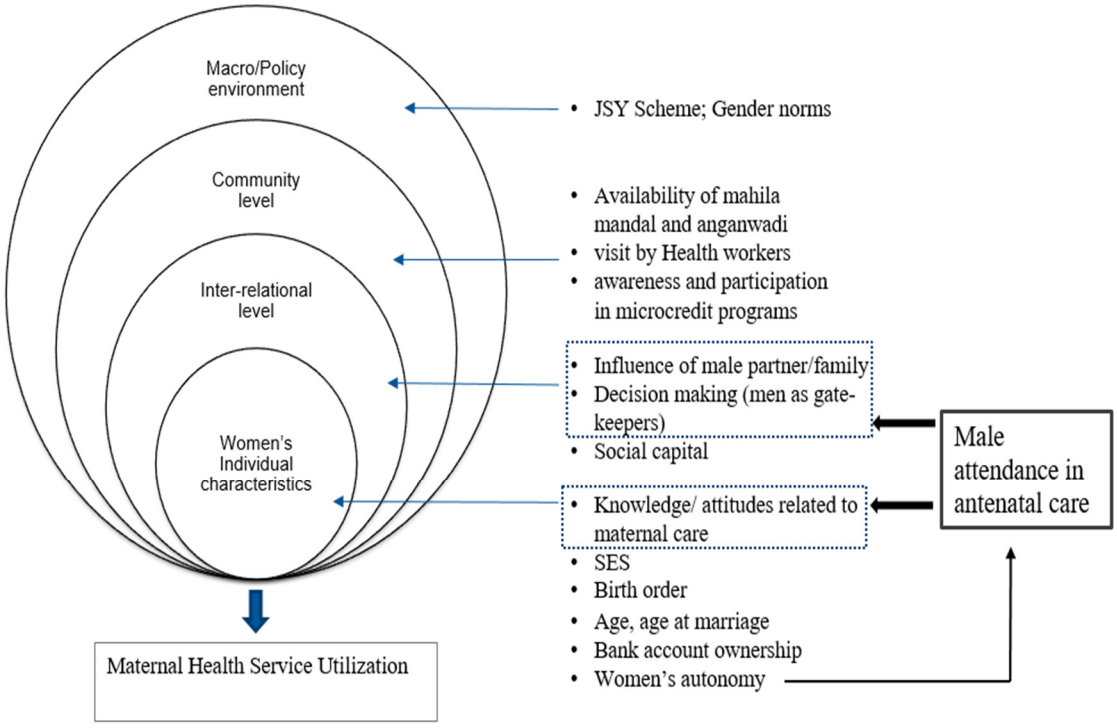
Theoretical frameworks

Numerous studies have used the *Social Ecological Model* proposed by Bronfenbrenner (1977), as a framework to examine maternal health service utilization (Antai & Adaji, 2012; Kaiser et al., 2019; Shahabuddin et al., 2017). According to *Social Ecological Model* (Bronfenbrenner, 1977), multiple systems influence an individual's development and behavior; these may range from systems that directly affect the

individual such as family or peer relationships, to those that may have a more indirect effect, such as gender roles and cultural norms. For instance, maternal health service utilization is influenced by pre-disposing socio-demographic factors such as age, education, standard of living, religion, caste, place of residence, pregnancy order, and age at marriage (Jat et al., 2011; Ogbo et al., 2019; Pallikadavath et al., 2004; Paul & Chouhan, 2019; Sunil et al., 2006); interactions at the mezzo-level including women's decision making autonomy, participation in microcredit programs, availability of *Mahila Mandal* and *Anganwadi* in the community, interactions with community health workers, social capital and family type (Mistry et al., 2009; Sunil et al., 2006); as well as broader cultural and policy factors at the macro level (Rahman & Pallikadavath, 2018).

In this paper, I will utilize the Social Ecological Model as a framework to contextualize the multiple influences on women's decision making in relation to maternal health service utilization, and will examine the influence of male partner attendance in antenatal care on maternal health service utilization, controlling for other socio-demographic and geographical factors (See figure 9).

Figure 9. Social Ecological Model as a framework to examine association between male partner attendance in antenatal care and maternal health service utilization.



In addition to the Social Ecological Model, I utilize the Gender Transformative Approach as a lens to build an understanding of male partner attendance in antenatal care. A *Gender Transformative Approach* is geared towards creating a structural change that addresses the root causes of gender inequality. It involves strategies that encourage individuals, families, and communities to examine and challenge prevalent gender norms and practices (Rottach, Schuler, & Hardee, 2009). This approach gained popularity post the *1994 International Conference on Population and Development* (ICPD), which signaled a shift towards viewing sexual and reproductive health from a rights-based framework (Dworkin & Barker, 2019). This is evident from Chapter 4 of the ICPD Programme on Action which specifically calls for an understanding of "joint responsibilities, so that men and women are equal partners in public and private life" (Ki-moon, 1994, p.36).

Informed by these two theoretical frameworks, the overall aim of this paper is to answer

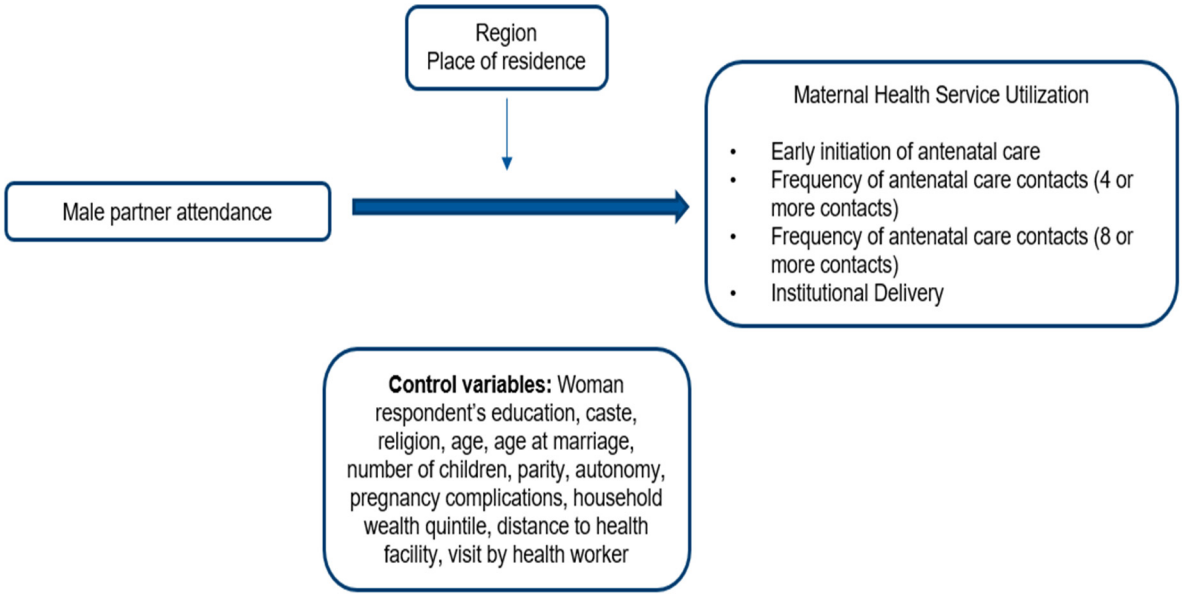
the following question: How important is male partner attendance in improving women's use of maternal health service utilization in India?

The sub-questions are:

- Is there an association between male partner attendance in antenatal care and timing and frequency of antenatal care contacts, after controlling for socio-demographic factors?
- Is there an association between male partner attendance in antenatal care and women's utilization of institutional delivery, after controlling for socio-demographic factors?
- Does place of residence (rural/urban) and region have an influence on the association between male partner attendance in antenatal care and maternal health service utilization?

I used data from the latest round of the 2015-16 National Family Health Survey (NFHS-4) to examine the association between male partner attendance and women's utilization of antenatal care and institutional delivery (see Figure 10). I also tested the interaction between male partner attendance in antenatal care and geographic factors (place of residence, region) on maternal health service utilization.

Figure 10. Diagram depicting association between male partner attendance in antenatal care and maternal health service utilization.



While examining the influence of male partner attendance on maternal health service utilization, it is vital to acknowledge that this involvement may negatively impact health-seeking behavior among some women. This is particularly important to consider for women who are in relationships involving control, coercion or sexual or physical violence. Globally, studies show that intimate partner violence (IPV) is negatively associated with maternal health service utilization (Beydoun, Tamim, Lincoln, Dooley, & Beydoun, 2011; Ononokpono & Azfredrick, 2014). This is further corroborated by findings from recent research in India, which also document that physical and sexual violence was associated with decreased odds of institutional delivery (Silverman et al., 2020). Despite this, none of the studies that examined male partner attendance and maternal health service utilization have accounted for the role of IPV in this relationship. To address this gap, this study includes a sub-analysis examining the associations

between male partner attendance and maternal health service utilization among women who reported experiencing any form of intimate partner violence.

Methods

To examine the association between male partner attendance in antenatal care and maternal health service utilization, data were used from the *National Family Health Survey (NFHS-4)* conducted in 2015-16. The NFHS-4 is a nationally representative, multi-topic survey undertaken by the International Institute for Population Sciences and Macro International (IIPS, 2017). The sampling design was a stratified two-stage sample and the 2011 census was used as the sampling frame with urban and rural samples drawn separately and proportionate to each state. The survey includes data on twenty-nine states and seven union territories. Overall, a sample of 699,686 women with a 97% response rate and a sample of 112,122 men with a 92% response rate was generated.
Further details of the survey and data collection procedure have been described in Chapter 1 of the dissertation.

Data selection

Question on male partner attendance in antenatal care was asked both in men's and women's questionnaires. Since only a subset of households was interviewed to collect data from male partners, in this paper, I have used data ***only from women's questionnaires*** to maintain a representative sample.

Sample selection for regression models examining antenatal care (early initiation of antenatal care and frequency of antenatal care contacts) and institutional delivery outcomes

In the NFHS-4 2015-16, there were 699,686 women aged 15-45 years interviewed at the time of the survey. Of these, excluding nulliparous women (those who had never

given birth) (223,067) and women who had given birth prior to five years preceding the survey (285,721), there were 190,898 women who had data available on antenatal care (timing and frequency of antenatal care contacts). Since the variable on male partner attendance in antenatal care requires women to have at least one antenatal care contact, I excluded women who reported having zero antenatal care contacts and women who had missing data on timing of antenatal care contacts (256) or frequency of antenatal care contacts (1,854). There was no missing data for the survey question on male partner attendance. Finally, women were excluded from the sample if they had missing data on caste (7,611), age at marriage (2,475), or pregnancy complications (220). The final analytic sample consisted of 144,840 women. Since missing data was less than 10% and the missing at random (MAR) assumption was not satisfied, complete case analysis approach was used to deal with the missing data (Madley-Dowd, Hughes, Tilling, & Heron, 2019). That is, the analysis was restricted only to women with complete data utilizing listwise deletion. This has been explained in the flowchart in Figure 11.

Data selection for institutional delivery outcome followed a similar process. Of the 190,797 women who had delivered within the past five years, 460 indicated their place of delivery as “other” and were excluded, leaving 190,337 for the analysis. Further, I restricted the sample to women who had data available on male partner attendance in antenatal care (158,985) and excluded those with missing data on any of the control variables: caste (9,048), age at marriage (3,131), or pregnancy complications (428). The final analytic sample consisted of 146,378 women. This has been detailed in the flowchart in Figure 12.

Figure 11. Flowchart for data selection for antenatal care outcomes

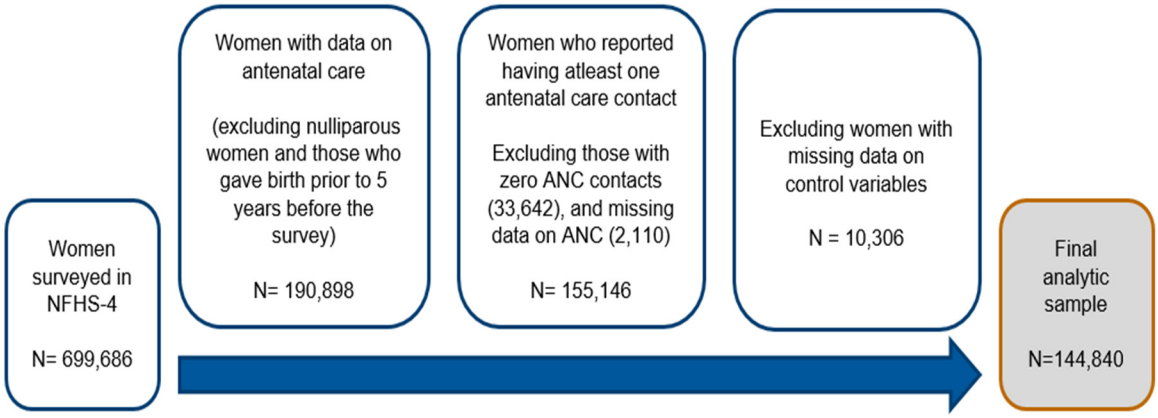
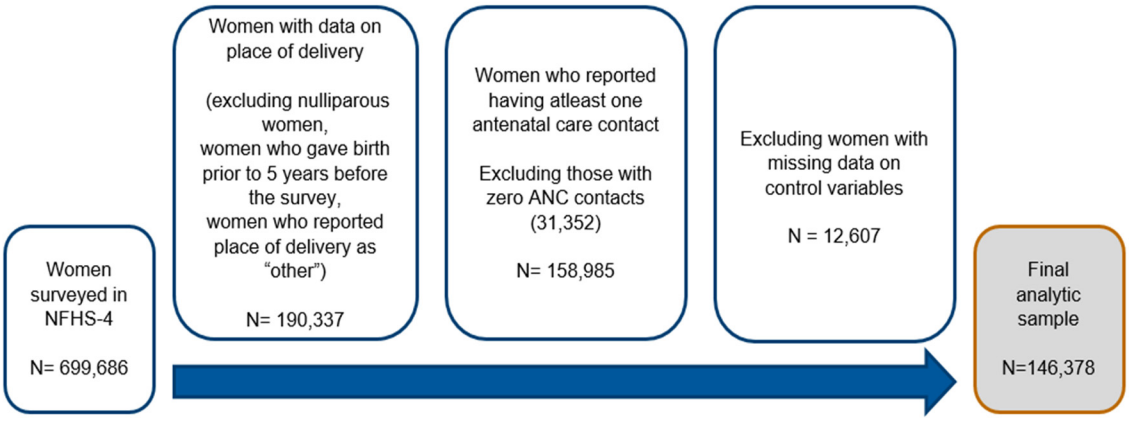


Figure 12. Flowchart for data selection for institutional delivery outcome



Sample selection for supplementary analysis including women who had zero antenatal care contacts

In an additional supplementary analysis examining the association between male partner attendance and institutional delivery, I retained the 31,352 women who reported that they had no antenatal care contacts. In this case, the independent variable on male partner attendance consisted of three categories: Zero ANC contacts; at least one ANC

contact, male partner absent; and at least one ANC contact, male partner present. The results of this analysis can be found in supplementary table 4.

Sample selection for sensitivity analysis using data on intimate partner violence

Further, to understand if intimate partner violence changed the effect of male partner attendance on antenatal care or institutional delivery, I conducted a sensitivity analysis with a sub-sample of women (79,729) who had completed the domestic violence module. In accordance with WHO ethical guidelines on the collection of data on domestic violence, only one woman per household was interviewed and the module on domestic violence was implemented only if privacy was obtained (IIPS, 2017). Of these, excluding those who had either never given birth or had a child five years prior to the survey, 25,232 women had data available on antenatal care (timing and frequency of antenatal care contacts) and 25,174 had information on institutional delivery. Women were excluded if they had zero antenatal care contacts (4,076), missing data on antenatal care (264), missing data on caste (1,140), age at marriage (263) and pregnancy complications (27) to obtain a final sub-sample of 19,462 women for the regression models examining antenatal care as the outcome. Similarly, women were excluded from the final sample if they had zero antenatal care contacts (4,062), missing data on caste (1,164), age at marriage (254) and pregnancy complications (29), leaving 19,462 women for the analysis with institutional delivery as the outcome.

Key Variables

Primary dependent variables

Timing and frequency of antenatal care: To measure *Early initiation of antenatal care*, a dichotomous variable was used based on women's timing of first antenatal care visit. Women who had their first antenatal care visit within 12 weeks of pregnancy (early initiation of antenatal care) were coded as 1 (WHO, 2016), and women who responded that they had their first antenatal care visit at 12 weeks and later were coded as 0. *Frequency of antenatal care contact* is based on the number of *antenatal care* contacts that a woman had during her pregnancy. This was recoded into two dichotomous variables - Frequency of antenatal care contacts (4 or more contacts) with two categories: Less than 4 contacts, 4 or more contacts; and, frequency of antenatal care contacts (8 or more contacts) with two categories: Less than 8 contacts, 8 or more contacts[10].

Institutional delivery: A dichotomous outcome variable was used to measure institutional delivery, based on women's choice for place of delivery. Women who delivered at a health facility (including both public and private) were coded as 1, and women who responded that they delivered at home were coded as 0.

Primary independent variable

Male partner attendance: Male partner attendance in antenatal care is recoded based on the survey question: "Was the child's father present at any antenatal care contact for your most recent child?"; women who answered yes to this question were coded as 1, otherwise as 0.

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[10] The 2016 WHO recommendation states that women should have at least 8 antenatal care contacts, with the first contact taking place in the first trimester (WHO, 2016).

Control variables

Within this analysis, I examined the relationship between male partner attendance in antenatal care and maternal health service utilization, controlling for women's socio-demographic characteristics (female respondent's education, caste, religion, age, age at marriage, number of children, parity, pregnancy complications) and household characteristics (household wealth index, place of residence, region, distance to health facility). The variable on the visit by health worker was added only for the regression model for institutional delivery as this variable only provided data on women who were visited by a health worker in the last three months of their pregnancy. Predictor variables and their operational definitions included in the analyses are detailed in Supplementary Table 14 in Appendix 1.

Statistical analyses

I conducted weighted (probability weights) descriptive statistics, bi-variate analysis, and logistic regression analysis to assess the association between male attendance in antenatal care and maternal health service utilization. Multivariable logistic regression models were constructed to estimate the relationship between the predictor variables and outcomes for the full sample. Odds Ratio (OR) and 95% confidence interval (CI) were reported. Four separate logistic regression models were used to examine the association between male partner attendance in antenatal care and each of the four outcome variables: early initiation of antenatal care, frequency of antenatal care contacts (4 or more contacts; and 8 or more contacts), and institutional delivery. The following multivariable regression model estimates the odds of maternal health service utilization, where X1 is a vector of individual characteristics (female respondent's

education, caste, religion, age, age at marriage, number of children, parity, pregnancy complications, visit by health worker), X_2 is a vector of household characteristics (household wealth index, place of residence, region, distance to health facility) and X_3 is a vector of male partner attendance in antenatal care for individual i:

$$y = \begin{cases} 0 \text{ if did not utilize maternal health service} \\ 1 \text{ if utilized maternal health service} \end{cases}$$

$$Logit\ p\ (y_i = 1) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3}$$

In the equation above, β_0 is the intercept and, β_1, and β_2 are the coefficients associated with each of covariates, β_3 is associated with the predictor variable. y_i is an indicator variable that represents log of odds of each of the outcomes of interest (Early initiation of antenatal care, Frequency of antenatal care contact, Institutional Delivery). Additionally, I also tested the moderating effects of place of residence and region on male partner attendance in antenatal care and maternal health service utilization. I used margins command to obtain the predicted probabilities of each outcome among women who reported that the male partner was present during antenatal care across regions and place of residence (urban/rural) and visually presented these using a marginsplot (see Figures 13-16).

Interaction effect (region and place of residence)

$$Logit\ p\ (y_i = 1) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 (X_{i3} * Place\ of\ residence)$$

$$Logit\ p\ (y_i = 1) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 (X_{i3} * Region)$$

As a sensitivity analysis, I replicated the multivariable regression models controlling for women's autonomy and intimate partner violence (physical violence, emotional violence

and sexual violence) among a sub-sample of women who had been interviewed for each module.

Data analyses was conducted using the statistical package Stata SE version 14.2 (Stata Corp, College Station, TX). In order to account for the complex sample design, survey weights were used to obtain representative estimates.

Research Ethics

In alignment with the ethical guidelines, permission was from Boston College Institutional Review Board (IRB) and the study was considered exempt.

Results

Table 3.1 provides an overview of the socio-demographic and geographical characteristics of the respondents. Overall, of the women who had at least one antenatal care contact, 82% reported that the male partner was present during antenatal care. Among the women who had at least one antenatal care contact, around 70% of women reported early initiation of antenatal care (at 12 weeks or less). Further, around 61% of women reported having 4 or more antenatal care contacts and around 24% women reported having 8 or more contacts. About 86% of women reported that they had delivered at a health facility. About 22% of the sample reported having no formal education, and the majority of the women were educated till secondary school level (up to 9^{th} grade). The majority of the women belonged to Hindu religion and belonged to the Other Backward Classes (OBC) caste group; and, about 40% of women belonged to households classified as being in the lowest wealth quintiles. Around three-fourths of the women were rural and a large proportion belonged to the Central, Eastern and Southern

region. The average age of the women was 27 years and most reported having either 1 or 2 children. About 34% of women reported being married before 18 years of age.

Predicting early initiation of antenatal care (commencing antenatal care at 12 weeks or less)

According to the study results (see Table 3.2, Model 1), male partner attendance in antenatal care, women's education, household wealth, region, distance to health facility, caste, number of children, age at marriage and parity were significantly associated with odds of commencing antenatal care in the first trimester. Controlling for all socio-demographic variables, the results show a significant association between male partner attendance in antenatal care and timing of first antenatal care contact. Women who reported that the male partner was present during at least one antenatal care contact were 18% more likely to report commencing antenatal care in the first trimester (OR= 1.18, 95% CI [1.13 -1.23]). Further, women who had secondary (OR= 1.15, 95% CI [1.10 - 1.21]) and higher secondary education (OR= 1.30, 95% CI [1.20 - 1.41]) were more likely to initiate antenatal care in the first trimester as compared with women who had no formal education. Women belonging to households classified as the richest had almost twice the odds (OR= 1.93, 95% CI [1.76 - 2.12]) of having their first antenatal care contact within 12 weeks of pregnancy compared to those who belonged to the poorest households. Although women's age was not associated with the timing of first antenatal care contact, age at marriage was significantly associated. Women married at 18 years and older were 8% more likely to have their first antenatal care contact within the first trimester (OR= 1.08, 95% CI [1.04 -1.12]).

In contrast, the number of children, parity, and distance to health facilities were inversely associated with the timing of the first antenatal care contact. In particular, women who reported that the distance to the health facility was a big problem were 15% less likely to have initiated antenatal care in the first trimester (OR= 0.85, 95% CI [0.81 - 0.89]). Furthermore, compared to the southern region, women belonging to all other regions had lower odds of commencing antenatal care in the first trimester. Respondent's age and place of residence (rural/urban) were not associated with the early initiation of antenatal care.

To understand if geographic factors (region and place of residence) moderated the relationship between male partner attendance and first trimester antenatal care use, I included the interaction term of these two variables. The results revealed that the effect of male partner attendance on the early initiation of antenatal care varied by region. In comparison to the Southern region, the effect of male partner attendance on early initiation of antenatal care was lower in the Eastern region (OR= 0.74, 95% CI [0.63 - 0.88]), Western region (OR= 0.76, 95% CI [0.60 - 0.97]) and Northern region (OR= 0.79, 95% CI [0.66 – 0.94]) (see Table 3.5, 3.6).

Separately, the moderating effect of place of residence between male partner attendance and first trimester antenatal care was examined. The interaction term was not significant.

Predicting the number of Antenatal care contacts (4 or more contacts)

I found that women who reported that the male partner was present during antenatal care, those who had high levels of education, belonged to households with the higher wealth index, were older, and had pregnancy complications were significantly

more likely to have 4 or more antenatal care contacts. In contrast, rural women, those that reported distance to a health facility as a problem, had higher number of children and higher parity had lower odds of having 4 or more antenatal care contacts (see Table 3.2, Model 2).

Controlling for all other variables, women who reported that the male partner was present during at least one antenatal care contact were 72% more likely to report having 4 or more antenatal care contacts during their pregnancy (OR= 1.72, 95% CI [1.64 - 1.80]). Women with higher education and those from the richest households were more likely to have had 4 or more antenatal care contacts during pregnancy. Additionally, caste and religion were also significantly associated with the number of antenatal care contacts. In comparison to women in the General category, women belonging to Scheduled Caste (SC) (OR= 0.91, 95% CI [0.85 - 0.97]) and Other Backward Classes (OBC) (OR= 0.75, 95% CI [0.71 - 0.79]) were less likely to have 4 or more antenatal care contacts during pregnancy. Further, women's age was significantly associated with the number of antenatal care contacts. Every year increase in women's age was associated with a 2% increase in the likelihood of having 4 or more antenatal care contacts during pregnancy. Additionally, women who reported having pregnancy complications were 10% more likely to have 4 or more antenatal care contacts (OR=1.10, 95% CI [1.06 - 1.14]).

In contrast, number of children (OR= 0.91, 95% CI [0.90 - 0.93]), parity (OR= 0.84, 95% CI [0.82 - 0.85]) and distance to health facility (OR=0.87, 95% CI [0.83 - 0.91]) had a negative relationship with likelihood of having 4 or more antenatal care contacts. Furthermore, compared to the southern region, women from all other regions had significantly lower odds of having 4 or more antenatal care contacts. Within this

model, only age at marriage was not significantly associated with odds of having 4 or more antenatal care contacts.

Finally, based on the results from the model including the interaction effects (see table 3.5, 3.6), in comparison to the Southern region, male partner attendance was associated with increased odds of 4 or more antenatal care contacts among Northern (OR=1.42, 95% CI [1.19 – 1.70]), Central (OR=1.58, 95% CI [1.34 -1.86]), Eastern (OR= 1.98, 95% CI [1.66 - 2.36]), North-Eastern (OR=1.55, 95% CI [1.27 – 1.88]) and Western regions (OR= 1.54, 95% CI [1.15 – 2.06]) (see Table 5,6). It is interesting to note that there was no statistically significant effect of the interaction between male partner attendance and place of residence on frequency of antenatal care contacts.

Predicting the number of Antenatal care contacts (8 or more contacts)

I also examined the factors influencing the likelihood of women having 8 or more antenatal care contacts as this is the latest standard recommended by the WHO (see Table 3.2, Model 3). Overall, I found that male partner presence was significantly associated with women being more likely to report 8 or more antenatal care contacts. Women who reported that the male partner was present during at least one antenatal care contact were 45% more likely to report having 8 or more antenatal care contacts during their pregnancy (OR= 1.45, 95% CI [1.35 - 1.55]).

The results also show that education, household wealth, caste, religion, place of residence, region, distance to health facility, women's age, number of children, parity and pregnancy complications were significantly associated with odds of women having 8 or more antenatal care contacts. Women belonging to the richest households (OR= 2.32, 95% CI [2.06 - 2.63]) and those with higher secondary education had higher odds of

having 8 or more antenatal care contacts during their pregnancy (OR= 2.01, 95% CI [1.82 - 2.23]), in comparison to women in the poorest wealth quintile and those with no formal education. Additionally, women were less likely to have 8 or more antenatal care contacts during pregnancy if they belonged to Scheduled Tribes (OR= 0.87, 95% CI [0.78 - 0.97]) and Other Backward Classes (OBC) (OR= 0.82, 95% CI [0.77 - 0.88]) compared to General category. Interestingly, Muslim women were more likely to have 8 or more antenatal care contacts (OR= 1.18, 95% CI [1.07 - 1.30]) as compared to Hindu women.

While the odds of having 8 or more antenatal care contacts during pregnancy increased with age, higher number of children (OR= 0.95, 95% CI [0.92 - 0.98]) and parity (OR= 0.82, 95% CI [0.79 - 0.84]) were associated with decreased odds of having 8 or more antenatal care contacts. In addition, women who reported having pregnancy complications were 22% more likely to have 8 or more antenatal care contacts (OR=1.22, 95% CI [1.16 - 1.28]). Also, distance to the health facility had a negative relationship with the frequency of antenatal care contacts, such that women who reported that the distance to health facility was a problem were 20% less likely to have 8 or more antenatal care contacts (OR=0.80, 95% CI [0.75 - 0.85]). Compared with the southern region, women belonging to all other regions had significantly decreased odds of having 8 or more antenatal care contacts.

Further, I also observed that the interaction effect of male partner attendance with region showed a positive and significant correlation with frequency of antenatal care contacts (see table 3.5, 3.6). In comparison to the Southern region, the effect of male partner attendance on the odds of having 8 or more antenatal care contacts was higher among women from the Northern (OR=1.23, 95% CI [1.02 – 1.49]), Central (OR=1.35,

95% CI [1.14 – 1.62]), Eastern (OR= 1.58, 95% CI [1.29 – 1.94]), North-Eastern (OR= 1.31, 95% CI [1.02 – 1.67]) and Western region (OR= 1.51, 95% CI [1.21 - 1.87]) (see Table 3.4, 3.5). The results showed that place of residence had no statistically significant effect on association between male partner attendance and frequency of antenatal care contacts.

Predicting Institutional Delivery

In this regression model, I examined the factors influencing institutional delivery (see Table 3.2, Model 4). The analyses results showed that women with higher education, higher household wealth, older women, women married at 18 years and older, women who reported having pregnancy complications, those visited by a health worker and women who reported that the male partner had accompanied them to antenatal care had significantly increased odds of having an institutional delivery.

Controlling for all social and demographic factors, male partner attendance in antenatal care was significantly associated with delivery at a health facility. Women who reported that the male partner was present during at least one antenatal care contact were 40% more likely to have an institutional delivery (OR= 1.40, 95% CI [1.34 - 1.48]).

Compared to women who had no formal education, those who had studied till higher secondary level were thrice as likely to have an institutional delivery (OR=3.09, 95% CI [2.71 - 3.53]). Further, the odds of having an institutional delivery was highest among women who belonged to the richest household (OR=3.50, 95% CI [3.08 - 3.98]), as compared to women belonging to households in the poorest wealth quintile. Also, higher age of women (OR= 1.01, 95% CI [1.01 - 1.02]) and being married at 18 years and older (OR= 1.16, 95% CI [1.10 - 1.21]) were significantly associated with increased odds

of delivering at a health facility. Additionally, women who reported having pregnancy complications (OR= 1.19, 95% CI [1.14 - 1.25]) and those who were visited by a health worker (OR= 1.24, 95% CI [1.18 - 1.30]) were more likely to have an institutional delivery.

In contrast, caste, religion, region, number of children and parity were associated with decreased odds of women having an institutional delivery. Compared to Hindu women, Muslim women and those belonging to other religions were significantly less likely to deliver at a health facility (OR=0.56, 95% CI [0.52 – 0.61]). Further, in comparison to the General category, women who belonged to Scheduled Tribes (ST) were 34% less likely to have a delivery at a health facility (OR= 0.66, 95% CI [0.60 - 0.74]). In comparison to women in Southern India, women in all other regions had significantly lower odds of delivering at a health facility. Furthermore, every unit increase in the number of children was associated with a 6% reduced odds of health facility births (OR= 0.94, 95% CI [0.92 - 0.96]) and every unit increase in parity was associated with a 18% reduced odds of facility births (OR= 0.82, 95% CI [0.78 - 0.86]). Also, women who reported that distance to health facilities was a big problem were 18% less likely to have an institutional delivery (OR= 0.82, 95% CI [0.78 - 0.86]).

The interaction effect with region showed a negative and significant correlation with male partner attendance only for the Northern region (see table 3.5, 3.6). The effect of male partner attendance on institutional delivery was higher among women from the Northern region (OR = 0.83, 95% CI [0.71 - 0.97]) as compared to those from the South (see Table 8, Model 4). The interaction effects showed that place of residence had no

statistically significant effect on the association between male partner attendance and institutional delivery.

Sensitivity Analysis: Logistic regression models controlling for women's autonomy

Multivariable logistic regression analysis models were replicated with the sub-sample of women who answered the survey questions on women's autonomy (see Table 3.3, Model 1-4). The study findings were consistent with those from the full sample. Controlling for women's autonomy, male partner attendance as positively associated with early initiation of antenatal care contacts (OR= 1.19, 95% CI [1.08 - 1.31]), having 4 or more antenatal care contacts (OR= 1.82, 95% CI [1.64 - 2.00]), having 8 or more antenatal care contacts (OR= 1.39, 95% CI [1.22 - 1.59]) and the odds of having an institutional delivery (OR= 1.46, 95% CI [1.30 - 1.63]).

Sensitivity Analysis: Logistic regression models controlling for intimate partner violence

Multivariable logistic regression analysis models were replicated with the sub-sample of women who answered the survey questions on intimate partner violence (see Table 3.4, Model 1-4). In the regression models, I controlled for intimate partner violence – physical violence, sexual violence and emotional violence. The results were consistent with findings from the full sample. For example, among women who had experienced intimate partner violence, male partner attendance was significantly associated with early initiation of antenatal care contact (OR= 1.16, 95% CI [1.04 - 1.30]) (See Table 3.4). Further, compared to women who reported that the male partner was not present during any antenatal care contacts, women who reported male partner attendance were 86% more likely to have 4 or more antenatal care contacts (OR= 1.86, 95% CI [1.65 - 2.10]). Similar results were found for 8 or more antenatal care contacts; women who reported

male partner attendance were 44% more likely to have 8 or more antenatal care contacts (OR= 1.44, 95% CI [1.23 - 1.70]). Finally, male partner attendance was also positively associated with institutional delivery (OR= 1.46, 95% CI [1.29 - 1.66]).

Supplementary Analysis

In a supplementary analysis, the multivariable logistic regression model predicting institutional delivery was replicated while retaining women who reported having zero antenatal care contacts. The study findings show that in comparison to women who had no antenatal care contacts, those who had at least one contact and had their male partner accompany them to antenatal care were about twice as likely to have an institutional delivery (OR= 2.37, 95% CI [2.26 – 2.49]) (see supplementary table 4).

Additionally, as a sensitivity analysis, the multivariable logistic regression models were replicated for the sub-sample of women who reported not having experienced any complications during pregnancy. The results were consistent with findings from the full sample (see supplementary table 5). In comparison to women who reported that their male partner did not accompany them to any antenatal care contacts, those women who reported male partner attendance were more likely to initiate antenatal care within the first trimester (OR= 1.16, 95% CI [1.10 – 1.24]), to have 4 or more contacts (OR=1.79, 95% CI [1.67 – 1.91]) and 8 or more contacts (OR= 1.50, 95% CI [1.36 – 1.65]), and also had increased odds of having an institutional delivery (OR=1.38, 95% CI [1.29 – 1.47]).

Discussion

In this study, I used nationally representative data to examine the associations between male partner attendance in antenatal care and maternal health service utilization (timing and frequency of antenatal care contacts, institutional delivery). The results

support a growing body of literature on the positive role of male partner attendance on maternal health service utilization (Chattopadhyay, 2012; Forbes, Wynter, Wade, Zeleke, & Fisher, 2018; Rahman et al., 2018; Suandi, Williams, & Bhattacharya, 2019; Teklesilasie & Deressa, 2018; Yargawa & Leonardi-Bee, 2015). The positive and significant association between male partner attendance and maternal health service utilization remains consistent even after controlling for socio-demographic and geographical factors, as well as among women who may have experienced intimate partner violence.

While discussing maternal health service utilization within the social and cultural context of India, it is important to understand that women's access to maternal health services is often not based on individual decision-making; rather, these decisions are shaped by multiple factors at the family, community and larger socio-economic and cultural level. Using the Social Ecological Model in this study serves as a reminder of the multiple systems that influence an individual's behavior (Bronfenbrenner, 1977), and allows for an apt contextualization of the social and cultural environment within which women make the decision to access and utilize maternal health services. Also, as indicated earlier, much of the support for interventions engaging men in maternal care derives from a Gender Transformative Approach to health. This approach actively seeks to examine and change harmful and unequal gender norms and power imbalance which lead to health inequities (Rottach et al., 2009). In the discussion that follows, utilizing both the *Social Ecological Model* and *Gender Transformative Approach* as frameworks, I attempt to interpret and explain this paper' findings and unpack some of the arguments in support of male partner attendance in antenatal care.

Are male partners key stakeholders or active agents of change?

Understanding men's role as key stakeholders or gatekeepers takes on added importance within the Indian family and household setting. This is so because within this context, women often have limited autonomy and control over their health choices, adversely impacting their reproductive health outcomes and service utilization (Banerjee, 2015; Mistry, Galal, & Lu, 2009; Mondal et al., 2020). Thus, from this perspective, interventions engaging with men at the family and household level follow the rationale that male partners are often the primary decision-makers. Interpreting the study findings from this perspective, the positive and statistically significant association between male partner attendance and maternal health service utilization could be explained by the fact that men being involved in maternal care could lead to greater access to resources, provisioning of means of transportation and financial support for women, all of which are critical in accessing care (Hamal et al., 2020; Kalter et al., 2011). Additionally, male partner attendance in antenatal care could also result in a greater understanding of maternal care and the benefits of facility births (Forbes et al., 2018), improvement in birth-preparedness and husband's knowledge of pregnancy-related complications, translating to increased health service utilization (Jungari & Paswan, 2019b).

A Gender Transformative lens supporting male partner attendance in antenatal care

Viewing men only as gate-keepers to accessing care and as decision-makers can be limiting, especially from a social justice and gender transformative lens. The benefit of using a gender transformative lens is that it acknowledges the cultural context within which maternal care occurs and launches a discussion positioned towards social change. Women's experience of pregnancy and their reproductive health choices are impacted to

a large extent by gendered social relations including those with their partner, family and community (Cottingham, 2002; Bussa et al., 2012). Particularly within the South-Asian cultural context, rigid gender norms produce the narrative where pregnancy and child care is primarily viewed as a "woman's domain" (Jungari & Paswan, 2019a). Within this broader cultural context of India, a Gender Transformative lens supports the male involvement model that views men as responsible and equal partners during the pregnancy period. As equal partners in maternal care, men may take on several roles including and not limited to arranging transportation to the health facility, arranging for skilled birth attendance, assisting in household chores, having knowledge of danger signs during pregnancy that require immediate obstetric care and accompanying women for antenatal care contacts (Suandi et al., 2019; Tweheyo, Konde-Lule, Tumwesigye, & Sekandi, 2010). Educated men and those who understand the need for shared responsibilities for maternal health can be in a better position to be involved in maternal care, also leading to improved intra-spousal communication (Chattopadhyay, 2012; Suandi et al., 2019). Additionally, presence at antenatal care contacts may be indicative of individuals' agency to challenge and negotiate existent gender norms and practices and be actively involved in maternal care. This can play a crucial role in transforming the overall narrative where pregnancy and maternal health is viewed solely as a woman's domain.

While there may be differing rationales for male partner attendance in antenatal care, when viewed from the perspective of strengthening antenatal care and increasing uptake of institutional delivery, these results are particularly encouraging. The results of this paper highlight that male partner attendance in antenatal care can be a crucial

strategy for promotion of early initiation of antenatal care and increase in frequency of antenatal care contacts. Currently, the National Health Mission in India has a dominant focus on incentivizing institutional delivery or facility births, with limited attention towards addressing antenatal care (IIPS, 2017). The evidence from this study points towards the need for policy and programs that focus on engaging with male partners and educating them on maternal health as a key component of strengthening the overall utilization of antenatal care. Furthermore, the positive effect of male partner attendance on early initiation of antenatal care is of particular importance. This is one of the first studies in India that has focused on male partner attendance as a determinant of early initiation of antenatal care, and the findings indicate that engaging with men and involving them in maternal care can play a crucial role in encouraging women to initiate antenatal care within the WHO recommended time period of 12 weeks of pregnancy, ensuring early screening and testing.

Apart from the positive role of male partners in increasing uptake of antenatal care, the results of this paper also highlight the association between male partner attendance and institutional delivery. Health policy in India has made concentrated efforts to increase uptake of institutional delivery, including the roll-out of one of the largest cash transfer programs in the world, Janini Suraksha Yojana. Although these initiatives have led to a considerable increase in the proportion of women having an institutional delivery (Lim et al., 2010), there still exist considerable disparities in access and utilization across regions and socio-economic groups (Ali et al., 2019). To accelerate improvements in maternal health care, there is a need for programs and interventions to acknowledge that women's health decisions are heavily influenced by their social

environment, including family and community. According to the study findings, women whose partners accompanied them to antenatal care contacts were about twice as likely to have an institutional delivery. These results are consistent with those of previous studies in India and other low and middle-income countries (Chattopadhyay, 2012; Mohammed, Johnston, Vackova, Hassen, & Yi, 2019; Suandi et al., 2019), and underscores the need for national policy frameworks that incorporate male involvement and support as an important strategy for increased access to maternal health service utilization.

Women's autonomy and Maternal Health service utilization

The importance of active male involvement in maternal care is further supported by the study findings which reveal that male partner attendance in antenatal care influences service utilization, even when controlling for women's autonomy. In this paper, women's autonomy was measured based on a score created from variables measuring women's ability to make decisions in relation to healthcare, finances and movement (see supplementary table 14, Appendix 1). The results show that while women's autonomy has a positive effect on both male partner attendance and maternal health service utilization, separately, it does not affect the relationship between the two. These results are consistent with prior research that found a positive effect of women's autonomy on service utilization (Mistry et al., 2009), and underscores the importance of women's empowerment as crucial to improving male partner attendance as well as maternal health service utilization. Strategies that are aimed at women's empowerment need to take into account the financial and social determinants that shape women's perceived level of autonomy (Banerjee, 2015). Improving women and girl's access to education, increasing financial independence through skill development and involvement

in Self-Help Groups (*Mahila Mandals*) which deliver micro-credit facilities can be important steps in this direction. Additionally, research also shows that political participation, particularly political reservations for women, can be an important step to women's empowerment (Priebe, 2017). It should be noted that while programs and interventions call for increased participation of male partners in maternal care, this should be implemented in a way that respects and promotes women's choices and decision-making autonomy.

Intimate partner violence and maternal health service utilization

The sensitivity analysis about intimate partner violence was conducted with the assumption that for women who have experienced intimate partner violence, male partners being involved in maternal care may have a negative effect on service utilization. The results of this study illustrate two major points – firstly, consistent with previous research (Beydoun, Tamim, Lincoln, Dooley, & Beydoun, 2011; Ononokpono & Azfredrick, 2014; Rahman, Nakamura, Seino, & Kizuki, 2012; Silverman et al., 2020), the results of this paper also document a significant and negative association between physical violence and maternal health service utilization. Second, no differences were found in the association between male partner attendance and service utilization when controlling for intimate partner violence within the model. Taken together, these findings have important implications for developing Gender Transformative strategies or interventions that engage with male partners and involve them in maternal care. In particular, these can also be viewed as a potential strategy to developing gender-equitable behaviors and reducing perpetration of intimate partner violence during pregnancy

(Barker, Ricardo, Nascimento, Olukoya, & Santos, 2010; UNFPA, 2013; Hossain et al., 2014).

Additional factors influencing maternal service utilization

The study results are consistent with previous research which documents that educated women and those belonging to the richest households were more likely to utilize maternal health services as compared to women with no formal education and those belonging to poorer households (Bhattacharyya, Srivastava, Roy, & Avan, 2016; Biplab, 2011; Srivastava & Joseph, 2018). Educated women would be more likely to have increased knowledge and awareness about maternal health services, and have greater freedom in health-related decision making (Babalola & Fatusi, 2009; Chattopadhyay, 2012). Further, the study results show that religion and caste were significant predictors of maternal health service utilization. In particular, these results are notable in the case of institutional delivery, which show that Muslim women in India were 45% less likely to have an institutional delivery as compared with Hindu women; and, in comparison with women from the General caste category, women from Scheduled Tribes were 35% less likely to have an institutional delivery. Multiple factors shape health service utilization among women from minority communities, including poor knowledge of sexual and reproductive health, low levels of education, and cultural and religious practices (Alomair, Alageel, Davies, & Bailey, 2020). Research also documents that provider mistreatment of women during childbirth and obstetric violence are additional barriers to maternal health service utilization, particularly among women from minority religious groups and socially disadvantaged caste groups (Scheduled Castes and Scheduled Tribes) (Goli et al., 2019; Raj et al., 2017; Shrivastava & Sivakami, 2020).

There is a need for an in-depth examination of the barriers to accessing maternal health services among minority communities, particularly addressing the influence of intersecting social identities.

The study findings also highlight the social and health consequences of early and child marriage, and calls for tighter laws regarding the practice[11]. The study results show that in contrast to women who were married below 18 years, those married at 18 years and older were more likely to initiate early antenatal care, have 8 or more antenatal care contacts and have their delivery at a health facility. While the government has implemented programs to increase age at marriage, there is also a need for sustained efforts towards increasing knowledge, awareness and access to healthcare among married adolescents. This takes on added importance within the COVID-19 pandemic which has resulted in a rise in the rate of child marriage both globally as well as in South Asia (Afrin & Zainuddin, 2021). Prioritizing the reproductive health needs of young mothers is further supported by the study findings which show that women's age and maternal health service utilization are positively associated, such that younger women are less likely to use maternal health services. There is a need for additional research that investigates maternal health service utilization based on age cohorts to obtain a nuanced understanding of which age groups are at highest risk of poor maternal and child health outcomes.

Additionally, this study also supports evidence from previous research that stresses community health workers' positive role in maternal care (Agarwal et al., 2019;

[11] Child marriage, defined as a formal marriage or an informal union between a child under the age of 18 years and an adult or another child, is a serious violation of human rights. Despite considerable declines worldwide over the past decade, child marriage still remains a persistent problem, particularly in South Asia which accounts for the largest number of child brides worldwide (UNICEF, 2019).

Paul & Pandey, 2020; Vellakkal et al., 2017; Wagner, Porth, Bettampadi, & Boulton, 2018). As the study findings suggest, community health workers can play a crucial role in raising awareness, building capacities, encouraging women to access and utilize health services and in engaging with male partners on being involved in maternal care. To meet these goals, policy and programs should consider increasing incentives and providing training opportunities that can bolster the role of community health workers as a crucial link between the health systems and community.

It is also essential to consider maternal health service utilization in the context of pregnancy complications. Pregnancy complications are one of the leading causes of maternal morbidity and mortality; yet, most pregnancy-related deaths are preventable with adequate access to care during pregnancy and delivery (World Health Organization, 2016). Previous studies also note that women who have experienced pregnancy complications were more likely to have an increased number of antenatal care contacts and to choose to deliver at a health facility. The results of this paper support this evidence. However, based on an additional sensitivity analysis using only the sub-sample of women who reported having pregnancy complications, the study results remain consistent (see supplementary table 4). These findings further confirm the results' robustness and reinforce the importance of male partner attendance in antenatal care as an important strategy to improve maternal health service utilization.

Limitations

The dissertation has some limitations. This dissertation was limited to survey questions on male partner attendance in antenatal care, and inclusion of variables measuring other forms of support such as financial support for antenatal care, arranging

transportation for delivery, planning for a potential blood donor, involvement in decision making of the location for delivery and accompaniment to the place of delivery could not be included in the model. Social desirability bias could also have a role in influencing report of male partner attendance in antenatal care, particularly due to prevalent gender norms within the study context. As a result of this, it is possible that women over-report male partner attendance, leading to a possible over-estimation of the positive role of male partner attendance on maternal health service utilization. Further, the study excludes a sub-population of women who have had no antenatal care contacts (and hence have no information on male partner attendance). It is likely that women who had no contact with the health system during pregnancy often have lower levels of education and belong to the most vulnerable socio-economic groups (Ali, Dhillon, & Mohanty, 2019). This was further demonstrated in a supplementary analysis using a model to predict exclusion (see supplementary table 6). Thus, the overall findings of this study cannot be generalized to this sub-population. The dissertation uses cross-sectional data and hence it is not possible to establish a causal relationship between male partner attendance in antenatal care and utilization of maternal health services. Further, since the survey asks questions on fertility based on the woman's last pregnancy in the past 5 years, the report of details could suffer from recall bias. Due to a lack of available data, I could not control for the number of pregnancies (gravida) within the model. Furthermore, due to the unavailability of variables within the dataset, I could not control for the spacing of antenatal care contacts and whether the male partner accompanied the woman for multiple antenatal care contacts. Another limitation of this study is that I could not control for health system level factors, including quality of health infrastructure and attitudes/perceptions of health

providers. Harsh treatment or discrimination by health providers can influence women's decision to utilize maternal health services. Further research should focus on attitudes and perceptions of health providers as a key determinant of maternal health service utilization. Finally, due to the survey's limitations, this dissertation only includes understanding health behavior among partners of a specific gender. It focuses on women as primary childbearing individuals, excluding persons of other genders who may be childbearing individuals (trans men).

Implications and conclusions

Overall, this study found that consistent with previous literature, education, household wealth, caste, religion, age, age at marriage, number of children, parity, place of residence and region were all significantly associated with odds of maternal health service utilization. Controlling for these socio-demographic and geographical factors, male partner attendance in antenatal care had a positive effect on early initiation of antenatal care, frequency of antenatal care contacts and women having an institutional delivery. Particularly in relation to institutional delivery, this study draws attention to the dual importance of antenatal care and male partner attendance. Engaging with male partners and educating them in antenatal care could lead to improved knowledge levels among the couple, increased support for women accessing services during pregnancy and an uptake in both institutional delivery and antenatal care utilization. There should be a focus on strengthening antenatal care, with interventions aimed at capacity building and awareness generation both of individuals, as well as the family and community. There is also a need for research aimed at providing a more nuanced understanding of the reasons

why women do not initiate antenatal care within the first trimester, and women's preferences in relation to male partners being involved in antenatal care.

Further, evidence shows that community health workers or Accredited Social Health Activist (ASHA) workers have been one of the key stakeholders in increasing overall uptake of antenatal care services for women in India (Agarwal et al., 2019). Being members of the community, ASHA workers, in particular, male community health workers/ Male Health Activists can also be an important pathway for engaging with male partners (Fotso, Higgins-Steele & Mohanty, 2015), particularly for populations living in rural and tribal areas. Social workers and community health workers in particular can play an important role by partnering with community based Non-Governmental Organizations (NGOs) to design and advocate for community-outreach interventions that target not only male partners of women but also other male members within the community such as community leaders, religious or village heads. Previously in India, NGOs and civil society organizations have made some efforts to involve male partners in reproductive health projects, including using male peer educators, male health workers, organizing education camps and particularly focusing on newly married couples (World Health Organisation, 2002). However, the lack of adequate assessment and evaluation provides limited understanding of the impact of these interventions. There is a need for research that systematically investigates the effectiveness and impact of programs and interventions in maternal health that are targeted on active involvement of male partners.

Taken together, these results provide some support for interventions that aim at a more inclusive or *gender transformative approach* to maternal health. At the same time, they also raise some interesting policy and intervention-related questions. Not only is

there need for a nuanced understanding of the mechanisms which cause male partner attendance in antenatal care to translate into improved service utilization, it is also essential to understand what constitutes this involvement. Male involvement in maternal care is a multifaceted concept; and, beyond attendance in antenatal care, male partners could also be involved in other activities such as initiating conversation on prenatal care, reminding the partner of their ANC follow-up, covering transportation/medical cost of antenatal care (Rahman et al., 2018), be included in group counselling (Kalembo, Zgambo, Mulaga, Yukai, & Ahmed, 2013) or assist in household chores (Thapa & Niehof, 2013). Qualitative research including dialogue with women could provide meaningful insights on the extent to which each of these activities support women during their pregnancy. Further research can also include a sensitivity analysis based on men's report of attendance in antenatal care and its association with maternal health service utilization.

Table 3.1. Socio-demographic characteristics and maternal health service utilization among women respondents in the full sample, NFHS-4, 2015-16

	Women with data on antenatal care	Women with data on institutional delivery
	N = 144,840 %	N = 146,378 %
Male partner attendance		
Male partner not present	17.54	17.54
Male partner present	82.46	82.46
Early initiation of ANC (timing of first contact)		
Later than 12 weeks	29.44	
At or less than 12 weeks	70.56	
Frequency of ANC contacts (4 or more)		
Less than 4 visits	38.47	
4 or more visits	61.53	
Frequency of ANC contacts (8 or more)		
Less than 8 visits	76.06	
8 or more visits	23.94	
Place of delivery		
Home		13.68
Health facility		86.32
Respondent's education		
No formal education	22.53	18.25
Primary	13.18	13.16
Secondary	50.40	50.41
Higher secondary	13.89	13.91
Respondent's caste		
Scheduled caste (SC)	21.85	21.77
Scheduled tribe (ST)	10.24	10.31
Other Backward Classes (OBC)	45.21	45.22
General	22.71	22.70
Respondent's religion		
Hindu	81.18	81.16
Muslim	13.34	13.37
Others	5.48	5.47
Wealth quintile		
Poorest	18.27	18.25
Poorer	20.56	20.54
Middle	21.11	21.07

Richer	20.98	21.02
Richest	19.08	19.12
Place of residence		
Urban	32.01	32.08
Rural	67.99	67.92
Region		
North	13.90	13.86
Central	25.25	25.19
East	22.05	22.00
North-East	3.28	3.34
West	14.41	14.41
South	21.11	21.21
Respondent's age at marriage		
Below 18 years	34.80	34.73
18 years and older	65.20	65.27
Pregnancy complications		
No	57.38	57.33
Yes	42.62	42.67
Distance to health facility		
Not a problem	70.49	70.46
Big problem	29.51	29.54
Visit by health worker (in last three months before delivery)		
No		45.46
Yes		54.54
Respondent's age (Mean, SD)	26.68 (4.93)	26.69 (4.93)
Number of children (Mean, SD)	1.49 (0.88)	1.49 (0.88)
Parity (Number of live births) (Mean, SD)	2.14 (1.29)	2.14 (1.29)

Table 3.2. Multivariate logistic regression results for each outcome measure: Adjusted Odds Ratios (AOR) (95% Confidence Interval), NFHS-4, 2015-16

	Early initiation of ANC N = 144,840		Frequency of ANC (4 or more contacts) N = 144,840		Frequency of ANC (8 or more contacts) N = 144,840		Institutional Delivery N = 146,378	
	Model 1		Model 2		Model 3		Model 4	
	Odds ratio	(CI)	Odds ratio	(CI)	Odds ratio	(CI)	Odds	(CI)
Male Partner Attendance (Ref: Male partner not present)								
Male partner present	1.18***	(1.13 - 1.23)	1.72***	(1.64 - 1.80)	1.45***	(1.35 - 1.55)	1.40***	(1.34 - 1.48)
Individual level variables								
Education (ref: No education)								
Primary	1.05	(1.00 - 1.11)	1.36***	(1.29 - 1.44)	1.31***	(1.19 - 1.43)	1.09**	(1.02 - 1.16)
Secondary	1.15***	(1.10 - 1.21)	1.48***	(1.41 - 1.55)	1.63***	(1.51 - 1.76)	1.67***	(1.56 - 1.77)
Higher	1.30***	(1.20 - 1.41)	1.62***	(1.50 - 1.76)	2.01***	(1.82 - 2.23)	3.09***	(2.71 - 3.53)
Caste (ref: General)								
Scheduled Caste (SC)	0.92*	(0.86 - 0.99)	0.91**	(0.85 - 0.97)	0.95	(0.87 - 1.04)	0.92	(0.85 - 1.01)
Scheduled Tribe (ST)	1.06	(0.98 - 1.15)	1.05	(0.97 - 1.14)	0.87**	(0.78 - 0.97)	0.66***	(0.60 - 0.74)
Other Backward Classes (OBC)	1.00	(0.94 - 1.05)	0.75***	(0.71 - 0.79)	0.82***	(0.77 - 0.88)	0.99	(0.92 - 1.07)
Religion (ref: Hindu)								
Muslim	1.06	(0.99 - 1.13)	1.04	(0.96 - 1.12)	1.18**	(1.07 - 1.30)	0.56***	(0.52 - 0.61)
Others	0.93	(0.82 - 1.05)	1.18**	(1.05 - 1.33)	1.09	(0.98 - 1.21)	0.70***	(0.60 - 0.81)
Age at Marriage (ref: Below 18 years)								
18 years and older	1.08***	(1.04 - 1.12)	0.98	(0.94 - 1.02)	1.05	(1.00 - 1.11)	1.16***	(1.10 - 1.21)
Respondent's age	1.00	(1.00 - 1.01)	1.02***	(1.02 - 1.03)	1.03***	(1.02 - 1.04)	1.01***	(1.01 - 1.02)
Number of children	0.95***	(0.93 - 0.97)	0.91***	(0.90 - 0.93)	0.95**	(0.92 - 0.98)	0.94***	(0.92 - 0.96)
Parity (Number of live births)	0.93***	(0.91 - 0.95)	0.84***	(0.82 - 0.85)	0.82***	(0.79 - 0.84)	0.81***	(0.79 - 0.83)
Pregnancy complications (ref: None)								
Yes	0.96	(0.93 - 1.00)	1.10***	(1.06 - 1.14)	1.22***	(1.16 - 1.28)	1.19***	(1.14 - 1.25)
Visit by health worker (ref: No)								
Yes							1.24***	(1.18 - 1.30)
Household level variables								
Wealth Quintile (ref: Poorest quintile)								
Poorer	1.11***	(1.06 - 1.17)	1.44***	(1.36 - 1.51)	1.33***	(1.21 - 1.46)	1.29***	(1.22 - 1.38)

Middle	1.31***	(1.24 - 1.39)	1.68***	(1.58 - 1.79)	1.47***	(1.33 - 1.63)	1.67***	(1.55 - 1.79)
Richer	1.51***	(1.40 - 1.63)	1.95***	(1.82 - 2.09)	1.68***	(1.52 - 1.87)	2.11***	(1.92 - 2.33)
Richest	1.93***	(1.76 - 2.12)	2.56***	(2.34 - 2.78)	2.32***	(2.06 - 2.63)	3.50***	(3.08 - 3.98)
Place of residence (ref: Urban)								
Rural	1.01	(0.95 - 1.08)	0.83***	(0.78 - 0.88)	0.91**	(0.84 - 0.97)	0.94	(0.86 - 1.02)
Region (ref: South)								
North	0.80***	(0.74 - 0.87)	0.24***	(0.22 - 0.26)	0.19***	(0.18 - 0.21)	0.37***	(0.32 - 0.43)
Central	0.59***	(0.55 - 0.63)	0.18***	(0.16 - 0.19)	0.13***	(0.12 - 0.14)	0.24***	(0.21 - 0.27)
East	0.62***	(0.57 - 0.66)	0.34***	(0.32 - 0.37)	0.30***	(0.28 - 0.33)	0.27***	(0.24 - 0.31)
Northeast	0.60***	(0.55 - 0.66)	0.32***	(0.29 - 0.36)	0.13***	(0.12 - 0.14)	0.25***	(0.22 - 0.29)
West	0.95	(0.86 - 1.05)	0.74***	(0.64 - 0.84)	0.86**	(0.78 - 0.94)	0.57***	(0.49 - 0.67)
Distance to health facility (ref: not a problem)								
Big problem	0.85***	(0.81 - 0.89)	0.87***	(0.83 - 0.91)	0.80***	(0.75 - 0.85)	0.82***	(0.78 - 0.86)
Constant	2.34***	(1.95 - 2.81)	1.65***	(1.40 - 1.95)	0.20***	(0.16 - 0.26)	8.71***	(6.96 - 10.90)

***p<0.001, ** p<0.01, *p<0.05

Table 3.3 Multivariate logistic regression results for each outcome measure: Adjusted Odds Ratios (AOR) (95% Confidence Interval), adjusted for women's autonomy, NFHS-4, 2015-16

	Early initiation of ANC N = 25,722		Frequency of ANC (4 or more contacts) N = 25,722		Frequency of ANC (8 or more contacts) N = 25,722		Institutional Delivery N = 25,965	
	Model 1		Model 2		Model 3		Model 4	
	Odds ratio	(CI)	Odds ratio	(CI)	Odds ratio	(CI)	Odds ratio	(CI)
Male Partner Attendance (Ref: Male partner not present)								
Male partner present	1.19***	(1.08 - 1.31)	1.82***	(1.64 - 2.00)	1.39***	(1.22 - 1.59)	1.46***	(1.30 - 1.63)
Individual level variables								
Education (ref: No education)								
Primary	1.02	(0.89 - 1.17)	1.27***	(1.13 - 1.44)	1.52***	(1.23 - 1.87)	1.04**	(0.90 - 1.20)
Secondary	1.18**	(1.06 - 1.32)	1.39***	(1.25 - 1.54)	1.70***	(1.45 - 2.00)	1.51***	(1.30 - 1.76)
Higher	1.22*	(1.01 - 1.49)	1.52***	(1.28 - 1.81)	2.04***	(1.65 - 2.54)	2.65***	(1.96 - 3.58)
Caste (ref: General)								
Scheduled Caste (SC)	0.92	(0.79 - 1.08)	0.91	(0.80 - 1.05)	0.94	(0.78 - 1.13)	0.85	(0.70 - 1.03)
Scheduled Tribe (ST)	1.03	(0.87 - 1.22)	1.14	(0.95 - 1.36)	0.81	(0.64 - 1.03)	0.63***	(0.52 - 0.77)
Other Backward Classes (OBC)	1.04	(0.91 - 1.20)	0.73***	(0.65 - 0.82)	0.82**	(0.71 - 0.95)	0.90	(0.77 - 1.06)
Religion (ref: Hindu)								
Muslim	1.08	(0.94 - 1.25)	1.05	(0.92 - 1.21)	1.02	(0.86 - 1.21)	0.55***	(0.47 - 0.65)
Others	1.02	(0.84 - 1.23)	1.14	(0.91 - 1.44)	1.09	(0.88 - 1.35)	0.73**	(0.58 - 0.92)
Age at Marriage (ref: Below 18								
18 years and older	1.17**	(1.07 - 1.29)	0.98	(0.90 - 1.08)	1.18*	(1.03 - 1.34)	1.16*	(1.03 - 1.30)
Respondent's age	1.01	(1.00 - 1.02)	1.02***	(1.01 - 1.03)	1.02***	(1.01 - 1.04)	1.01	(0.99 - 1.02)
Number of children	0.92***	(0.89 - 0.96)	0.96	(0.91 - 1.00)	1.00	(0.94 - 1.06)	0.94	(0.88 - 1.01)
Parity (Number of live births)	0.92***	(0.89 - 0.96)	0.84***	(0.80 - 0.88)	0.81***	(0.76 - 0.86)	0.82***	(0.78 - 0.86)
Women's Autonomy	1.03	(0.98 - 1.07)	1.15***	(1.11 - 1.20)	1.07*	(1.02 - 1.12)	1.04	(0.99 - 1.10)
Pregnancy complications (ref: None)								
Yes	1.02	(0.93 - 1.11)	1.12**	(1.03 - 1.22)	1.23***	(1.11 - 1.36)	1.23***	(1.10 - 1.37)
Visit by health worker (ref: No)								
Yes							1.16**	(1.04 - 1.28)
Household level variables								
Wealth Quintile (ref: Poorest								
Poorer	1.05	(0.93 - 1.19)	1.36***	(1.20 - 1.54)	1.32*	(1.05 - 1.65)	1.41***	(1.21 - 1.63)
Middle	1.35***	(1.18 - 1.55)	1.75***	(1.53 - 2.00)	1.56***	(1.24 - 1.97)	1.75***	(1.47 - 2.09)

Richer	1.59***	(1.36 - 1.87)	2.18***	(1.87 - 2.56)	1.71***	(1.34 - 2.18)	2.27***	(1.79 - 2.88)
Richest	2.05***	(1.69 - 2.49)	2.71***	(2.23 - 3.30)	2.28***	(1.74 - 2.98)	3.90***	(2.93 - 5.20)
Place of residence (ref: Urban)								
Rural	1.12	(0.99 - 1.27)	0.90	(0.80 - 1.02)	0.91	(0.79 - 1.05)	0.97	(0.80 - 1.16)
Region (ref: South)								
North	0.84*	(0.72 - 0.98)	0.24***	(0.20 - 0.28)	0.20***	(0.17 - 0.24)	0.30***	(0.22 - 0.41)
Central	0.62***	(0.54 - 0.71)	0.16***	(0.14 - 0.19)	0.12***	(0.10 - 0.14)	0.19***	(0.14 - 0.26)
East	0.65***	(0.56 - 0.76)	0.32***	(0.27 - 0.38)	0.28***	(0.23 - 0.32)	0.22***	(0.16 - 0.30)
Northeast	0.60***	(0.50 - 0.72)	0.27***	(0.22 - 0.33)	0.12***	(0.09 - 0.15)	0.19***	(0.14 - 0.27)
West	1.11	(0.91 - 1.36)	0.73**	(0.59 - 0.91)	0.86	(0.71 - 1.03)	0.42***	(0.29 - 0.60)
Distance to health facility (ref: not a problem)								
Big problem	0.92*	(0.84 - 1.00)	0.84**	(0.76 - 0.93)	0.72***	(0.62 - 0.82)	0.87*	(0.78 - 0.97)
Constant	1.64*	(1.08 - 2.49)	1.15	(0.80 - 1.64)	0.18***	(0.11 - 0.30)	11.58***	(6.79 - 19.76)

***p<0.001, ** p<0.01, *p<0.05

Table 3.4. Multivariable logistic regression results for each outcome measure: Adjusted Odds Ratios (AOR) (95% Confidence Interval), controlling for Intimate Partner Violence, NFHS-4, 2015-16

	Early Initiation of ANC N= 19,462		Frequency of ANC contacts (4 or more contacts) N= 19,462		Frequency of ANC contacts (8 or more contacts) N= 19,462		Institutional Delivery N= 19,655	
	Model 1		Model 2		Model 3		Model 4	
	Odds ratio	CI	Odds ratio	CI	Odds ratio	CI	Odds ratio	CI
Male Partner Attendance (Ref: Male partner not present)								
Male partner present	1.16**	(1.04 - 1.30)	1.86***	(1.65 - 2.10)	1.44***	(1.23 - 1.70)	1.46***	(1.29 - 1.66)
Individual level variables								
Education (ref: No education)								
Primary	1.04	(0.90 - 1.20)	1.31***	(1.15 - 1.49)	1.64***	(1.32 - 2.05)	1.08	(0.92 - 1.27)
Secondary	1.14**	(1.01 - 1.30)	1.41***	(1.26 - 1.59)	1.84***	(1.54 - 2.20)	1.58***	(1.34 - 1.85)
Higher	1.21	(0.96 - 1.53)	1.66***	(1.35 - 2.04)	2.24***	(1.76 - 2.86)	2.36***	(1.66 - 3.35)
Caste (ref: General)								
Scheduled Caste (SC)	0.91	(0.76 - 1.08)	0.92	(0.79 - 1.08)	1.01	(0.83 - 1.24)	0.91	(0.74 - 1.12)
Scheduled Tribe (ST)	1.00	(0.83 - 1.20)	1.20	(0.99 - 1.45)	0.91	(0.70 - 1.17)	0.68**	(0.55 - 0.86)
Other Backward Classes (OBC)	1.02	(0.87 - 1.19)	0.75***	(0.66 - 0.86)	0.86	(0.73 - 1.01)	0.92	(0.77 - 1.10)
Religion (ref: Hindu)								
Muslim	1.06	(0.91 - 1.25)	1.07	(0.92 - 1.25)	1.06	(0.86 - 1.29)	0.59***	(0.49 - 0.70)
Others	1.03	(0.84 - 1.27)	1.11	(0.88 - 1.41)	1.09	(0.87 - 1.37)	0.65**	(0.51 - 0.84)
Age at Marriage (ref: Below 18 years)								
18 years and older	1.13*	(1.01 - 1.26)	1.01	(0.91 - 1.12)	1.15	(0.99 - 1.34)	1.15**	(1.02 - 1.31)
Respondent's age	1.01	(1.00 - 1.02)	1.02***	(1.01 - 1.04)	1.02**	(1.01 - 1.04)	1.02	(1.00 - 1.03)
Number of children	0.94*	(0.89 - 1.00)	0.97	(0.91 - 1.03)	0.98	(0.91 - 1.06)	0.96	(0.88 - 1.03)
Parity (Number of live births)	0.92**	(0.88 - 0.97)	0.84***	(0.80 - 0.88)	0.83***	(0.77 - 0.89)	0.80***	(0.76 - 0.85)
Autonomy	1.02	(0.97 - 1.07)	1.17***	(1.12 - 1.22)	1.09**	(1.03 - 1.15)	1.04	(0.98 - 1.10)
Pregnancy complications (ref: None)								
Yes	1.00	(0.91 - 1.11)	1.14**	(1.04 - 1.26)	1.28***	(1.14 - 1.43)	1.27***	(1.13 - 1.43)
Visit by health worker (ref: No)								
Yes							1.14*	(1.01 - 1.28)
Household level variables								
Wealth Quintile (ref: Poorest								

Poorer	1.06	(0.93 - 1.21)	1.30***	(1.14 - 1.49)	1.19	(0.92 - 1.53)	1.44***	(1.24 - 1.68)
Middle	1.47***	(1.26 - 1.71)	1.72***	(1.48 - 1.99)	1.45**	(1.12 - 1.88)	1.79***	(1.47 - 2.17)
Richer	1.57***	(1.32 - 1.87)	2.11***	(1.77 - 2.52)	1.58**	(1.19 - 2.08)	2.33***	(1.82 – 3.00)
Richest	2.15***	(1.72 - 2.69)	2.37***	(1.89 - 2.97)	1.87***	(1.38 - 2.54)	4.21***	(3.08 - 5.74)
Place of residence (ref: Urban)								
Rural	1.12	(0.98 - 1.27)	0.93	(0.82 - 1.06)	0.89	(0.76 - 1.03)	0.99	(0.82 - 1.19)
Region (ref: South)								
North	0.86	(0.72 - 1.02)	0.24***	(0.20 - 0.29)	0.20***	(0.17 - 0.25)	0.32***	(0.23 - 0.44)
Central	0.64***	(0.55 - 0.75)	0.16***	(0.13 - 0.19)	0.11***	(0.09 - 0.13)	0.22***	(0.16 - 0.30)
East	0.66***	(0.56 - 0.78)	0.32***	(0.27 - 0.39)	0.25***	(0.21 - 0.30)	0.24***	(0.17 - 0.34)
Northeast	0.60***	(0.49 - 0.73)	0.26***	(0.21 - 0.33)	0.11***	(0.08 - 0.14)	0.21***	(0.15 - 0.29)
West	1.18	(0.94 - 1.49)	0.77*	(0.60 - 0.98)	0.83	(0.68 - 1.01)	0.46***	(0.32 - 0.68)
Distance to health facility (ref: Not a problem)								
Big problem	0.92	(0.83 - 1.01)	0.83**	(0.74 - 0.92)	0.74***	(0.63 - 0.86)	0.85**	(0.75 - 0.96)
Intimate partner violence								
Physical violence (ref: No)								
Yes	0.82***	(0.73 - 0.91)	0.84**	(0.76 - 0.94)	0.79**	(0.68 - 0.91)	0.91	(0.79 - 1.05)
Emotional violence (ref: No)								
Yes	0.97	(0.84 - 1.12)	1.10	(0.94 - 1.28)	1.05	(0.86 - 1.27)	0.94	(0.78 - 1.12)
Sexual violence (ref: No)								
Yes	0.95	(0.80 - 1.12)	1.02	(0.86 - 1.22)	0.87	(0.64 - 1.18)	1.01	(0.81 - 1.27)
Constant	1.66*	(1.04 - 2.66)	1.01	(0.66 - 1.52)	0.20***	(0.12 - 0.36)	8.49***	(4.67 - 15.44)

***p<0.001, ** p<0.01, * p<0.05

Table 3.5. Interaction effects of male partner attendance and region on maternal health service utilization, NFHS-4, 2015-16

	Early Initiation of ANC		Frequency of ANC (4 or more contacts)		Frequency of ANC (8 or more contacts)		Institutional delivery	
	Model 1		Model 2		Model 3		Model 4	
	Odds ratio	(CI)	Odds	Odds ratio	Odds ratio	(CI)	Odds ratio	(CI)
Male Partner Attendance (MPA) (Ref: Male partner not present)								
Male partner present	1.42***	(1.23 - 1.64)	1.11	(0.95 - 1.29)	1.13	(0.99 - 1.28)	1.60***	(1.40 - 1.84)
Region (ref: South)								
North	0.98	(0.83 - 1.16)	0.18***	(0.15 - 0.21)	0.16***	(0.13 - 0.19)	0.74***	(0.66 - 0.84)
Central	0.67***	(0.58 - 0.78)	0.12***	(0.10 - 0.14)	0.10***	(0.08 - 0.12)	0.82***	(0.71 - 0.95)
East	0.79**	(0.67 - 0.93)	0.19***	(0.16 - 0.23)	0.20***	(0.17 - 0.25)	0.66**	(0.56 - 0.78)
Northeast	0.69***	(0.57 - 0.84)	0.22***	(0.18 - 0.27)	0.10***	(0.08 - 0.13)	1.57***	(1.25 - 1.96)
West	1.19	(0.95 - 1.51)	0.51***	(0.38 - 0.69)	0.60***	(0.48 - 0.74)	3.15***	(2.45 - 4.06)
Interaction of MPA with region (ref: MPA x South)								
Male partner attendance x North	0.79**	(0.66 - 0.94)	1.42***	(1.19 - 1.70)	1.23*	(1.02 - 1.49)	0.83*	(0.71 - 0.97)
Male partner attendance x Central	0.87	(0.74 - 1.01)	1.58***	(1.34 - 1.86)	1.35**	(1.14 - 1.62)	0.85	(0.72 - 1.01)
Male partner attendance x East	0.74**	(0.63 - 0.88)	1.98***	(1.66 - 2.36)	1.58***	(1.29 - 1.94)	1.04	(0.86 - 1.26)
Male partner attendance x Northeast	0.86	(0.70 - 1.04)	1.55***	(1.27 - 1.88)	1.31*	(1.02 - 1.67)	0.97	(0.75 - 1.26)
Male partner attendance x West	0.76*	(0.60 - 0.97)	1.54**	(1.15 - 2.06)	1.51***	(1.21 - 1.87)	0.82	(0.62 - 1.08)
Constant	1.98***	(1.60 - 2.46)	2.42***	(1.97 - 2.97)	0.25***	(0.20 - 0.32)	2.94**	(2.36 - 3.65)

***p<0.001, ** p<0.01, * p<0.05

Table 3.6. Interaction effects of male partner attendance and place of residence on maternal health service utilization, NFHS-4, 2015-16

	Early Initiation of ANC N=144,840		Frequency of ANC (4 or more contacts) N=144,840		Frequency of ANC (8 or more contacts) N=144,840		Institutional Delivery N=146,378	
	Model 1		Model 2		Model 3		Model 4	
	Odds ratio	(CI)	Odds ratio	(CI)	Odds ratio	(CI)	Odds ratio	(CI)
Male Partner Attendance (MPA) (Ref: Male partner not present)								
Male partner present	1.20**	(1.06 - 1.36)	1.63***	(1.42 - 1.87)	1.49***	(1.29 - 1.71)	1.55***	(1.36 - 1.78)
Region (ref: urban)								
Rural	1.03	(0.91 - 1.17)	0.78**	(0.67 - 0.91)	0.94	(0.80 - 1.10)	1.03	(0.91 - 1.18)
Interaction of MPA with residence (ref: MPA x Urban)								
Male partner attendance x Rural	0.97	(0.86 - 1.11)	1.07	(0.92 - 1.24)	0.96	(0.82 - 1.13)	0.88	(0.77 - 1.02)
Constant	2.30***	(1.87 - 2.85)	1.73***	(1.41 - 2.11)	0.20***	(0.15 - 0.26)	8.07**	(6.33 - 10.28)

***p<0.001, ** p<0.01, * p<0.05

Supplementary table 4. Multivariable logistic regression results for Institutional Delivery: Adjusted Odds Ratios (AOR) (95% Confidence Interval) (N= 177,730)

	Institutional Delivery Model 1	
	Odds ratio	CI
Male Partner Attendance in Antenatal care (ref: No ANC)		
Atleast one ANC, Male partner absent	1.68***	(1.59 - 1.78)
Atleast one ANC, Male partner present	2.37***	(2.26 - 2.49)
Individual level variables		
Education (ref: No education)		
Primary	1.13***	(1.07 - 1.19)
Secondary	1.70***	(1.61 - 1.79)
Higher	3.21***	(2.85 - 3.61)
Caste (ref: General)		
Scheduled Caste (SC)	0.94	(0.88 - 1.02)
Scheduled Tribe (ST)	0.64***	(0.59 - 0.70)
Other Backward Classes (OBC)	1.02	(0.95 - 1.09)
Religion (ref: Hindu)		
Muslim	0.56***	(0.52 - 0.59)
Others	0.68***	(0.60 - 0.77)
Age at Marriage (ref: Below 18 years)		
18 years and older	1.15***	(1.10 - 1.20)
Respondent's age	1.01**	(1.00 - 1.01)
Number of children	0.94***	(0.92 - 0.96)
Parity (Number of live births)	0.84***	(0.82 - 0.85)
Autonomy	1.01	(0.99 - 1.03)
Pregnancy complications (ref: None)		
Yes	1.16***	(1.11 - 1.20)
Visit by health worker (ref: No)		
Yes	1.32***	(1.27 - 1.38)
Household level variables		
Wealth Quintile (ref: Poorest quintile)		
Poorer	1.29***	(1.22 - 1.36)
Middle	1.64***	(1.54 - 1.74)
Richer	2.07***	(1.90 - 2.25)
Richest	3.48***	(3.10 - 3.91)
Place of residence (ref: Urban)		

Rural	0.96	(0.89 - 1.03)
Region (ref: South)		
North	0.35***	(0.31 - 0.40)
Central	0.25***	(0.22 - 0.28)
East	0.28***	(0.25 - 0.32)
Northeast	0.24***	(0.21 - 0.27)
West	0.56***	(0.48 - 0.65)
Distance to health facility (ref: Not a problem)		
Big problem	0.79***	(0.76 - 0.83)
Constant	5.26***	(4.30 - 6.43)

***p<0.001, ** p<0.01, * p<0.05

Supplementary Table 5. Multivariate logistic regression results for each outcome measure: Odds Ratios (AOR) (95% Confidence Interval), subsample of women with no pregnancy complications, NFHS-4, 2015-16

	Early Initiation of ANC Model 1 N=82,401		Frequency of ANC (4 or more Model 2 N=82,401		Frequency of ANC (8 or Model 3 N=82,401		Institutional delivery Model 4 N=83,193	
	Odds ratio	CI	Odds ratio	CI	Odds ratio	CI	Odds ratio	CI
Male Partner Attendance (Ref: Male partner not present)								
Male partner present	1.16***	(1.10 - 1.24)	1.79***	(1.67 - 1.91)	1.50***	(1.36 - 1.65)	1.38***	(1.29 - 1.47)
Individual level variables								
Education (ref: No education)								
Primary	1.05	(0.97 - 1.12)	1.42**	(1.32 - 1.52)	1.41***	(1.25 - 1.59)	1.07	(0.98 - 1.16)
Secondary	1.15***	(1.08 - 1.22)	1.54**	(1.44 - 1.65)	1.78***	(1.60 - 1.97)	1.60***	(1.47 - 1.74)
Higher	1.28***	(1.15 - 1.43)	1.64**	(1.48 - 1.82)	2.09***	(1.82 - 2.39)	2.90***	(2.46 - 3.41)
Caste (ref: General)								
Scheduled Caste (SC)	0.93	(0.85 - 1.01)	0.90*	(0.83 - 0.98)	0.97	(0.87 - 1.08)	0.94	(0.85 - 1.05)
Scheduled Tribe (ST)	1.03	(0.92 - 1.15)	1.02	(0.91 - 1.14)	0.84*	(0.73 - 0.96)	0.69***	(0.60 - 0.79)
Other Backward Classes (OBC)	1.01	(0.94 - 1.08)	0.77***	(0.72 - 0.83)	0.84***	(0.77 - 0.92)	0.99	(0.90 - 1.09)
Religion (ref: Hindu)								
Muslim	1.08	(0.99 - 1.17)	0.97	(0.87 - 1.08)	1.08	(0.99 - 1.17)	0.53***	(0.48 - 0.59)
Others	0.93	(0.81 - 1.07)	1.20**	(1.05 - 1.36)	0.93	(0.81 - 1.07)	0.69***	(0.60 - 0.80)
Age at Marriage (ref: Below 18 years)								
18 years and older	1.08**	(1.03 - 1.14)	1.00	(0.95 - 1.05)	1.04	(0.97 - 1.11)	1.17***	(1.10 - 1.25)
Respondent's age	1.00	(0.99 - 1.01)	1.02***	(1.01 - 1.02)	1.03**	(1.02 - 1.03)	1.01**	(1.00 - 1.02)
Number of children	0.95***	(0.93 - 0.98)	0.91***	(0.89 - 0.94)	0.95*	(0.91 - 0.99)	0.95***	(0.91 - 0.98)
Parity (Number of live births)	0.94***	(0.92 - 0.97)	0.84***	(0.82 - 0.86)	0.84**	(0.80 - 0.87)	0.80**	(0.78 - 0.82)
Visit by health worker (ref: No)								
Yes							1.19***	(1.12 - 1.27)
Household level variables								
Wealth Quintile (ref: Poorest quintile)								
Poorer	1.12**	(1.05 - 1.20)	1.41***	(1.31 - 1.50)	1.28**	(1.13 - 1.45)	1.33***	(1.23 - 1.44)
Middle	1.29***	(1.20 - 1.40)	1.61***	(1.49 - 1.74)	1.46**	(1.29 - 1.66)	1.73***	(1.58 - 1.90)
Richer	1.51***	(1.37 - 1.67)	1.89***	(1.74 - 2.07)	1.65**	(1.44 - 1.90)	2.15***	(1.90 - 2.44)
Richest	1.92***	(1.71 - 2.16)	2.42***	(2.15 - 2.72)	2.27**	(1.93 - 2.66)	3.67***	(3.13 - 4.31)
Place of residence (ref: Urban)								
Rural	1.00	(0.92 - 1.09)	0.80***	(0.73 - 0.87)	0.91*	(0.83 - 0.99)	0.90	(0.80 - 1.01)

Region (ref: South)								
North	0.74***	(0.66 - 0.82)	0.24***	(0.22 - 0.26)	0.19**	(0.18 - 0.22)	0.40***	(0.34 - 0.47)
Central	0.58***	(0.53 - 0.63)	0.18***	(0.16 - 0.19)	0.13**	(0.12 - 0.14)	0.27***	(0.24 - 0.31)
East	0.61***	(0.55 - 0.67)	0.38***	(0.35 - 0.42)	0.36**	(0.32 - 0.40)	0.30***	(0.26 - 0.35)
Northeast	0.67***	(0.60 - 0.74)	0.35***	(0.31 - 0.39)	0.12**	(0.11 - 0.14)	0.31***	(0.27 - 0.37)
West	1.05	(0.93 - 1.19)	0.75**	(0.64 - 0.88)	0.91	(0.81 - 1.01)	0.64***	(0.54 - 0.76)
Distance to health facility (ref: Not a								
Big problem	0.85***	(0.80 - 0.91)	0.87***	(0.82 - 0.93)	0.82**	(0.76 - 0.89)	0.81***	(0.76 - 0.87)
Constant	2.57***	(2.03 - 3.24)	1.70***	(1.37 - 2.10)	0.18**	(0.14 - 0.24)	9.10***	(6.89 - 12.02)

***p<0.001, ** p<0.01, * p<0.05

Supplementary table 6. Multivariate logistic regression predicting exclusion (missing data as outcome): Adjusted Odds Ratios (AOR) (95% Confidence Interval) (N= 178,247)

	Missing data Model 1 N=178,247	
	Odds ratio	CI
Individual level variables		
Education (ref: No education)		
Primary	0.64***	(0.60 - 0.67)
Secondary	0.55***	(0.53 - 0.58)
Higher	0.52***	(0.47 - 0.58)
Caste (ref: General)		
Scheduled Caste (SC)	1.07	(0.99 - 1.15)
Scheduled Tribe (ST)	0.99	(0.91 - 1.08)
Other Backward Classes (OBC)	1.24***	(1.16 - 1.33)
Religion (ref: Hindu)		
Muslim	1.12***	(1.05 - 1.21)
Others	0.88**	(0.78 - 0.98)
Age at Marriage (ref: Below 18 years)		
18 years and older	0.90***	(0.86 - 0.93)
Respondent's age	1.01***	
Number of children	1.08***	(1.00 - 1.01)
Parity (Number of live births)	1.14***	(1.06 - 1.10)
Pregnancy complications (ref: None)		
Yes	0.89***	(0.85 - 0.92)
Household level variables		
Wealth Quintile (ref: Poorest)		
Poorer	0.60***	(0.57 - 0.62)
Middle	0.46***	(0.43 - 0.49)
Richer	0.38***	(0.36 - 0.42)
Richest	0.30***	(0.27 - 0.34)
Place of residence (ref: Urban)		
Rural	0.97	(0.90 - 1.04)
Region (ref: South)		
North	1.61***	(1.44 - 1.80)
Central	1.93***	(1.75 - 2.13)

East	2.32***	(2.09 - 2.56)
Northeast	1.57***	(1.38 - 1.79)
West	1.44***	(1.26 - 1.64)
Distance to health facility (ref: Not a problem)		
Big problem	1.26***	(1.21 - 1.32)
Constant	0.14***	(0.12 - 0.17)

***p<0.001, ** p<0.01, * p<0.05

Figure 13. Marginsplot depicting predicted probability of early initiation of antenatal care among women who reported male partner attendance, by region and place of residence

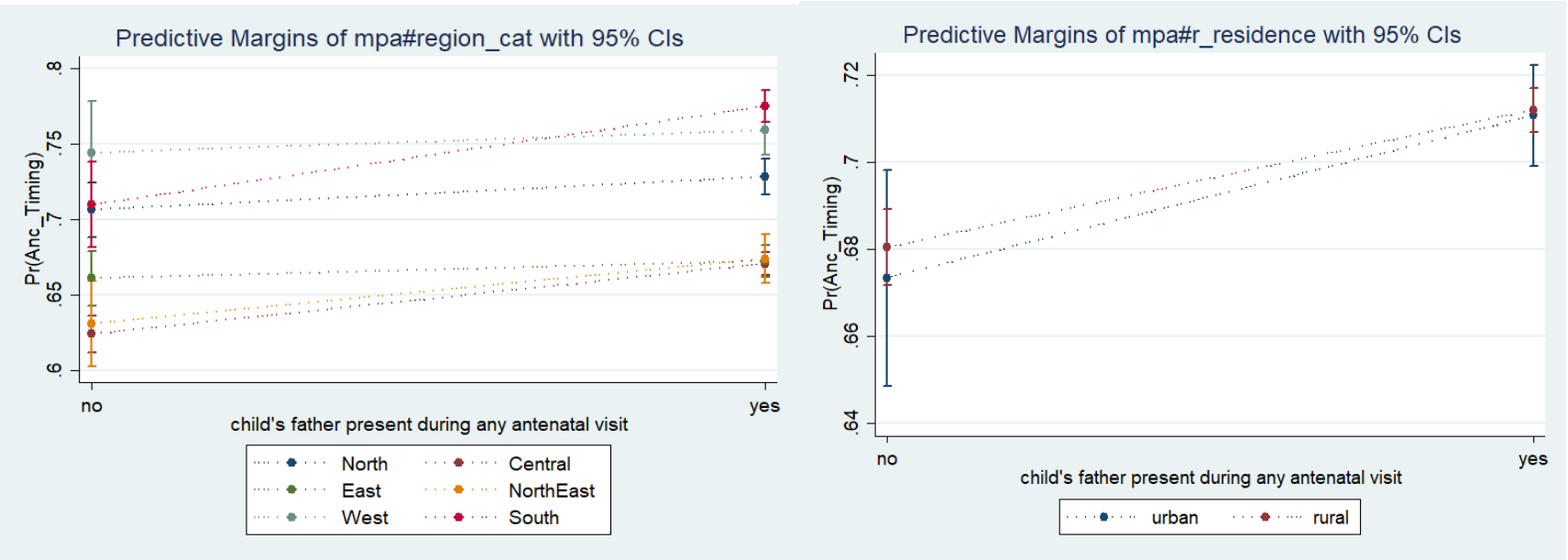


Figure 14. Marginsplot depicting predicted probability of frequency of antenatal care (4 or more antenatal care contacts) among women who reported male partner attendance, by region and place of residence

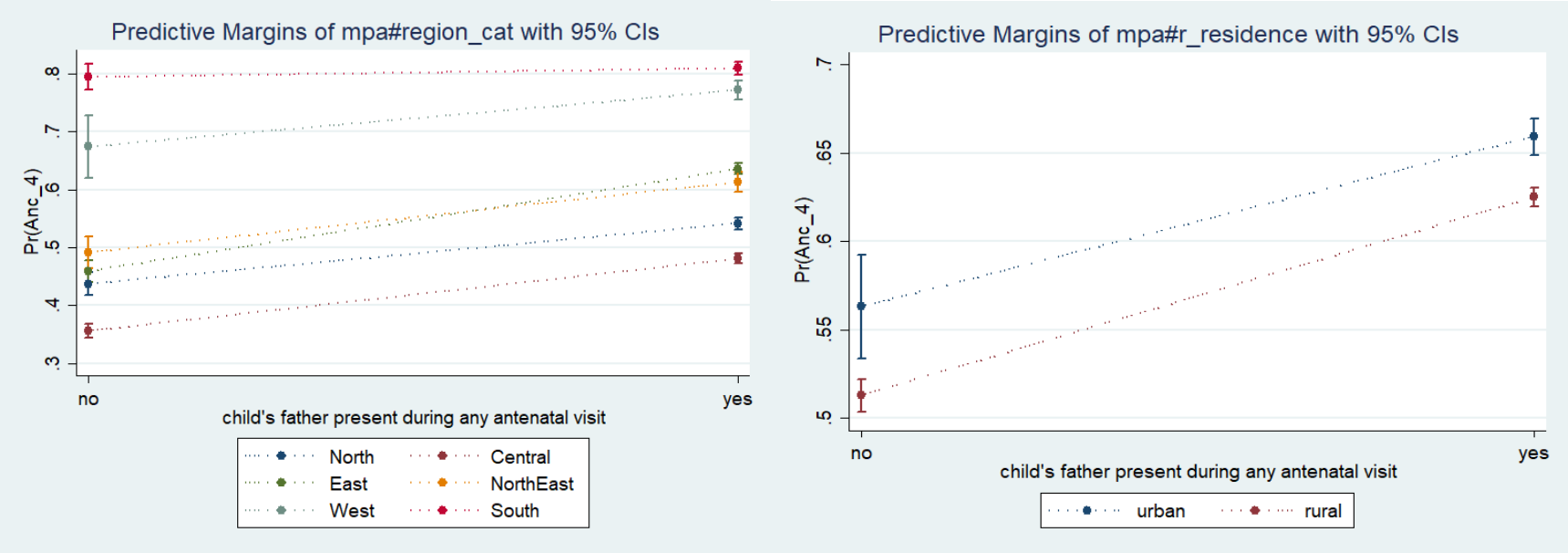


Figure 15. Marginsplot depicting predicted probability of frequency of antenatal care (8 or more antenatal care contacts) among women who reported male partner attendance, by region and place of residence

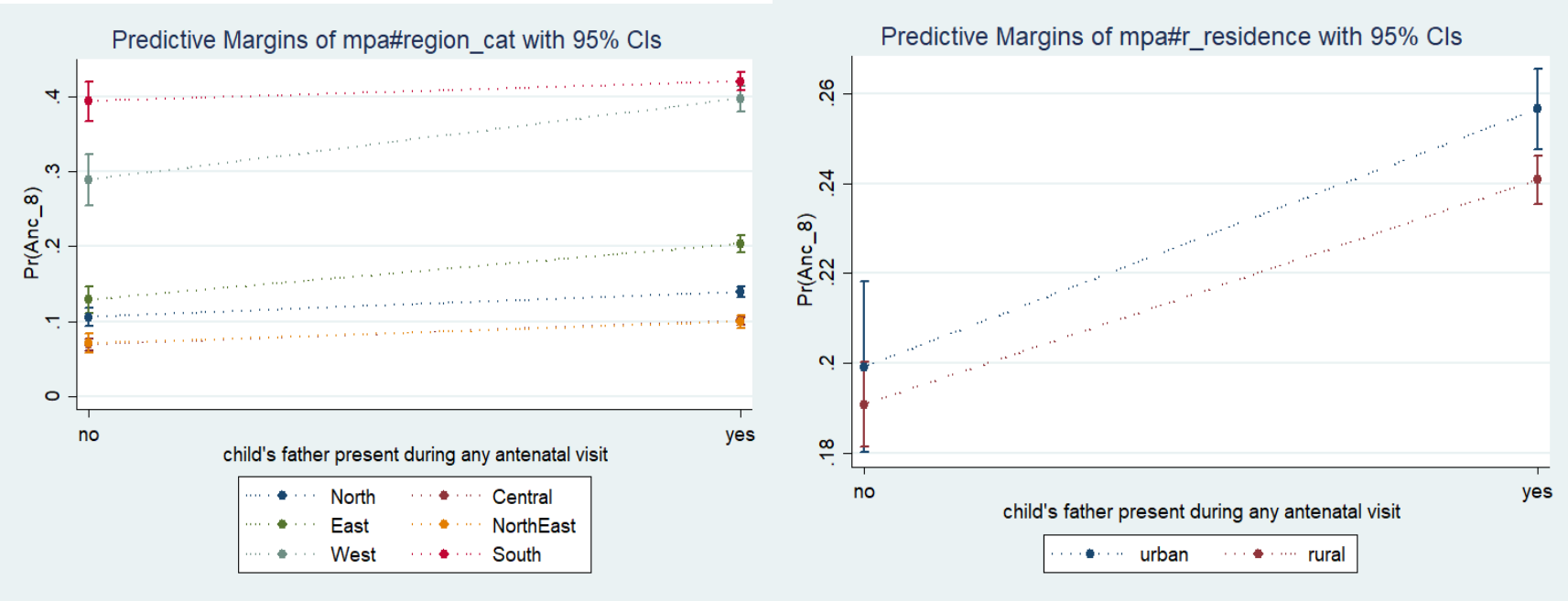
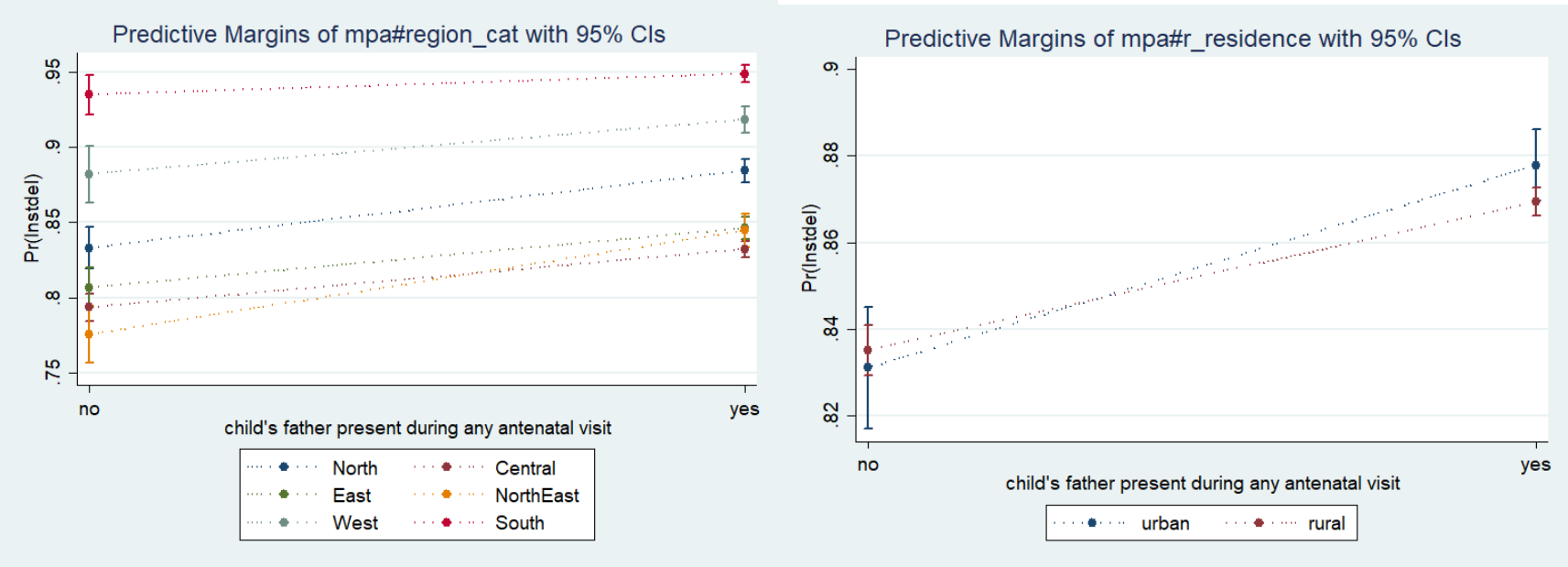


Figure 16. Marginsplot depicting predicted probability of institutional delivery among women who reported male partner attendance, by region and place of residence



CHAPTER IV. Examining the effects of antenatal care and male partner attendance on infant birth weight

Background

The first four weeks of life are often the most crucial. Estimates show that in 2019, globally, about 2.4 million children died during the first 28 days of life; and neonatal mortality due to preventable causes constituted about 47% of all deaths among children under five years (World Health Organization, 2020). According to research, complications due to preterm birth and low birth weight are one of the most important predictors of neonatal mortality (Larroque, Bertrais, Czernichow, & Léger, 2001; Risnes et al., 2011). While the prevalence of low birth infants worldwide varies considerably by region, estimates show that a large majority of low birth weight births occur in low- and middle-income countries, with South Asia accounting for about one-third of all low birth infants (World Health Organization, 2014). More specifically in India, although there has been a reduction in the prevalence of low birth weight infants (25% in 1991-92 to 18% in 2015-16), this number still remains unacceptably high (IIPS, 2018).

Numerous individual and environmental factors influence infant birth weight. Research shows that socio-demographic factors such as low maternal age, lack of education and low household income, unemployment and residence in an urban area; as well as, biological factors such as high body mass index, pregnancy complications, and anemia have all been associated with increased risk for low infant birth weight (Paul et al., 2020; Bhowmik et al., 2019; Demelash et al., 2015; Gebremedhin et al., 2015; Manyeh et al., 2016; Singh et al., 2017). In addition, environmental factors such as in

utero exposure to tobacco smoke (Salmasi et al., 2010) and highly polluting cooking fuels (Singh et al., 2017) have also been associated with increased odds of low birth weight among infants. Interestingly, studies examining determinants of low birth weight in India also found that female infants and first-born infants were more likely to have low birth weight (Apte et al., 2019). Additionally, a study in India that used infant birth weight as a continuous measure in grams found that maternal social capital was also positively associated with infant birth weight. In particular, membership in a women's group or a religious group was associated with higher infant birth weight (Lee et al., 2019).

Apart from individual and environmental factors, there is also considerable research documenting the positive influence of antenatal care on infant birth weight (da Fonseca et al., 2014; Hueston et al., 2003; Khanal et al., 2014; Pinzón-Rondón et al., 2015; Servan-Mori et al., 2016; Zhou et al., 2019). Studies found that adjusting for gestational age, women who had less than seven antenatal care visits were more likely to deliver a low birth weight infant (da Fonseca et al., 2014; Servan-Mori et al., 2016), and women who received no antenatal care were about twice as likely to deliver a low birth weight infant (Pinzón-Rondón et al., 2015). Similar evidence has been documented by studies from South Asia. For instance, a study using the Nepal Demographic and Health Survey found that women not attending antenatal care were about twice as likely to deliver a low birth weight infant than those who attended antenatal care (Khanal et al., 2014). Evidence from a more recent community-based study from China found that the odds of low birth weight were lower among women with a higher frequency of antenatal care visits and those who received adequate antenatal care (Zhou et al., 2019). Studies from India also found similar results; and, the findings demonstrate that women who had

4 or more antenatal care contacts (Kader & Perera, 2014; Zaveri, Paul, Saha, Barman, & Chouhan, 2020), and received adequate antenatal care (Khan, Mozumdar, & Kaur, 2019) were significantly less likely to deliver low birth weight infants.

Although not as well documented, research also shows that male involvement in maternal care is an important predictor of infant birth weight. Studies based in the United States have shown that missing paternal information (used as a proxy for the lack of paternal involvement) was associated with increased odds of low birth weight, including both preterm and small for gestational age infants (Alio, Kornosky, Mbah, Marty, & Salihu, 2010; Alio et al., 2011; Cheng, Hawkins, Rifas-Shiman, Gillman, & Taveras, 2016), with pronounced adverse effects among black women (Alio et al., 2011). Only one recent study from India that utilized data collected from a city hospital in Gujarat found that women who reported low paternal support and low levels of male partner attendance in antenatal care were more likely to deliver a low birth weight infant (Godbole et al., 2020).

Gap in literature:

While there has been extensive research on the socio-economic, biological and environmental determinants of low infant birth weight (Lee et al., 2019; Apte et al., 2019), few studies have assessed the association between antenatal care and infant birth weight in India (Kader & Perera, 2014; Khan et al., 2019; Zaveri et al., 2020). Although two studies using the National Family Health Survey (NFHS-4) have found a positive effect of adequate antenatal care and frequency of antenatal care contacts (4 or more) on infant birth weight (Kader & Perera, 2014; Zaveri, Paul, Saha, Barman, & Chouhan, 2020), neither study assessed the effect of early initiation of care during pregnancy, nor

examined the separate components of antenatal care (receipt of tetanus toxoid injection, testing, counselling). Further, these studies have not considered the recent WHO recommendation of 8 or more antenatal care contacts, and its role in influencing infant birth weight. More importantly, despite the documented association between paternal involvement and infant birth weight, none of the studies from India have controlled for the effect of male partner attendance.

Within the Indian context, where neonatal mortality rates are high, examining key predictors such as infant birth weight is particularly important. While it is crucial to assess associations between antenatal care and low infant birth weight, it is also useful to understand how the effect of antenatal care on birth weight varies across groups of women based on their report of male partner attendance at antenatal care. The objective of this study is to investigate the association between frequency, timing and components of antenatal care and infant birth weight, controlling for male partner attendance. Additionally, I also examine the interaction effects of antenatal care with male partner attendance on infant birth weight.

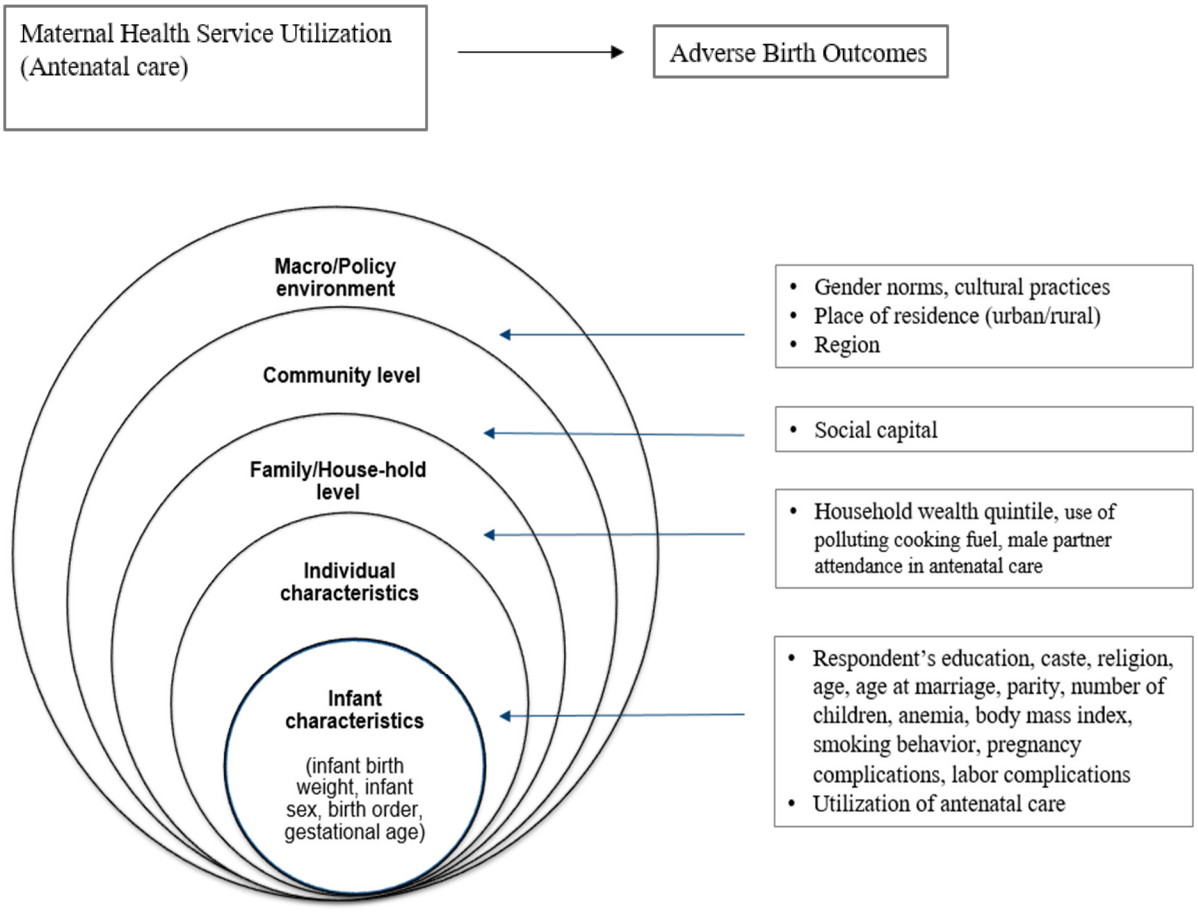
Theoretical framework

Social Ecological Model

The *Social-Ecological Model* proposed by Bronfenbrenner (1977) has often been used as a framework to examine maternal health service utilization (Antai & Adaji, 2012; Kaiser et al., 2019; Shahabuddin et al., 2017). According to the *Social-Ecological Model* (Bronfenbrenner, 1977), multiple systems influence an individual's development and behavior; and, these may range from systems that directly affect the individual such as family or peer relationships, to those that may have a more indirect effect, such as gender

roles and cultural norms. While numerous individual and environmental factors – mother's age, occupation, household income, education, rural place of residence, health problems during pregnancy, body mass index, maternal height, birth order, exposure to tobacco smoke – influence infant birth weight (Bhowmik et al., 2019; Demelash et al., 2015; Gebremedhin et al., 2015; Manyeh et al., 2016; Singh et al., 2017), antenatal care also emerges as a crucial predictor (da Fonseca et al., 2014; Hueston et al., 2003; Khanal et al., 2014; Pinzón-Rondón et al., 2015; Servan-Mori et al., 2016; Zhou et al., 2019). I utilized the *Social-Ecological Model* as a framework to inform maternal health service use and birth outcomes (See figure 17).

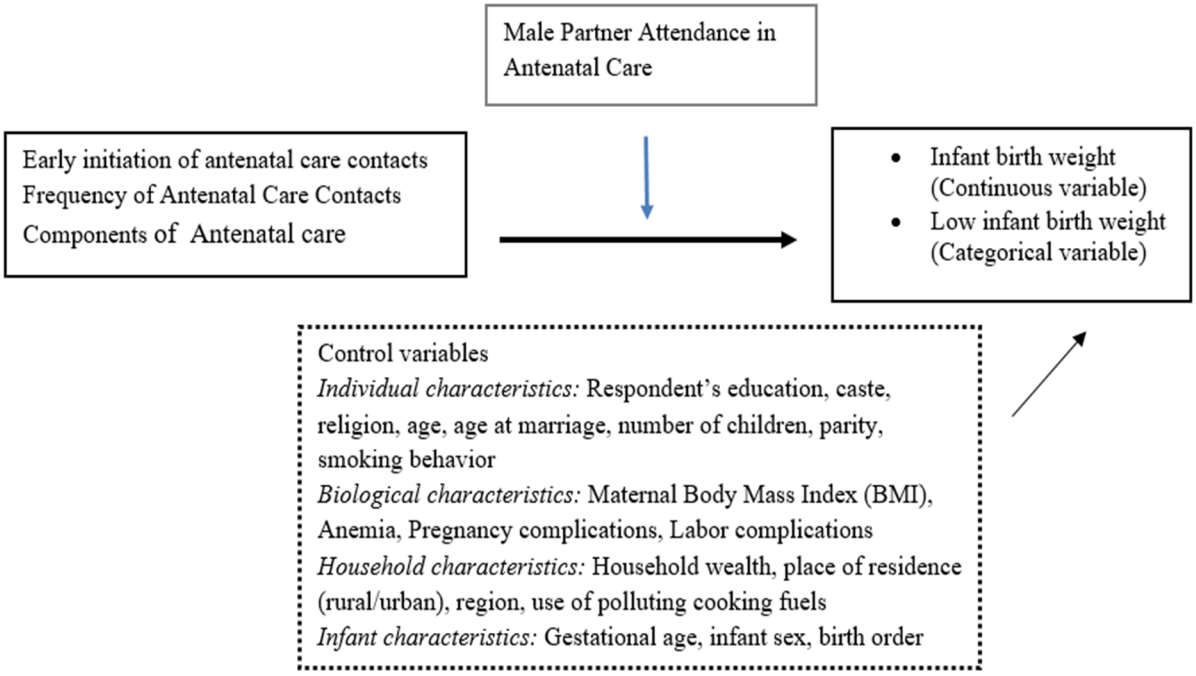
Figure 17. Social Ecological Model to examine the influence of antenatal care on infant birth weight



Applying the Social Ecological Model, this paper examines the influence of women's utilization of antenatal care on infant birth weight, controlling for male partner attendance and other socio-demographic and biological factors. Additionally, it also explores how this association varies based on women's report of male partner attendance in antenatal care. The study questions are:

- What is the association between antenatal care and infant birth weight, after controlling for male partner attendance and other factors?
- Does male partner attendance in antenatal care have an influence on the association between antenatal care and infant birth weight?

Figure 18. Diagram depicting association between antenatal care and infant birth weight, and the interaction effects of male partner attendance with antenatal care on infant birth weight



Methods

Data

In this study, data were used from the National Family Health Survey (NFHS-4) 2015-16. The NFHS-4 is a nationally representative, multi-topic survey undertaken by the International Institute for Population Sciences and Macro International (IIPS, 2017). The sampling design was a stratified two-stage sample with the 2011 census used as the sampling frame; further, urban and rural samples were drawn separately and proportionate to each state. The survey includes data on twenty-nine states and seven union territories. Overall, a sample of 699,686 women with a 97% response rate, and a sample of 112,122 men with a 92% response rate was generated.

Further details of the survey and data collection procedure have been described previously in chapter 1.

Conceptualizing the birth weight variable

The main outcome variable for this study was infant birth weight, available within the survey data as a continuous measure in grams. Although preterm birth is considered the most common cause of low birth weight among infants, low birth weight is multifactorial in nature and can include sub-populations of preterm neonates, small for gestational age neonates at term, as well as a sub-group that consists of an overlap of these groups – that is, preterm *and* small for gestational age neonates (World Health Organization, 2014). However, due to the lack of a precise measure of gestational age (in weeks), this study includes both preterm as well as small for gestational age neonates at term. Instead, gestational age is used as a control variable within the regression model.

Data selection and management

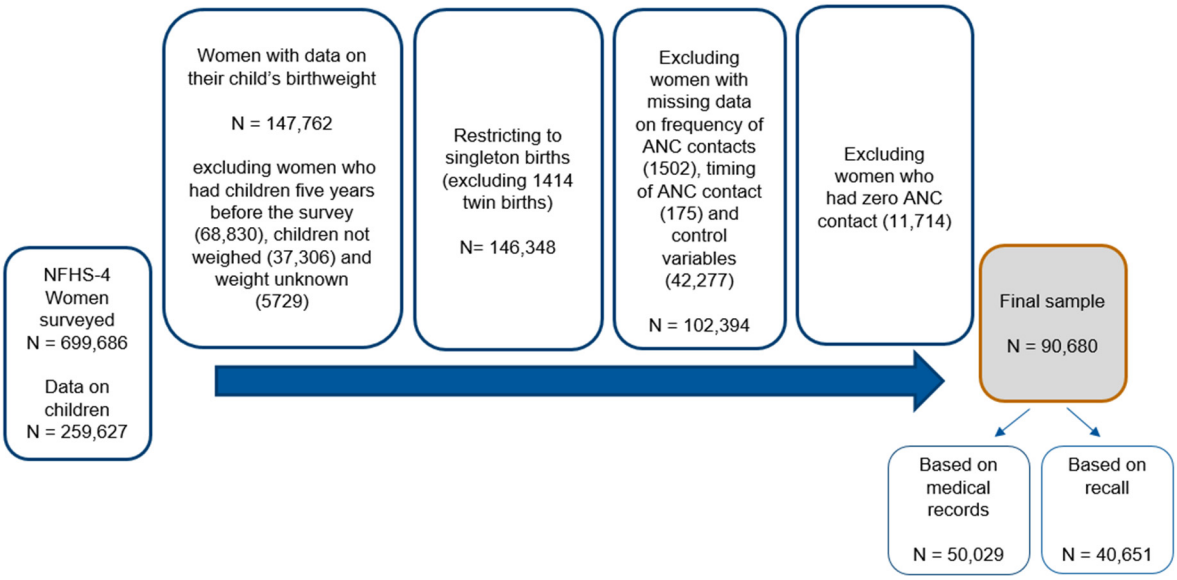
Question on male partner attendance in antenatal care was asked both in men's and women's questionnaire. Since data from male partners was collected only in a subset of households, in this paper I have used data collected from women to maintain a representative sample. In NFHS-4, there are data on 699,686 women aged 15-45 years and information on 259, 627 children. To avoid recall bias, the study was limited to the most recent births in the five years preceding the survey (190,797). Excluding 37,306 respondents whose children were not weighed at birth and 5729 who reported that they did not know their children's birth weight, information on birth weight was available for 147,742 children. Further, to keep the analysis restricted only to singleton children, 1,414 respondents were dropped; and, I excluded those women who had zero antenatal care contacts (11,714). Finally, women with missing data on the timing of ANC contact (175) and frequency of ANC contact (1502), age at marriage (2399), caste (6687), body mass index (BMI) (125), anemia (28,917), type of cooking fuel (8,260) and pregnancy and labor complications (1,493) were excluded to obtain the final analytic sample of 90,680 women. Data selection process is explained in the figure 19.

Further, I examined the associations stratified by report of birth weight (based on medical records or respondent's recall). Estimates were computed for each subpopulation (those who reported birth weight based on medical records, N= 50,029 and those who reported birth weight based on recall, N= 40,651) using the subpop command for survey data, while retaining the full sample in the analyses to calculate correct standard errors.

In order to account for missing data on anemia and cooking fuels, I chose to code the missing data as a separate category to retain these within the sample to carry out

additional supplementary analysis (see supplementary table 12). Further, to account for outliers in the birth weight variable, I restricted the sample to singleton births, and identified additional outliers using the inter-quartile range method (Kwak & Kim, 2017). A supplementary analysis (see supplementary table 11) with the outliers removed showed consistent results, and thus, I chose to retain this data within the sample.

Figure 19. Flowchart for data selection process



Key Variables

Dependent Variables

This study used two dependent variables:

- ***Infant birth weight***[12]***:*** Infant birth weight data measured in grams was used as a continuous variable.

[12] Records of birth weight are based on both written medical records and on recall. In the NFHS- 4, 41% of birth weight data were based on recall (IIPS, 2017). According to research, birth weight based on recall is considered sufficiently accurate in developing countries (Swaminathan et al., 2019).

- ***Low Infant Birth Weight:*** For measuring this variable, I used birth weight data from the last child born within five years preceding the survey. Based on the WHO definition (2014), a child was coded as 1 if having low birth weight (birth weight was less than 2500 grams), otherwise coded as 0. (Gestational age (in months) was included as a control variable within the regression models).

Independent Variables

This study employed five independent variables and a multiplicative term as follows:

- ***Early initiation of antenatal care/Timing of antenatal care:*** To measure *Early Initiation of antenatal* care*,* a dichotomous variable was used based on women's timing of first antenatal care visit. Women who had their first antenatal care contact within 12 weeks of pregnancy were coded as 1 (WHO, 2016), and women who responded that they had their first antenatal care contact at 12 weeks and later were coded as 0.
- ***Frequency of antenatal care contacts***: This variable captures the number of *antenatal care contacts* that a woman had during her pregnancy. It was recoded into a variable with three categories - Less than 4 contacts, 4-7 contacts, 8 or more contacts[13].

This study investigated the association between three individual components of antenatal care that a pregnant woman should receive at a health facility (Ministry of Health and Family Welfare, 2013). (It is important to note that these components in isolation do not

[13] The 2016 WHO recommendation states that women should have at least 8 antenatal care contacts, with the first contact taking place in the first trimester (WHO, 2016).

constitute complete antenatal care. Due to the lack of data on all requisite components of antenatal care as recommended by the WHO (2016), a score defining *complete antenatal care* was not utilized in the main analysis).

- ***Receipt of tetanus toxoid (TT) injection:*** A dichotomous outcome variable was used to measure if a respondent has had at least one tetanus toxoid injection during their visits to antenatal care clinic.
- ***Antenatal care testing:*** A dichotomous variable was used to measure whether women received all the components of antenatal care testing. Women who responded yes to all questions on whether they had been weighed, their blood and urine sample and blood pressure had been taken, and abdomen examined were coded as 1 otherwise as 0.
- ***Antenatal care counselling:*** A dichotomous variable was used to measure whether women received counselling on pregnancy complications. Women who responded that they had been told about pregnancy complications and had been told about where to receive medical help for pregnancy complications were coded as 1 otherwise as 0.
- ***Male partner attendance in antenatal care:*** To measure male partner attendance in antenatal care, I used a dichotomous variable, based on whether male partner was present during at least one antenatal check-up. Males who accompanied their wives for at least one antenatal care visit were coded as 1, otherwise as 0.
- ***Male partner attendance as a moderator:*** Finally, to assess if the relationship between antenatal care use and infant birth weight varies by male partner

attendance in antenatal care, a multiplicative term (antenatal care*male partner attendance) was included in all models.

Control Variables

Within the multivariable logistic regression models, I controlled for respondent's individual characteristics (respondent's education, caste, religion, age, age at marriage, number of children, parity, smoking behavior), biological characteristics (maternal BMI, anemia, pregnancy and labor complications), infant characteristics (infant sex, gestational age and birth order) and household characteristics (household wealth index, place of residence, region, type of cooking fuel used). Predictor variables and their operational definition included in the analyses are detailed in supplementary table 14 in the appendix 1.

Statistical analyses

As part of the study I first conducted weighted (probability weights) descriptive statistics to examine the socio-demographic and biological characteristics of the respondent and the infant characteristics. Following this, I used adjusted multivariable linear and logistic regression analysis to assess the association between infant birth weight and three aspects of antenatal care separately: (1) early initiation/timing of antenatal care, (2) frequency of antenatal care contacts and (3) components of antenatal care (receipt of tetanus toxoid injection, antenatal testing and counselling on pregnancy complications). For each aspect of antenatal care, I conducted three separate multivariable logistic regression analyses and reported the Odds Ratio (OR) and 95% confidence interval (CI). Each of the models was adjusted for gestational age; furthermore, I controlled for male partner attendance in antenatal care within all

regression models. For each aspect of antenatal care, the first model used the subsample of women's report of infant birth weight based on medical records only, the second model used the subsample of women's recall of infant birth weight only, and the third model used the full sample of women who either presented medical records of their infant's birth weight or were able to recall the birth weight of their infant at the time of the interview. Next, I included a multiplicative term (Male partner attendance in antenatal care*antenatal care) in each model to assess the varying effect of antenatal care on birth weight among groups of women based on their report of male partner attendance.

The following multivariable logistic regression model estimates the odds of low infant birth weight, where X1 is a vector of respondent's characteristics (respondent's education, caste, religion, age, age at marriage, number of children, parity, smoking behavior), X2 is a vector of biological factors (body mass index, pregnancy complications, labor complications, anemia), X3 is a vector of infant characteristics (infant sex, gestational age, birth order), X4 is a vector of household characteristics (household wealth index, place of residence, region, type of cooking fuel), X5 is a vector for male partner attendance in antenatal care, and X6 is vector for antenatal care utilization for individual i; and X7 will represent the multiplicative term.

Logistic regression model

$$y = \begin{cases} 0 \text{ if child does not have low birth weight} \\ 1 \text{ if child has low birth weight} \end{cases}$$

$$Logit\ p\ (y_i = 1) = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 X_{i4} + \beta_5 X_{i5} + \beta_6 X_{i6} + \beta_7 (X_{i6} * Male\ attendance\ in\ Antenatal\ Care)$$

In this equation, β_0 is the intercept and, β_1, β_2, β_3, β_4, are the coefficients associated with each of covariates, β_5 is associated with the predictor variable. y_i is an indicator variable

that represents log odds of low infant birth weight. β_7 (X*Male partner attendance in antenatal care) represents the interaction effect between antenatal care and male partner attendance in antenatal care.

In a supplementary analysis, these models were replicated using infant birth weight as a continuous variable. Thus, for each aspect of antenatal care, three separate linear (OLS) regression models were constructed using the full sample, subsample based on medical records and subsample based on recall respectively. The same set of variables as in the logistic regression, served as predictors in this model.

Linear model with multiplicative term:

$$y_i = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i3} + \beta_4 X_{i4} + \beta_5 X_{i5} + \beta_6 X_{i6} + \beta_7 (X_{i6} * \textit{Male attendance in Antenatal Care}) + \varepsilon_i$$

In an additional supplementary analysis, I replicated these models removing outliers in infant birth weight identified using the inter-quartile range method (sample was restricted to the range of 1750-3750 grams; N = 83413).

Data analyses was conducted using the statistical package Stata SE version 14.2 (Stata Corp, College Station, TX). In order to account for the complex sample design, survey weights were used to obtain representative estimates.

Research Ethics

In alignment with the ethical guidelines, permission was received from Boston College Institutional Review Board (IRB) for the analysis of secondary data utilized in this study.

Results

The socio-demographic and geographical characteristics of the respondents are provided in Table 4.1. Within the full sample, 16% of women reported having low birth

weight infants and average birth weight of infants within the sample was 2823.44 grams. In terms of antenatal care, 16% of women reported not receiving any antenatal care at all. Of the women who had at least one antenatal care contact, 84% reported that the male partner was present during antenatal care. Further, among the women who had at least one antenatal care contact, around 72% of women reported early initiation of antenatal care (at 12 weeks or less), around 39% women reported having 4-7 antenatal care contacts and about 27% reported having 8 or more antenatal care contacts. Furthermore, 95% of women reported receiving at least one tetanus toxoid injection, 96% reported receiving antenatal care testing and about 80% reported receiving counselling on pregnancy complications.

About 19% of the sample reported having no formal education, and the majority of women were educated till secondary school level (up to 9th grade). The majority of women were Hindu and belonged to Other Backward Classes (OBC) caste; and, about 35% of women belonged to households classified as being in the lowest wealth quintiles. Around three-fourths of the women were rural and a large proportion belonged to the Central, Eastern and Southern regions. The average age of the women was 27 years and most reported having either 1 or 2 children. About 34% of women reported being married before 18 years of age. In terms of biological characteristics, about 58% of respondents had BMI in the range of 18.5-24.9, and about 41% reported not being anemic. Among the survey respondents, about 42% of women reported having pregnancy complications and about 56% reported having labor complications during their most recent pregnancy.

The study results show some inconsistencies in sample characteristics based on method of reporting infant birth weight (medical records or recall) (Table 4.1). As

compared to the subsample of women who had medical records, a higher proportion of women who reported infant birth weight from recall had no education (23%), reported higher parity (2.19) and absence of male partner at antenatal care (17%), had fewer than 4 antenatal care contacts (39%) and were predominantly from the Central region of India (31%). Further, results from multivariable regression models show some inconsistencies based on the method of reporting infant birth weight (medical records or recall). Thus, to avoid recall bias I have chosen to focus on the results for the subsample of infant birth weight based only on medical records.

*Logistic regression model examining the relationship between **early initiation of antenatal care** (commencing antenatal care at 12 weeks or less) and infant birth weight*

According to results for the subsample based only on medical records (Table 4.1, Model 1a), women's education, caste, household wealth, age, age at marriage, parity, birth order, child's gender, mother's BMI, smoking, place of residence and region were significantly associated with low birth weight in infants (see table 4.2, Model1a). Controlling for male partner attendance and all other factors, the results show that early initiation of antenatal care was associated with an 8% reduced likelihood of low birth weight among infants (OR= 0.92, 95% CI [0.85 - 1.00]). Further, an interaction term was added to Model 1a, retaining all other control variables. The results show that the effect of early initiation of antenatal care on infant birth weight did not vary based on male partner attendance (see model 1b).

In Model 1a, women with higher secondary education were less likely to deliver a low birth weight infant (OR= 0.78, 95% CI [0.66, 0.92]) as compared to women with no formal education. Women belonging to wealthier households were about 30% less likely (OR= 0.69, 95% CI [0.57 - 0.83]) to deliver a low birth weight infant with reference to

those belonging to the poorest households. Further, age at marriage was also significantly associated with low birth weight, such that, women married at 18 years and older were 10% less likely to deliver a low birth weight infant (OR= 0.90, 95% CI [0.83 - 0.98]). In addition to these, the odds of low birth weight were lower among women with higher parity (OR= 0.94, 95% CI [0.89, 0.99]) and appropriate BMI levels (OR= 0.76, 95% CI [0.69, 0.82]. It is also interesting to note the effect of place of residence on birth weight, such that women who lived in rural areas were 9% (OR= 0.91, 95% CI [0.83 - 1.00]) less likely to deliver a low birth weight infant. In terms of region, compared to women in Southern region, those living in Northern and Central, and Western region were more likely to deliver a low birth weight infant; while those living in Eastern and North-Eastern region were less likely to deliver a low birth weight infant. In contrast, belonging to Scheduled Tribes (OR=1.20, 95% CI [1.04 – 1.38]) was associated with increased odds of having a low birth weight infant. Additionally, the odds of low birth weight were higher among women who reported that they smoked cigarettes (OR=1.36, 95% CI [1.06 – 1.74]), and among female infants (OR= 1.19, 95% CI [1.11 - 1.27]) and first born infants (OR=1.32, 95% CI [1.18 - 1.47]).

Controlling for other factors, several individual level variables were not significantly associated with infant birth weight. For example, male partner attendance, religion, number of children, use of polluting fuels, anemia and pregnancy and labor complications were not associated with odds of low infant birth weight.

In the analyses of sub-sample of women who recalled birth weight (Model 2a), the relationship between early initiation of antenatal care and infant birth weight was

inconsistent. In this model, controlling for all variables, there was no association between early initiation of antenatal care and infant birth weight.

*Results of Logistic regressions examining the association between the **frequency of antenatal care** contacts and infant birthweight*

Based on the results from the sub-sample including women who only reported birth weight based on medical records (Table 4.3, Model 1a) there was no significant association between frequency of antenatal care and infant birth weight. Despite this, the results from the model including the interaction term (table 4.3, model 1b) showed that the effect of women having 4-7 antenatal care contacts on infant birth weight varied by report of male partner attendance, such that among women in this category, those who reported being accompanied by their male partner to antenatal care were less likely to deliver a low birth weight infant as compared to those who reported that the male partner was absent (OR= 0.80, 95% CI [0.64 – 1.00]). However, I interpret these results with caution as they are not consistent across subsamples and there is no observed direct effect of either frequency of antenatal care contacts or male partner attendance on infant birth weight.

Similar to the previous model, the findings of this model show that women with higher education, women from wealthier households, those with higher parity, appropriate BMI, women residing in rural areas and those living in Eastern and North-Eastern region were less likely to deliver a low birth weight infant as compared to their counterparts (see table 4.3, model 1a). Further, the results show that the odds of low birth weight were higher among female infants and first-born infants. Additionally, maternal smoking and higher maternal age were associated with increased odds of low birth weight among infants. Also, women belonging to Scheduled Tribes were more likely to

deliver a low birth weight infant than women belonging to the General caste category. Overall, religion, age, number of children, use of polluting fuels, and labor complications were not associated with low birth weight among infants.

In this case, the analysis with the subsample of mothers who reported infant birth weight based on recall is consistent with the model based on medical records and shows no association between frequency of antenatal care and infant birth weight (see Table 4.3, Model 2a).

Results from Logistic regressions examining the relationship between ***components of antenatal care (receipt of TT injection, testing, antenatal counselling on pregnancy complications)*** *and infant birth weight*

According to results for the subsample based only on medical records (Table 4.4, Model 1a), the study results show that receiving tetanus toxoid (TT) injection, women's education, household wealth, caste, age at marriage, age, parity, birth order, child's gender, mother's BMI, maternal smoking behavior, place of residence, and region were significantly associated with odds of having a low birth weight infant (see table 4.4, model 1a). Controlling for male partner attendance, gestational age and all other variables, the results show that receipt of tetanus toxoid injection (maternal immunization) was associated with 21% reduced likelihood of low birth weight among infants (OR= 0.79, 95% CI [0.69 - 0.92]). There was no statistically significant association between antenatal care testing, antenatal counseling and infant birth weight.

According to Model 1b, the interaction of receipt of tetanus toxoid injection and male partner attendance was not significant. However, the interaction of antenatal testing with male partner attendance (OR= 0.57, 95% CI [0.37 – 0.87]) and interaction of antenatal counselling with male partner attendance (OR = 0.71, 95% CI [0.56 – 0.90])

showed a significant association with infant birth weight (see Model 1c and Model 1d). I interpret these results with caution as there is no observed direct effect of either antenatal testing or counselling on infant birth weight.

Like previous models, adjusting for gestational age, women who had higher secondary education and those belonging to wealthier households were less likely to deliver a low birth weight infant as compared with their counterparts. Further, women married at 18 years or older were less likely to have a low birth weight infant, as compared to those married as young adolescents. Additionally, the odds of low birth weight were lower among women with higher parity and appropriate BMI. Similar to previous models, women who lived in urban areas and those living in Northern and Central, and Western region were more likely to deliver a low birth weight infant, while those living in Eastern and North-Eastern region were less likely to deliver a low birth weight infant as compared to rural women and women from the Southern region. Further, women belonging to Scheduled Tribes (ST) were more likely to deliver a low birth weight infant than women belonging to the General category. Similar to previously reported models, controlling for all other factors, the odds of low birth weight were higher among female infants and first-born infants. Further, women who reported that they smoke cigarettes were more likely to deliver a low birth weight infant. Overall, antenatal testing (weight, urine and blood sample, blood pressure taken, abdomen examined) and antenatal counselling on pregnancy complications, religion, number of children, use of polluting fuels, anemia and pregnancy and labor complications had no association with odds of low birth weight.

In the sub-sample analyses that included only the women who reported birth weight based on recall (Table 4.4, Model 2a), none of the components of antenatal care showed a direct effect on infant birth weight. Further, the interaction terms of components of antenatal care with male partner attendance also showed no statistically significant association with infant birth weight.

Results from supplementary linear regression analyses using infant birth as a continuous variable

The results from the linear regression models show fairly consistent results. From the results presented in Supplementary Table 8, Model 1a, we see that there is no statistically significant association between frequency of antenatal care contacts and infant birth weight. In contrast to the findings from the logistic regression model, the results provided in Supplementary Table 7, Model 1a shows no significant association between early initiation of antenatal care and infant birth weight. With respect to the models depicting the components of antenatal care (supplementary table 9, model 1a, 2a, 3a), there is a positive and statistically significant effect of receipt of tetanus toxoid injection in the full sample (model 3a) however, this disappears in the subsample based on medical records. Results from the linear regression models (supplementary table 7, Model 1b - 3b; supplementary table 8, model 1b-3b; supplementary table 9, model 1b-3b) show that there is no statistically significant interaction effect of antenatal care with male partner attendance on infant birth weight.

Results from supplementary analysis predicting complete antenatal care (as a score)

Findings from the full sample show that every unit increase in the score for complete antenatal care was associated with a 2% reduced odds of low birth weight among infants (see supplementary table 10, model 3a). Further, on adding an interaction

term (interaction with male partner attendance), results show that the positive effect of complete antenatal care on infant birth weight was higher among women that reported male partner attendance, in comparison to women who reported that the male partner did not accompany them to antenatal care. However, these results are not consistent across sub-samples. The findings from the sub-sample of women who reported infant birth weight based only on medical records show no association between complete antenatal care (score) and infant birth weight.

Discussion

In this study, I examined the association between antenatal care and infant birth weight, and tested the variation in this relationship based on women's report of male partner attendance. I examined these models for the full sample, as well as with subpopulations stratified by the method of birth weight reporting – written medical records or mothers' recall. Overall, the study results based on medical records show that antenatal care had a positive effect on infant birth weight. Among the aspects that were examined, the study results found that early initiation of antenatal care and receipt of tetanus toxoid injection was associated with reduced odds of low birth weight among infants. However, I obtained mixed results regarding the interaction effects of antenatal care with male partner attendance on birth weight. Apart from antenatal care, the study results also found that higher education and household wealth, rural residence, being married at 18 years and above, higher parity and having normal BMI were associated with reduced odds of low infant birth weight; while, older maternal age, maternal smoking, belonging to Scheduled Tribes (ST), female gender of infant, and first birth order were associated with increased odds of having a low birth weight infant.

Prior research shows that beyond biological characteristics of the mother and sex of the infant, there are multiple individual, family, community and broader socio-cultural and policy level factors that influence infant birth weight (Bhowmik et al., 2019; Demelash et al., 2015; Gebremedhin et al., 2015; Manyeh et al., 2016; Singh et al., 2017; da Fonseca et al., 2014; Hueston et al., 2003; Khanal et al., 2014; Pinzón-Rondón et al., 2015; Servan-Mori et al., 2016; Zhou et al., 2019). Thus, the Social Ecological Model provides an appropriate framework to contextualize the multiple predictors of infant birth weight. Bronfenbrenner's (1977) Social-Ecological Model posits that to understand human behavior or development, it is imperative to consider the entire ecological system within which the individual exists. With this framework in place, I have highlighted some of the key findings of the study below:

Positive effect of antenatal care on infant birth weight

One interesting finding of this study was that among women who have had at least one antenatal care contact, early initiation of this contact positively affects infant birth weight. The results of this study show that controlling for gestational age, women who initiated antenatal care within the first trimester of pregnancy were 8% less likely to give birth to a low birth weight infant. It is possible that women who initiated antenatal care early would be more likely to be screened for pregnancy complications, genetic and congenital disorders, iron deficiency and low body mass index, all of which are known to be key predictors of low infant birth weight (Bhowmik et al., 2019; Demelash, Motbainor, Nigatu, Gashaw, & Melese, 2015; Kader & Perera, 2014). Further, early initiation of antenatal care may also lead to women being counselled on pregnancy care and nutrition, have greater awareness of the benefits of health facility births, and to have

received the requisite tetanus injections and iron supplementation that are essential to neonatal health (Singh, Pallikadavath, Ram, & Alagarajan, 2014). This is one of the first studies in India to separately examine the role of early initiation of antenatal care on infant birth weight, and these results add to the evidence base indicating that timing of the first antenatal contact can be crucial to improved infant health outcomes (Moller, Petzold, Chou, & Say, 2017). Furthermore, it highlights the need for future research examining on antenatal care to take into consideration timing of antenatal contact as a crucial component of overall care during pregnancy.

Another finding of this study is that mother's receipt of tetanus toxoid (TT) injection was associated with reduced odds of having a low birth weight infant. Pregnant women are often more susceptible to respiratory illnesses and infections, resulting in outcomes such as fetal death, premature onset of labor and low infant birth weight (Pan American Health Organization, 2017). Apart from this, neonatal tetanus is considered one of most common and fatal infections during the neonatal period, with low birth weight babies having increased odds of death from neonatal tetanus (Fetuga, Ogunlesi, & Adekanmbi, 2010; Lambo & Anokye, 2013). While the results presented here reinforce the overall importance of receiving maternal immunization (Thwaites, 2015), it might be worthwhile to consider the lack of receipt of tetanus vaccination as a potential proxy for quality of health infrastructure. A possible explanation is that women lacking access to maternal immunization may be residing in low-resource settings with poor health infrastructure, which could add to potential risk factors leading to low birth weight infants. Taken together, these findings indicate the need for increased coverage of maternal vaccination, as well targeted interventions aimed at improving infant birth

outcomes among remote areas with poor health infrastructure. Further, as part of receiving comprehensive antenatal care, women should receive tetanus toxoid injections in conjunction with all other components of antenatal care.

Additionally, previous research documents that in comparison to women who had no antenatal care, having 4 or more contacts was associated with reduced odds of low birth weight among infants (Kader & Perera, 2014; Khan et al., 2019; Zaveri et al., 2020). Within this study, I focused on women who have had at least one contact with the health system during their pregnancy; and, the results show that increased frequency of antenatal care contacts did not affect infant birth weight. These contrasting findings may be a result of differences in comparison groups. Most previous studies examining frequency of antenatal care contacts include women with no antenatal care as the reference group. Taken together, these findings could potentially suggest that among those who have received some antenatal care, increased number of contacts may not affect birth weight; on the other hand, women who received no antenatal care may be at the most risk for having low birth weight infants. This presents an important issue for further research. Women who have had no contact with the health system during pregnancy often have lower levels of education, belong to the most vulnerable socio-economic groups and are less likely to access health facilities for delivery or postpartum care (Ali, Dhillon, & Mohanty, 2019). Future research should examine why women do not initiate antenatal care and the barriers to accessing 8 or more antenatal care contacts as per the latest WHO recommendation (World Health Organization, 2016). Further research studies should also consider the varying effects of antenatal care across different comparison groups.

Although the findings provide some insights into the effect of individual components of antenatal care on infant birth weight, it is vital that all pregnant women have access to complete antenatal care, including nutritional interventions, maternal and fetal assessments, preventive measures and mental health interventions (World Health Organization, 2016). Thus, while this dissertation provides crucial information on the effect of individual components of antenatal care on infant birth weight, taken together, it is also important to consider the clinical significance of these findings. Another approach taken to address this issue was the inclusion of a score capturing all components of antenatal care, including maternal immunization, screening, testing and antenatal counselling. In a supplementary analysis, I assessed the association between a score for complete antenatal care and infant birth weight. Results from this supplementary analysis (see supplementary table 9) demonstrates some evidence of an association between complete antenatal care (as a score) and infant birth weight. However, these results are not consistent across subsamples. Additionally, due to limitations of data, this measure does not capture all requisite components of antenatal care as defined by the World Health Organization (2016). Thus, it should be noted that both approaches to contextualizing antenatal care have their limitations. Future studies using primary data collection should focus on developing a more comprehensive antenatal care score to provide stronger evidence of the link between complete antenatal care and infant birth weight within the Indian context.

Variation in effect of antenatal care based on male partner attendance

An important aspect of this study was investigating how the effect of antenatal care on birth weight varied based on women's reports of male partner attendance.

Evidence from low- and middle-income countries shows that education-based interventions with male partners has been associated with a decrease in occurrence of stillbirths and neonatal mortality (Mullick, Kunene, & Wanjiru, 2017; Tokhi et al., 2018). Further, some studies from the United States have documented that missing paternal information or male partner absence was associated with increased risk of giving birth to a low birth weight infant (Alio et al., 2010, 2011; Cheng et al., 2016). Although one recent study found an association between low paternal support and infant birth weight (Godbole et al., 2020), none of the studies in India have used nationally representative data to evaluate the positive role of male partner attendance, nor have they examined the moderating influence of male partner attendance on the association between antenatal care and infant birth weight.

In this study, I hypothesized that the effect of antenatal care on birth weight would vary across groups of women based on their report of male partner attendance. The rationale being that male partner presence might lead to improved knowledge and awareness about pregnancy care, shared decision making and increased understanding of the benefits of health facility delivery and postpartum care, translating to reduced likelihood of low birth weight infants. However, contrary to expectations, the results of this study showed no direct effect of male partner attendance on infant birth weight. Additionally, while there was some evidence of variation in effect of antenatal care (frequency of contacts, antenatal testing and counselling on pregnancy complications) on infant birth weight based on whether the male partner was present during the visit to the clinic, I interpret these findings with caution. A source of uncertainty here is that these findings were not consistent across subsamples, and further there was a lack of any

observed direct effect of antenatal care on birth weight in these cases. Despite these results, this is one of the first studies in India that has examined the role of male partner attendance on infant birth weight, and lays the foundation for further research on how engaging with men in maternal health service utilization could positively impact infant birth outcomes. Beyond accompanying women to antenatal care, male partners could be involved in providing financial support, arranging transportation to health facility and assisting in household chores. In future investigations, it could be useful to examine how these different aspects of male involvement may be effective in improving birth outcomes.

Increased risk for low birth weight among first-born babies and young mothers

The results of this study also call for increased focus on first-time mothers. The findings of this study corroborate evidence from prior research both in India (Mishra, Ram, Singh, & Yadav, 2018) and globally (Brenøe & Molitor, 2018; Buckles & Kolka, 2014)(Brenøe & Molitor, 2018; Buckles & Kolka, 2014)(Brenøe & Molitor, 2018; Buckles & Kolka, 2014)(Brenøe & Molitor, 2018; Buckles & Kolka, 2014)(Brenøe & Molitor, 2018; Buckles & Kolka, 2014)(Brenøe & Molitor, 2018; Buckles & Kolka, 2014) which documents that first-borns are at higher risk for being low birth weight babies, and also for neonatal and infant mortality. This should be taken into consideration by policy-makers while designing programs and interventions aimed providing comprehensive care to the most vulnerable groups.

Another interesting finding of the study is the association between age at marriage and infant birth weight. The results of this study document that in comparison to women married as young girls, those married at 18 years and older were less likely to have a low

birth weight infant. These results lend support to prior research which documents the negative consequences of early and child marriage on women's health outcomes and maternal health service utilization (Raj, 2010; Raj et al., 2019). Women married as young girls are particularly more vulnerable to unwanted pregnancies, multiple births and poor utilization of maternal health services. Also, they are more likely to become pregnant and have children at a young age, putting them at increased risk for having low birth weight infants. Although laws banning the practice of child marriage have been in place as early as 1929, India remains one of the countries with the highest rate of child marriage, disproportionately affecting poorer and socially disadvantaged populations (Crivello, Roest, Vennam, Singh, & Winter, 2018; Pankhurst, Tiumelissan, & Chuta, 2016). This evidence calls for tighter laws around the practice of child marriage and interventions that focus on education of the girl child.

Improved education and socio-economic status of women improved infant birth-weight

Finally, the findings of this study also support previous research that documents the importance of women's education, and socio-economic status (SES) on infant birth weight (Apte et al., 2019; Kader & Perera, 2014). It is likely that women who have better education and higher SES would be more likely to initiate antenatal care in a timely manner, have increased access to the required number of antenatal care contacts, and be more likely to deliver at a health facility (Ali et al., 2019; Jat, Ng, & San Sebastian, 2011), all of which are critical factors shaping the likelihood of having a low birth weight infant (Kader & Perera, 2014; Khan et al., 2019). Further, women with better education may also be more likely to have greater awareness of nutrition and care during pregnancy. Apart from education, access to health services is also determined to a large

extent on the basis of women's place of residence (Ali et al., 2019). In this study, I found that women in rural areas were less likely to have an infant with low birth weight as compared to those living in urban areas. This is in contrast to the findings reported by Kader and Perera (2014), which show that urban residence had a positive effect on infant birth weight. However, similar findings were reported by two recent studies in India that examined infant birth weight (Khan et al., 2019; Paul et al., 2020). As suggested by the authors, this could be a result of the National Rural Health Mission (NRHM) in India which has been instrumental in improving antenatal care and service utilization. Further, the prevalence of low birth weight in children was seen more in the Northern and Central regions (Khan et al., 2019), highlighting the need for targeted interventions in these areas to combat low birth weight.

Limitations

This dissertation has several limitations. Firstly, the data on infant birth weight are based both on written records as well as on recall. Although there has been a decline in the proportion of recall-based infant birth weight data, about 41% of birth weight data within NFHS-4 are still reported based on mother's recall (Khan, Mozumdar, & Kaur, 2019). From the results of this study we see some inconsistencies in sample characteristics based on method of report. For instance, the sub-sample of women who reported birth weight based on recall seems to be skewed in terms of education, age at marriage, utilization of antenatal care and male partner attendance. Further, the study findings indicate that women who reported birth weight based on recall were more likely to deliver a low birth weight infant (see table 4.2, 4.3, 4.4, model 3c). Due to these inconsistencies and the possible bias that may be associated with recalling infant birth weight, I have chosen to

focus on the findings for the sub-sample based only on medical records. Another major limitation of this study is that in order to account for male partner attendance in antenatal care, this study sample is restricted to women who have had at least one antenatal care contact. As a consequence, the study excludes an important subpopulation of women who had no contact with the health system during pregnancy. A regression model was fitted to predict the socio-demographic characteristics of the missing data. The results of the prediction model (see supplementary table 13) show that the respondents with missing data were more likely to have lower levels of education, lower household wealth, belonged to Muslim religion and lived in rural areas. Since the data are not missing at random, I used complete case analysis as the approach to deal with the missing cases. It should be noted that utilization of complete case analysis method and dropping of missing data may lead to reduced statistical power of the model. However, the final analytic sample is representative of the groups with missing data, and thus does not significantly affect the overall generalizability of the results as compared to the original dataset. Further, due to the lack of variables on mental health within the dataset, I could not control for maternal depression as a potential confounder. Additionally, this study was unable to control for spacing of antenatal care contacts, number of pregnancies (gravida) and quality of health services. While gestational age is included as a control variable in the analyses, this is measured in months and I could not include a more precise measure of gestational age in weeks. Further, as the survey asks questions on fertility based on the woman's last pregnancy in the past five years, the report of details could suffer from recall bias; and, since this dissertation uses cross-sectional data, it is not

possible to establish a causal relationship between utilization of antenatal care and low birth weight.

Implications for theory, policy and practice

This study sheds some light on the positive role of antenatal care in reducing the prevalence of low birth weight among infants. However, despite the importance of antenatal care in overall maternal and child health, India is far from achieving the goal of universal antenatal coverage, with considerable disparities in utilization by economic status, caste and educational levels (Ali, Dhillon, & Mohanty, 2019). Within this context, this study's findings have important implications for policy and programs in India and other low- and middle-income countries. First and foremost, there is a need to increase accessibility to and availability of quality antenatal care services, particularly focusing on first-time mothers and those who are married as young girls or adolescents. As per the recent WHO recommendations, all pregnant women should have access to 8 or more antenatal care contacts, with the first contact taking place within the first 12 weeks of pregnancy (World Health Organization, 2016). Thus, programs and interventions should be targeted towards encouraging early initiation of antenatal care and at least 8 or more antenatal care contacts as crucial for optimal care during pregnancy. Based on evidence demonstrating the effectiveness of community health workers or ASHA workers in increasing antenatal care utilization and immunization coverage (Agarwal et al., 2019), one of the key strategies to achieve these goals could be to include ASHA workers within programs designed to strengthen antenatal care.

Additionally, programs aimed at improving overall utilization of antenatal care should ensure access to all components of care including maternal immunization, testing,

and counselling on pregnancy complications. A crucial limitation of this study is that it does not provide strong evidence on the positive effect of complete antenatal care on infant birth weight due to the lack of requisite variables within the dataset. This is an area for future studies, especially those that involve collection of primary data on all components of antenatal care. Future research should also investigate maternal health service utilization among women who have missing data on infant birth weight. Missing data could be an important proxy for the lack of contact with the health system during pregnancy and childbirth, and findings of such research can provide crucial policy and program implications. Although this paper did not find evidence of male partner attendance having a positive effect on infant birth weight, future investigations should explore how other aspects of male involvement may impact birth outcomes.

Table 4.1 Socio-demographic characteristics of the full sample (N= 90,680), NFHS-4

Variables	Full sample including report based on record and recall	Report based on medical records	Report based on recall
	(N = 90,680)	(N = 50,029)	(N = 40,651)
Low birth weight			
More than 2500g	83.97	84.74	82.87
<2500g	16.03	15.26	17.13
Infant birth weight (continuous)	2823.44 (568.39)	2830.34 (534.99)	2818.63 (612.52)
Timing of antenatal care			
At or before 12 weeks	72.40	71.16	74.16
Later than 12 weeks	27.60	28.84	25.84
Frequency of antenatal care			
Less than 4 contacts	33.72	29.72	39.39
4- 7 contacts	39.32	39.17	39.52
8 or more contacts	26.97	31.11	21.08
Receipt of tetanus toxoid (TT) injection			
None	5.00	6.23	3.24
At least one injection	95.00	93.77	96.76
Antenatal care testing (weight, blood, urine sample, blood pressure)			
No	3.74	2.29	5.79
Yes	96.26	97.71	94.21
Receipt of antenatal counselling on pregnancy complications			
No	19.66	15.96	24.91
Yes	80.34	84.04	75.09
Male partner attendance			
No	15.08	13.43	17.43
Yes	84.92	86.57	82.57
Individual level factors			
Socio-demographic characteristics			
Mother's educational level			
No formal Education	18.95	16.29	22.72
Primary	12.7	12.17	13.47
Secondary	53.65	56.66	49.38
Higher	14.7	14.88	14.43
Mother's caste			
Scheduled Castes (SC)	21.77	22.99	20.04
Scheduled Tribe (ST)	9.91	10.10	9.63

Other Backward Classes (OBC)	44.94	44.08	46.16
General	23.39	22.83	24.17
Mother's religion			
Hindu	82.15	81.67	82.84
Muslim	11.92	11.67	12.27
Others	5.92	6.66	4.89
Age at marriage			
Less than 18 years	33.63	32.49	35.26
18 years and older	66.37	67.28	64.74
Smoking			
Smokes cigarettes	1.48	1.37	1.64
Does not smoke cigarettes	98.52	98.63	98.36
Respondent's age	26.97 (4.87)	26.74 (4.73)	27.11 (4.86)
Number of children	1.56 (0.78)	1.51 (0.75)	1.58 (0.80)
Parity	2.13 (1.25)	1.96 (1.07)	2.19 (1.28)
Individual level factors			
Biological characteristics			
Body Mass Index (BMI - kg/m2)			
<18.5	22.93	22.51	23.54
18.5-24.9	58.3	58.36	58.22
>25	18.76	19.13	18.24
Anemia			
Anemic	58.26	57.14	59.84
Not anemic	41.74	42.86	40.16
Pregnancy complications			
No	57.80	57.93	57.63
Yes	42.20	42.07	42.37
Labor Complications			
No	43.74	40.68	48.07
Yes	56.26	59.32	51.93
Family/ Household Factors			
Household wealth index			
Poorest	15.04	14.31	16.07
Poorer	19.32	19.69	18.80
Middle	21.73	22.21	21.06
Richer	22.76	23.40	21.86
Richest	21.15	20.40	22.21
Cooking fuel			
Polluting	44.52	45.03	43.78

Non polluting	55.48	54.97	56.22
Place of residence			
Rural	65.56	65.96	64.98
Urban	34.44	34.04	35.02
Region			
North	14.41	12.02	17.78
Central	20.55	13.18	31.01
West	22.04	25.98	16.44
East	3.25	3.65	2.69
North-East	16.24	15.14	17.80
South	23.52	30.03	14.28
Infant characteristics			
Birth Order			
First child	36.62	38.72	33.65
2nd or higher	63.38	61.28	66.35
Gender of infant			
Male	55.29	54.86	55.90
Female	44.71	45.14	44.10
Gestational age	9.07 (0.49)	9.08 (0.50)	9.08 (0.49)

Table 4.2. Results from multivariable logistic regression estimating the association between early initiation of antenatal care and low infant birth weight, NFHS-4 (2015-16)

	Birth weight based on medical records (N = 50,029)		Birth weight based on recall (N = 40,651)		Full sample including report based on medical record or recall (N = 90,680)	
	Model 1a		Model 2a		Model 3a	
	Odds ratio	CI	Odds ratio	CI	Odds ratio	CI
Early initiation of antenatal care contact (ref: Later than 12 weeks)						
At or before 12 weeks	0.92*	(0.85 – 1.00)	0.95	(0.87 - 1.04)	0.93*	(0.88 - 0.99)
Male partner attendance (MPA) (ref: Male partner not present)						
Male partner present	1.02	(0.93 - 1.13)	0.91*	(0.83 – 1.00)	0.96	(0.90 - 1.03)
Individual characteristics						
Educational level (ref: No formal education)						
Primary	1.02	(0.90 - 1.15)	1.12*	(1.00 - 1.26)	1.06	(0.98 - 1.16)
Secondary	0.95	(0.86 - 1.05)	0.94	(0.85 - 1.04)	0.94	(0.88 - 1.02)
Higher Secondary	0.78***	(0.66 - 0.92)	0.71***	(0.60 - 0.84)	0.75***	(0.67 - 0.84)
Caste (ref: General)						
Scheduled Caste (SC)	1.07	(0.95 - 1.21)	1.02	(0.90 - 1.16)	1.05	(0.96 - 1.15)
Scheduled Tribe (ST)	1.20**	(1.04 - 1.38)	0.98	(0.84 - 1.14)	1.10	(0.98 - 1.23)
Other Backward Classes (OBC)	1.02	(0.92 - 1.14)	0.93	(0.84 - 1.03)	0.98	(0.91 - 1.05)
Religion (ref: Hindu)						
Muslim	0.92	(0.80 - 1.05)	1.01	(0.89 - 1.14)	0.96	(0.88 - 1.05)
Others	0.920	(0.783 - 1.081)	1.039	(0.842 - 1.282)	0.966	(0.855 - 1.092)
Age at marriage (ref: Below 18 years)						
18 years and older	0.90**	(0.83 - 0.98)	0.91**	(0.83 - 0.98)	0.91***	(0.86 - 0.96)
Respondent's Age	1.02***	(1.00 - 1.03)	1.00	(0.98 - 1.01)	1.01*	(1.00 - 1.02)
Number of children	1.00	(0.95 - 1.06)	1.03	(0.98 - 1.08)	1.02	(0.98 - 1.06)
Parity	0.94**	(0.89 - 0.99)	0.97	(0.93 - 1.02)	0.96***	(0.92 - 0.99)
Smoking (ref: Does not smoke)						
Smokes cigarettes	1.36*	(1.06 - 1.74)	0.83	(0.62 - 1.12)	1.09	(0.90 - 1.33)
Biological characteristics						
Body Mass Index (BMI - kg/m2) (ref: <18.5)						
18.5-24.9	0.76**	(0.69 - 0.82)	0.84**	(0.77 - 0.92)	0.79**	(0.75 - 0.84)
>25	0.69**	(0.61 - 0.79)	0.79**	(0.69 - 0.90)	0.73**	(0.67 - 0.81)
Anemia (ref: Anemic)						
Not anemic	0.93	(0.87 - 1.00)	0.87**	(0.81 - 0.95)	0.91**	(0.86 - 0.96)
Pregnancy complications (ref: No complications)						
Yes	1.05	(0.97 - 1.13)	1.02	(0.94 - 1.10)	1.03	(0.98 - 1.09)

Labor Complications (ref: No complications)						
Yes	1.01	(0.94 - 1.09)	1.05	(0.97 - 1.13)	1.02	(0.96 - 1.07)
Household characteristics						
Household wealth index (ref: Poorest)						
Poorer	1.00	(0.89 - 1.13)	0.91	(0.81 - 1.02)	0.96	(0.89 - 1.05)
Middle	0.91	(0.81 - 1.04)	0.91	(0.80 - 1.03)	0.92	(0.84 - 1.01)
Richer	0.98	(0.84 - 1.14)	0.92	(0.79 - 1.08)	0.96	(0.86 - 1.08)
Richest	0.69**	(0.57 - 0.83)	0.72**	(0.59 - 0.88)	0.71**	(0.62 - 0.81)
Type of cooking fuel (ref: Polluting fuel)						
Use of non- polluting fuel	1.00	(0.90 - 1.11)	0.96	(0.86 - 1.08)	0.98	(0.91 - 1.06)
Place of residence (ref: Urban)						
Rural	0.91*	(0.83 - 1.00)	0.96	(0.87 - 1.07)	0.93*	(0.87 - 1.00)
Region (ref: South)						
North	1.32**	(1.18 - 1.49)	1.32**	(1.13 - 1.55)	1.32**	(1.21 - 1.44)
Central	0.95	(0.86 - 1.06)	1.27**	(1.09 - 1.47)	1.15**	(1.06 - 1.25)
East	0.86**	(0.77 - 0.96)	0.91	(0.76 - 1.08)	0.87**	(0.80 - 0.96)
North-East	0.70**	(0.60 - 0.81)	0.74**	(0.60 - 0.91)	0.72**	(0.64 - 0.81)
West	1.25**	(1.09 - 1.43)	1.18	(0.97 - 1.42)	1.21**	(1.09 - 1.35)
Infant characteristics						
Gestational age	0.64**	(0.59 - 0.69)	0.60**	(0.54 - 0.66)	0.62**	(0.58 - 0.67)
Birth order (ref: 2nd or above)						
First child	1.32**	(1.18 - 1.47)	1.09	(0.98 - 1.22)	1.23**	(1.14 - 1.33)
Gender (ref: Male)						
Female	1.19**	(1.11 - 1.27)	1.26**	(1.17 - 1.35)	1.22**	(1.16 - 1.28)
Type of report (ref: Medical Records)						
Recall					1.10***	(1.04 - 1.16)
Constant	10.23**	(4.62 - 22.62)	33.21**	(12.65 - 87.17)	16.40**	(8.64 - 31.13)
Results from interaction effects of antenatal care (early initiation of antenatal care) and male partner attendance on infant birth weight, using NFHS-4, 2015-16						
Interaction terms	**Model 1b**		**Model 2b**		**Model 3b**	
Timing of ANC*MPA	0.90	(0.74 - 1.09)	0.93	(0.81 - 1.09)	0.93	(0.81 - 1.08)
Constant	9.96***	(4.43 - 22.37)	31.33***	(11.84 - 82.91)	15.76***	(8.218 - 30.22)

***p<0.001, ** p<0.01, *p<0.05

Table 4.3 Results from multivariable logistic regression estimating the association between frequency of antenatal care and low infant birth weight

	Birth weight based on medical records (N = 50,029)		Birth weight based on recall (N = 40,651)		Full sample including report based on medical record or recall (N = 90,680)	
	Model 1a		Model 2a		Model 3a	
	Odds ratio	CI	Odds ratio	CI	Odds ratio	CI
Frequency of antenatal care contacts (ref: Less than 4 contacts)						
4-7 contacts	0.94	(0.86 - 1.03)	1.03	(0.95 - 1.12)	0.98	(0.92 - 1.04)
8 or more contacts	0.90	(0.81 - 1.00)	1.01	(0.89 - 1.14)	0.95	(0.87 - 1.03)
Male partner attendance (MPA) (ref: Male partner not present)						
Male partner present	1.03	(0.93 - 1.14)	0.90**	(0.82 - 0.99)	0.97	(0.90 - 1.04)
Individual characteristics						
Educational level (ref: No formal education)						
Primary	1.02	(0.90 - 1.16)	1.12**	(1.00 - 1.26)	1.06	(0.98 - 1.16)
Secondary	0.96	(0.86 - 1.06)	0.94	(0.84 - 1.04)	0.95	(0.88 - 1.02)
Higher Secondary	0.79***	(0.67 - 0.92)	0.71***	(0.60 - 0.83)	0.75***	(0.67 - 0.84)
Caste (ref: General)						
Scheduled Caste (SC)	1.08	(0.95 - 1.21)	1.02	(0.90 - 1.16)	1.05	(0.96 - 1.15)
Scheduled Tribe (ST)	1.20**	(1.04 - 1.38)	0.97	(0.83 - 1.13)	1.09	(0.98 - 1.22)
Other Backward Classes (OBC)	1.02	(0.92 - 1.13)	0.93	(0.84 - 1.03)	0.98	(0.91 - 1.05)
Religion (ref: Hindu)						
Muslim	0.92	(0.80 - 1.05)	1.01	(0.89 - 1.14)	0.96	(0.88 - 1.05)
Others	0.92	(0.79 - 1.08)	1.04	(0.84 - 1.28)	0.97	(0.86 - 1.09)
Age at marriage (ref: Below 18 years)						
18 years and older	0.90**	(0.83 - 0.98)	0.90**	(0.83 - 0.98)	0.91***	(0.85 - 0.96)
Respondent's Age	1.02***	(1.01 - 1.03)	1.00	(0.98 - 1.01)	1.01**	(1.00 - 1.02)
Number of children	1.00	(0.94 - 1.06)	1.03	(0.98 - 1.0)	1.02	(0.98 - 1.06)
Parity	0.93**	(0.89 - 0.98)	0.97	(0.93 - 1.02)	0.96***	(0.92 - 0.99)
Smoking (ref: Does not smoke)						
Smokes cigarettes	1.36**	(1.06 - 1.75)	0.83	(0.62 - 1.12)	1.09	(0.90 - 1.33)
Biological characteristics						
Body Mass Index (BMI - kg/m2) (ref: <18.5)						
18.5-24.9	0.76***	(0.70 - 0.82)	0.84***	(0.77 - 0.92)	0.79***	(0.75 - 0.84)
>25	0.70***	(0.62 - 0.79)	0.79***	(0.69 - 0.90)	0.74***	(0.67 - 0.81)
Anemia (ref: Anemic)						
Not anemic	0.93	(0.87 - 1.00)	0.88***	(0.81 - 0.95)	0.91***	(0.86 - 0.96)
Pregnancy complications (ref: No complications)						
Yes	1.05	(0.97 - 1.13)	1.02	(0.94 - 1.10)	1.04	(0.98 - 1.09)

Labor Complications (ref: No complications)						
Yes	1.01	(0.94 - 1.09)	1.04	(0.97 - 1.13)	1.02	(0.97 - 1.08)
Household characteristics						
Household wealth index (ref: Poorest)						
Poorer	1.01	(0.89 - 1.14)	0.91	(0.81 - 1.02)	0.96	(0.89 - 1.05)
Middle	0.92	(0.81 - 1.04)	0.90	(0.79 - 1.02)	0.92	(0.84 - 1.00)
Richer	0.98	(0.84 - 1.14)	0.91	(0.78 - 1.07)	0.96	(0.86 - 1.07)
Richest	0.69***	(0.57 - 0.83)	0.71***	(0.58 - 0.87)	0.71***	(0.62 - 0.81)
Type of cooking fuel (ref: Polluting fuel)						
Use of non- polluting fuel	1.00	(0.90 - 1.11)	0.96	(0.86 - 1.08)	0.98	(0.91 - 1.06)
Place of residence (ref: Urban)						
Rural	0.91**	(0.83 – 1.00)	0.96	(0.87 - 1.07)	0.93	(0.87 - 1.00)
Region (ref: South)						
North	1.28***	(1.13 - 1.45)	1.33***	(1.14 - 1.57)	1.27***	(1.15 - 1.40)
Central	0.92	(0.82 - 1.03)	1.28***	(1.10 - 1.50)	1.10**	(1.01 - 1.20)
East	0.85***	(0.75 - 0.95)	0.92	(0.77 - 1.09)	0.87***	(0.78 - 0.96)
North-East	0.68***	(0.58 - 0.79)	0.74***	(0.60 - 0.92)	0.70***	(0.62 - 0.79)
West	1.24***	(1.09 - 1.42)	1.18	(0.98 - 1.42)	1.19***	(1.07 - 1.32)
Infant characteristics						
Gestational age	0.64***	(0.59 - 0.69)	0.60***	(0.54 - 0.66)	0.62***	(0.58 - 0.66)
Birth order (ref: 2nd or above)						
First child	1.31***	(1.18 - 1.47)	1.09	(0.98 - 1.22)	1.23***	(1.14 - 1.33)
Gender (ref: Male)						
Female	1.19***	(1.11 - 1.28)	1.26***	(1.17 - 1.35)	1.22***	(1.16 - 1.28)
Type of report (ref: Medical Records)						
Recall					1.10***	(1.04 - 1.16)
Constant	10.12***	(4.58 - 22.35)	32.02***	(12.23 - 83.79)	15.52***	(8.17 - 29.46)
Results from interaction effects of antenatal care (frequency of antenatal care contacts) and male partner attendance on infant birth weight, using NFHS-4, 2015-16						
Interaction terms	**Model 1b**		**Model 2b**		**Model 3b**	
4-7 antenatal contacts x MPA	0.80**	(0.64 – 1.00)	0.83	(0.68 - 1.02)	0.82**	(0.71 - 0.96)
8 or more antenatal contacts x MPA	0.81	(0.62 - 1.06)	0.85	(0.63 - 1.14)	0.86	(0.70 - 1.04)
Constant	8.95***	(4.05 - 19.79)	29.77***	(11.35 - 78.10)	14.64***	(7.731 - 27.72)

***p<0.001, ** p<0.01, *p<0.05

Table 4.4. Results from multivariable logistic regression estimating the association between components of antenatal care and low infant birth weight

	Birth weight based on medical records (N = 50,029)		Birth weight based on recall (N = 40,651)		Full sample including report based on medical records or recall (N = 90,680)	
	Model 1a		Model 2a		Model 3a	
	Odds ratio	CI	Odds ratio	CI	Odds ratio	CI
Receipt of TT injection (ref: No)						
Yes	0.79***	(0.69 - 0.92)	0.86	(0.71 - 1.06)	0.82***	(0.73 - 0.92)
Antenatal Testing (Blood, urine sample, blood pressure) (ref: No)						
Yes	1.07	(0.89 - 1.29)	1.02	(0.89 - 1.18)	1.01	(0.90 - 1.13)
Antenatal Counselling about pregnancy complications (ref: No)						
Yes	1.04	(0.94 - 1.15)	0.92	(0.85 - 1.01)	0.98	(0.91 - 1.04)
Male partner attendance (ref: Male partner not present)						
Male partner present	1.03	(0.93 - 1.14)	0.92	(0.83 - 1.01)	0.97	(0.91 - 1.04)
Individual characteristics						
Educational level (ref: No formal education)						
Primary	1.02	(0.90 - 1.15)	1.12**	(1.00 - 1.26)	1.06	(0.98 - 1.16)
Secondary	0.95	(0.85 - 1.05)	0.94	(0.85 - 1.04)	0.94	(0.88 - 1.02)
Higher Secondary	0.78***	(0.66 - 0.92)	0.71***	(0.60 - 0.84)	0.75***	(0.67 - 0.84)
Caste (ref: General)						
Scheduled Caste (SC)	1.07	(0.95 - 1.21)	1.02	(0.90 - 1.16)	1.05	(0.96 - 1.15)
Scheduled Tribe (ST)	1.19**	(1.03 - 1.38)	0.97	(0.83 - 1.14)	1.09	(0.98 - 1.22)
Other Backward Classes (OBC)	1.02	(0.92 - 1.13)	0.93	(0.84 - 1.03)	0.98	(0.91 - 1.05)
Religion (ref: Hindu)						
Muslim	0.92	(0.80 - 1.06)	1.00	(0.89 - 1.14)	0.96	(0.88 - 1.05)
Others	0.92	(0.79 - 1.08)	1.04	(0.84 - 1.28)	0.97	(0.86 - 1.09)
Age at marriage (ref: Below 18 years)						
18 years and older	0.90**	(0.83 - 0.98)	0.90**	(0.83 - 0.98)	0.90***	(0.85 - 0.96)
Respondent's Age	1.02***	(1.00 - 1.03)	1.00	(0.99 - 1.01)	1.01**	(1.00 - 1.02)
Number of children	1.00	(0.95 - 1.06)	1.03	(0.98 - 1.08)	1.02	(0.98 - 1.06)
Parity	0.94**	(0.89 - 0.99)	0.97	(0.93 - 1.02)	0.96***	(0.92 - 0.99)
Smoking (ref: Does not smoke)						
Smokes cigarettes	1.35**	(1.06 - 1.74)	0.84	(0.62 - 1.12)	1.09	(0.90 - 1.33)
Biological characteristics						
Body Mass Index (BMI - kg/m2) (ref: <18.5)						

18.5-24.9	0.75***	(0.69 - 0.82)	0.84***	(0.77 - 0.92)	0.79***	(0.75 - 0.84)
>25	0.69***	(0.61 - 0.78)	0.79***	(0.69 - 0.90)	0.73***	(0.67 - 0.80)
Anemia (ref: Anemic)						
Not anemic	0.93	(0.87 - 1.00)	0.88***	(0.81 - 0.94)	0.91***	(0.86 - 0.96)
Pregnancy complications (ref: No complications)						
Yes	1.05	(0.97 - 1.13)	1.03	(0.95 - 1.11)	1.04	(0.98 - 1.10)
Labor Complications (ref: No complications)						
Yes	1.01	(0.93 - 1.09)	1.05	(0.98 - 1.14)	1.03	(0.97 - 1.08)
Household characteristics						
Household wealth index (ref: Poorest)						
Poorer	1.00	(0.88 - 1.13)	0.91	(0.81 - 1.02)	0.96	(0.89 - 1.05)
Middle	0.91	(0.80 - 1.03)	0.90	(0.80 - 1.03)	0.92	(0.84 - 1.00)
Richer	0.97	(0.83 - 1.13)	0.92	(0.78 - 1.08)	0.96	(0.86 - 1.07)
Richest	0.68***	(0.56 - 0.82)	0.72***	(0.59 - 0.88)	0.71***	(0.62 - 0.81)
Type of cooking fuel (ref: Polluting fuel)						
Use of non- polluting fuel	1.00	(0.90 - 1.11)	0.97	(0.86 - 1.08)	0.98	(0.91 - 1.06)
Place of residence (ref: Urban)						
Rural	0.91**	(0.83 – 1.00)	0.97	(0.87 - 1.07)	0.94	(0.87 - 1.00)
Region (ref: South)						
North	1.35***	(1.20 - 1.52)	1.33***	(1.14 - 1.56)	1.31***	(1.19 - 1.43)
Central	0.98	(0.88 - 1.10)	1.28***	(1.10 - 1.48)	1.14***	(1.05 - 1.24)
East	0.89**	(0.79 - 0.99)	0.91	(0.77 - 1.08)	0.89**	(0.81 - 0.98)
North-East	0.71***	(0.61 - 0.82)	0.75***	(0.60 - 0.92)	0.72***	(0.64 - 0.81)
West	1.28***	(1.12 - 1.46)	1.18*	(0.97 - 1.42)	1.20***	(1.08 - 1.34)
Infant characteristics						
Gestational age	0.64***	(0.59 - 0.69)	0.60***	(0.54 - 0.66)	0.62***	(0.58 - 0.66)
Birth order (ref: 2nd or above)						
First child	1.32***	(1.18 - 1.47)	1.09	(0.98 - 1.22)	1.23***	(1.14 - 1.33)
Gender (ref: Male)						
Female	1.19***	(1.11 - 1.28)	1.26***	(1.17 - 1.36)	1.22***	(1.16 - 1.28)
Type of report (ref: Medical Records)					1.10***	(1.04 - 1.16)
Recall						
Constant	10.95***	(4.825 - 24.84)	37.88***	(14.24 - 100.80)	18.33***	(9.52 - 35.28)

Results from interaction effects of antenatal care (components of antenatal care) and male partner attendance on infant birth weight, using NFHS-4, 2015-16

Interaction terms	**Model 1b**		**Model 2b**		**Model 3b**	
	Odds ratio	CI	Odds ratio	CI	Odds ratio	CI
Receipt of TT injection * MPA	1.03	(0.74 - 1.44)	0.70	(0.45 - 1.10)	0.89	(0.68 - 1.16)

Constant	11.19***	(4.78 - 26.15)	29.46***	(10.54 - 82.34)	17.51***	(8.87 - 34.56)
	Model 1c		**Model 2c**		**Model 3c**	
ANC testing * MPA	0.57**	(0.37 - 0.87)	0.88	(0.67 - 1.15)	0.82	(0.66 - 1.03)
Constant	7.37***	(3.06 - 17.75)	30.99***	(11.71 - 81.98)	16.87***	(8.68 - 32.83)
	Model 1d		**Model 2d**		**Model 3d**	
ANC counselling* MPA	0.71***	(0.56 - 0.90)	0.87	(0.72 - 1.05)	0.83**	(0.72 - 0.96)
Constant	8.82***	(3.81 - 20.41)	36.19***	(13.71 - 95.55)	17.27***	(8.97 - 33.26)

***p<0.001, ** p<0.01, *p<0.05

Supplementary table 7. Results from OLS regression examining the association between early initiation of antenatal care and low infant birth weight

	Birth weight based on medical records (N = 50,029)		Birth weight based on recall (N = 40,651)		Full sample including report based on medical records or recall (N = 90,680)	
	Model 1a		Model 2a		Model 3a	
	Coeff	CI	Coeff	CI	Coeff	CI
Timing of antenatal care (ref: Later than 12 weeks)						
At 12 weeks or less	1.69	(-13.99 - 17.38)	-3.85	(-23.85 - 16.15)	-0.78	(-13.22 - 11.66)
Male partner attendance (ref: Male partner not						
Male partner present	-16.55	(-36.33 - 3.22)	-2.51	(-24.67 - 19.66)	-10.77	(-25.51 - 3.97)
Individual characteristics						
Educational level (ref: No formal education)						
Primary	11.89	(-12.50 - 36.29)	-30.20**	(-57.32 - -3.08)	-6.88	(-25.16 - 11.40)
Secondary	19.98	(-0.28 - 40.23)	16.08	(-8.12 - 40.29)	18.01**	(2.38 - 33.63)
Higher Secondary	82.81***	(54.87 - 110.80)	69.48***	(35.31 - 103.70)	77.56***	(55.68 - 99.44)
Caste (ref: General)						
Scheduled Caste (SC)	-32.02***	(-55.45 - -8.59)	-15.46	(-43.57 - 12.66)	-24.93***	(-42.76 - -7.10)
Scheduled Tribe (ST)	-41.02***	(-68.90 - -13.15)	-40.29**	(-73.13 - -7.45)	-38.99***	(-60.72 - -17.26)
Other Backward Classes (OBC)	-9.20	(-30.48 - 12.07)	14.84	(-7.58 - 37.27)	1.59	(-13.82 - 16.99)
Religion (ref: Hindu)						
Muslim	26.74**	(1.98 - 51.51)	25.65	(-3.99 - 55.30)	27.26***	(8.45 - 46.07)
Others	3.39	(-24.93 - 31.71)	-3.89	(-49.57 - 41.78)	1.76	(-20.66 - 24.18)
Age at marriage (ref: Below 18 years)						
18 years and older	13.43	(-3.04 - 29.89)	27.18***	(7.730 - 46.64)	19.26***	(6.63 - 31.90)
Respondent's Age	-2.03**	(-4.00 - -0.05)	-0.60	(-3.05 - 1.85)	-1.46	(-3.01 - 0.08)
Number of children	1.97	(-8.14 - 12.09)	0.94	(-9.94 - 11.8)	1.32	(-6.15 - 8.80)
Parity	25.08***	(15.10 - 35.07)	23.86***	(12.74 - 34.99)	24.24***	(16.78 - 31.70)
Smoking (ref: Does not smoke)						
Smokes cigarettes	-56.43**	(-107.70 - -5.12)	44.01	(-25.21 - 113.20)	-11.37	(-52.44 - 29.70)
Biological characteristics						
Body Mass Index (BMI - kg/m2) (ref: <18.5)						
18.5-24.9	78.25***	(62.31 - 94.20)	70.86***	(51.40 - 90.32)	75.32***	(63.04 - 87.60)
>25	143.30***	(120.80 - 165.90)	147.60***	(118.80 - 176.40)	144.80***	(126.80 - 162.80)
Anemia (ref: Anemic)						
Not anemic	14.54**	(1.00 - 28.08)	27.06***	(9.77 - 44.35)	19.96***	(9.28 - 30.63)
Pregnancy complications (ref: no complications)						
Yes	8.02	(-6.27 - 22.30)	3.50	(-13.73 - 20.71)	6.42	(-4.62 - 17.46)

Labor Complications (ref: no complications)						
Yes	7.22	(-6.72 - 21.17)	19.04**	(2.49 - 35.59)	12.48**	(1.86 - 23.10)
Household characteristics						
Household wealth index (ref: Poorest)						
Poorer	11.55	(-12.04 - 35.13)	8.10	(-18.89 - 35.08)	9.54	(-8.23 - 27.32)
Middle	43.65***	(18.40 - 68.90)	35.63**	(5.35 - 65.92)	39.38***	(19.90 - 58.85)
Richer	46.63***	(16.26 - 77.01)	43.80**	(8.82 - 78.78)	44.26***	(21.04 - 67.48)
Richest	114.30***	(79.27 - 149.30)	83.41***	(41.86 - 125.00)	100.80***	(73.70 - 127.90)
Type of cooking fuel (ref: Polluting fuel)						
Use of non- polluting fuel	1.17	(-18.16 - 20.51)	4.21	(-19.66 - 28.08)	3.11	(-12.01 - 18.23)
Place of residence (ref: Urban)						
Rural	31.36***	(14.04 - 48.68)	19.15	(-3.77 - 42.07)	26.76***	(12.71 - 40.80)
Region (ref: South)						
North	-110.10***	(-132.40 - -87.91)	-98.23***	(-131.50 - -64.92)	-105.40***	(-123.30 - -87.59)
Central	-17.55	(-38.77 - 3.67)	-37.67**	(-69.80 - -5.54)	-33.43***	(-50.48 - -16.38)
East	12.62	(-8.18 - 33.41)	27.28	(-7.06 - 61.61)	17.27	(-0.14 - 34.68)
North-East	79.89***	(53.48 - 106.30)	133.90***	(92.81 - 175.10)	97.99***	(75.81 - 120.20)
West	-51.53***	(-80.05 - -23.02)	-44.97**	(-85.54 - -4.39)	-47.95***	(-70.83 - -25.06)
Infant characteristics						
Gestational age	84.50***	(65.68 - 103.30)	127.10***	(103.30 - 150.90)	101.50***	(86.05 - 116.90)
Birth order (ref: 2nd or above)						
First child	-42.01***	(-62.09 - -21.94)	-4.99	(-29.40 - 19.42)	-28.20***	(-43.73 - -12.67)
Gender (ref: male)						
Female	-68.35***	(-81.58 - -55.11)	-74.34***	(-90.70 - -57.98)	-70.43***	(-80.64 - -60.22)
Constant	1,967***	(1,784 - 2,150)	1,513***	(1,280 - 1,747)	1,786***	(1,637 - 1,936)
Results from interaction effects of antenatal care (early initiation of antenatal care) and male partner attendance on infant birth weight, using NFHS-4, 2015-16						
Interaction terms	**Model 1b**		**Model 2b**		**Model 3b**	
Timing of ANC* MPA	42.51	(-2.23 - 87.26)	59.54**	(12.35 -106.70)	49.80***	(17.21 - 82.38)
Constant	1,992***	(1,805 - 2,180)	1,546***	(1,312 - 1,781)	1,815***	(1,664 - 1,967)

***p<0.001, ** p<0.01, *p<0.05

Supplementary table 8. Results from OLS regression for association between frequency of antenatal care contacts and low infant birth weight

	Birth weight based on medical records (N = 50,029)		Birth weight based on recall (N = 40,651)		Full sample including report based on medical records or recall (N = 90,680)	
	Model 1a		Model 2a		Model 3a	
	Coeff	CI	Coeff	CI	Coeff	CI
Frequency of antenatal care contacts (ref: Less than 4 contacts)						
4-7 contacts	-6.95	(-25.91 - 12.01)	-6.95	(-25.91 - 12.01)	-3.46	(-16.14 - 9.22)
8 or more contacts	18.20	(-8.77 - 45.17)	18.20	(-8.77 - 45.17)	10.69	(-5.32 - 26.70)
Male partner attendance (ref: Male partner not present)						
Male partner present	-2.69	(-25.00 - 19.63)	-2.69	(-25.00 - 19.63)	-11.13	(-25.98 - 3.73)
Individual characteristics						
Educational level (ref: No formal education)						
Primary	-30.05**	(-57.16 - -2.94)	-30.05**	(-57.16 - -2.94)	-6.94	(-25.22 - 11.35)
Secondary	15.59	(-8.62 - 39.80)	15.59	(-8.62 - 39.80)	17.48**	(1.85 - 33.11)
Higher Secondary	68.15***	(34.03 - 102.30)	68.15***	(34.03 - 102.30)	76.42***	(54.60 - 98.24)
Caste (ref: General)						
Scheduled Caste (SC)	-15.64	(-43.71 - 12.42)	-15.64	(-43.71 - 12.42)	-25.00***	(-42.82 - -7.18)
Scheduled Tribe (ST)	-39.71**	(-72.64 - -6.785)	-39.71**	(-72.64 - -6.78)	-38.66***	(-60.43 - -16.89)
Other Backward Classes (OBC)	14.91	(-7.49 - 37.32)	14.91	(-7.49 - 37.32)	1.73	(-13.68 - 17.13)
Religion (ref: Hindu)						
Muslim	25.52	(-4.07 - 55.11)	25.52	(-4.07 - 55.11)	26.87***	(8.077 - 45.67)
Others	-4.60	(-50.33 - 41.14)	-4.60	(-50.33 - 41.14)	1.44	(-20.99 - 23.88)
Age at marriage (ref: Below 18 years)						
18 years and older	26.99***	(7.54 - 46.44)	26.99***	(7.54 - 46.44)	19.13***	(6.50 - 31.76)
Respondent's Age	-0.68	(-3.14 - 1.77)	-0.68	(-3.14 - 1.77)	-1.51	(-3.06 - 0.03)
Number of children	1.00	(-9.88 - 11.89)	1.00	(-9.88 - 11.89)	1.42	(-6.07 - 8.92)
Parity	24.09***	(12.98 - 35.21)	24.09***	(12.98 - 35.21)	24.37***	(16.91 - 31.83)
Smoking (ref: Does not smoke)						
Smokes cigarettes	44.48	(-24.77 - 113.70)	44.48	(-24.77 - 113.70)	-11.42	(-52.52 - 29.68)
Biological characteristics						
Body Mass Index (BMI - kg/m2) (ref: <18.5)						
18.5-24.9	71.24***	(51.84 - 90.64)	71.24***	(51.84 - 90.64)	75.34***	(63.07 - 87.61)
>25	147.00***	(118.20 - 175.80)	147.00***	(118.20 - 175.80)	144.50***	(126.50 - 162.50)
Anemia (ref: Anemic)						
Not anemic	26.95***	(9.68 - 44.22)	26.95***	(9.68 - 44.22)	19.83***	(9.15 - 30.50)

Pregnancy complications (ref: No complications)						
Yes	2.67	(-14.58 - 19.92)	2.67	(-14.58 - 19.92)	5.97	(-5.10 - 17.03)
Labor Complications (ref: No complications)						
Yes	19.26**	(2.76 - 35.76)	19.26**	(2.76 - 35.76)	12.63**	(2.01 - 23.24)
Household characteristics						
Household wealth index (ref: Poorest)						
Poorer	8.23	(-18.79 - 35.24)	8.23	(-18.79 - 35.24)	9.58	(-8.20 - 27.35)
Middle	35.72**	(5.34 - 66.10)	35.72**	(5.34 - 66.10)	39.30***	(19.81 - 58.80)
Richer	42.76**	(7.78 - 77.74)	42.76**	(7.78 - 77.74)	43.76***	(20.56 - 66.96)
Richest	81.03***	(39.24 - 122.80)	81.03***	(39.24 - 122.80)	99.53***	(72.33 - 126.70)
Type of cooking fuel (ref: Polluting fuel)						
Use of non- polluting fuel	4.19	(-19.65 - 28.03)	4.19	(-19.65 - 28.03)	2.83	(-12.28 - 17.94)
Place of residence (ref: Urban)						
Rural	19.82	(-3.08 - 42.72)	19.82	(-3.08 - 42.72)	26.96***	(12.93 - 40.99)
Region (ref: South)						
North	-93.96***	(-128.00 - -59.89)	-93.96***	(-128.00 - -59.89)	-101.60***	(-120.20 - -82.96)
Central	-32.79	(-65.78 - 0.19)	-32.79	(-65.78 - 0.19)	-29.50***	(-47.39 - -11.61)
East	31.46	(-3.68 - 66.59)	31.46	(-3.68 - 66.59)	20.43**	(2.40 - 38.46)
North-East	139.60***	(97.88 - 181.20)	139.60***	(97.88 - 181.20)	102.60***	(79.73 - 125.50)
West	-45.86**	(-86.21 - -5.52)	-45.86**	(-86.21 - -5.52)	-47.31***	(-70.18 - -24.44)
Infant characteristics						
Gestational age	127.20***	(103.50 - 151.00)	127.20***	(103.50 - 151.00)	101.40***	(86.02 - 116.90)
Birth order (ref: 2nd or above)						
First child	-5.56	(-29.92 - 18.80)	-5.56	(-29.92 - 18.80)	-28.61***	(-44.14 - -13.09)
Gender (ref: Male)						
Female	-74.61***	(-90.98 - -58.23)	-74.61***	(-90.98 - -58.23)	-70.52***	(-80.72 - -60.31)
Constant	1,508***	(1,275 - 1,741)	1,508***	(1,275 - 1,741)	1,784***	(1,635 - 1,934)
Results from interaction effects of antenatal care (frequency of antenatal care contacts) and male partner attendance on infant birth weight						
Interaction terms	**Model 1b**		**Model 2b**		**Model 3b**	
4-7 contacts x MPA	1.84	(-48.08 - 51.76)	1.84	(-48.08 - 51.76)	6.95	(-26.35 - 40.25)
8 or more contacts x MPA	24.45	(-26.98 - 75.88)	11.29	(-54.02 - 76.61)	14.76	(-25.33 - 54.85)
Constant	1,977***	(1,795 - 2,159)	1,510***	(1,277 - 1,744)	1,789***	(1,640 - 1,939)

***p<0.001, ** p<0.01, *p<0.05

Supplementary table 9. Results from OLS regression for association between components antenatal care and low infant birth weight, NFHS-4, 2015-16

	Birth weight based on medical records (N = 50,029)		Birth weight based on recall (N = 40,651)		Full sample including report based on medical records or recall (N =	
	Model 1a		Model 2a		Model 3a	
	Coeff	CI	Coeff	CI	Coeff	CI
Receipt of TT injection (ref: No)						
Yes	27.81	(-1.89 - 57.51)	22.97	(-24.64 - 70.57)	26.01**	(1.061 - 50.96)
Antenatal Testing (Blood, urine sample, blood pressure)						
Yes	-12.89	(-50.20 - 24.42)	-17.23	(-54.21 - 19.75)	-12.63	(-39.75 - 14.48)
Antenatal Counselling about pregnancy complications						
Yes	-6.92	(-26.04 - 12.21)	0.65	(-20.32 - 21.63)	-3.10	(-17.13 - 10.93)
Male partner attendance (ref: Male partner not present)						
Male partner present	-16.87	(-36.87 - 3.14)	-1.76	(-24.18 - 20.66)	-10.64	(-25.56 - 4.27)
Individual characteristics						
Educational level (ref: No formal education)						
Primary	12.27	(-12.13 - 36.67)	-29.91**	(-57.04 - -2.78)	-6.57	(-24.85 - 11.71)
Secondary	20.38**	(0.08 - 40.68)	16.43	(-7.78 - 40.65)	18.38**	(2.74 - 34.02)
Higher Secondary	82.94***	(55.03 - 110.90)	69.75***	(35.60 - 103.90)	77.74***	(55.88 - 99.60)
Caste (ref: General)						
Scheduled Caste (SC)	-31.77***	(-55.25 - -8.30)	-15.64	(-43.74 - 12.46)	-24.78***	(-42.63 - -6.93)
Scheduled Tribe (ST)	-40.50***	(-68.38 - -12.62)	-39.61**	(-72.53 - -6.69)	-38.41***	(-60.16 - -16.65)
Other Backward Classes (OBC)	-9.17	(-30.45 - 12.10)	14.64	(-7.77 - 37.06)	1.50	(-13.90 - 16.91)
Religion (ref: Hindu)						
Muslim	26.36**	(1.62 - 51.11)	25.91	(-3.75 - 55.56)	27.15***	(8.35 - 45.94)
Others	3.21	(-25.10 - 31.52)	-4.02	(-49.73 - 41.70)	1.63	(-20.78 - 24.04)
Age at marriage (ref: Below 18 years)						
18 years and older	13.62	(-2.85 - 30.08)	27.24***	(7.78 - 46.69)	19.39***	(6.75 - 32.03)
Respondent's Age	-2.04**	(-4.01 - -0.06)	-0.60	(-3.04 - 1.85)	-1.46	(-3.00 - 0.08)
Number of children	1.72	(-8.41 - 11.84)	0.90	(-9.97 - 11.78)	1.18	(-6.29 - 8.66)
Parity	24.83***	(14.84 - 34.82)	23.72***	(12.58 - 34.87)	24.05***	(16.57 - 31.52)
Smoking (ref: Does not smoke)						
Smokes cigarettes	-55.77**	(-107.00 - -4.51)	44.34	(-24.93 - 113.60)	-11.09	(-52.24 - 30.06)
Biological characteristics						
Body Mass Index (BMI - kg/m2) (ref: <18.5)						
18.5-24.9	78.65***	(62.71 - 94.60)	70.94***	(51.50 - 90.39)	75.55***	(63.28 - 87.82)
>25	143.80***	(121.20 - 166.40)	147.70***	(118.90 - 176.50)	145.00***	(127.10 - 163.00)
Anemia (ref: Anemic)						

Not anemic	14.75**	(1.20 - 28.31)	26.99***	(9.70 - 44.27)	20.05***	(9.37 - 30.72)
Pregnancy complications (ref: No complications)						
Yes	7.90	(-6.42 - 22.21)	3.44	(-13.78 - 20.66)	6.32	(-4.73 - 17.37)
Labor Complications (ref: No complications)						
Yes	7.97	(-6.15 - 22.09)	19.26**	(2.61 - 35.91)	13.03**	(2.321 - 23.75)
Household characteristics						
Household wealth index (ref: Poorest)						
Poorer	12.09	(-11.52 - 35.69)	8.61	(-18.38 - 35.60)	10.02	(-7.77 - 27.81)
Middle	44.30***	(19.08 - 69.52)	36.05**	(5.740 - 66.36)	39.83***	(20.36 - 59.29)
Richer	47.02***	(16.69 - 77.34)	44.29**	(9.31 - 79.28)	44.63***	(21.41 - 67.86)
Richest	114.70***	(79.71 - 149.70)	83.50***	(41.92 - 125.1)	101.10***	(73.90 - 128.20)
Type of cooking fuel (ref: Polluting fuel)						
Use of non- polluting fuel	0.75	(-18.59 - 20.09)	4.18	(-19.71 - 28.06)	2.89	(-12.25 - 18.02)
Place of residence (ref: Urban)						
Rural	31.22***	(13.92 - 48.52)	18.72	(-4.24 - 41.67)	26.53***	(12.49 - 40.57)
Region (ref: South)						
North	-112.70***	(-135.00 - -90.48)	-98.65***	(-132.00 - -65.33)	-107.50***	(-125.50 - -89.57)
Central	-21.29	(-42.73 - 0.15)	-39.17**	(-71.27 - -7.07)	-36.56***	(-53.79 - -19.33)
East	9.51	(-11.41 - 30.43)	26.28	(-8.04 - 60.61)	14.95	(-2.59 - 32.49)
North-East	78.27***	(51.82 - 104.70)	134.40***	(93.43 - 175.40)	96.86***	(74.61 - 119.10)
West	-53.99***	(-82.65 - -25.32)	-45.45**	(-85.98 - -4.917)	-49.89***	(-72.84 - -26.94)
Infant characteristics						
Gestational age	84.73***	(65.89 - 103.60)	127.20***	(103.50 - 150.90)	101.50***	(86.14 - 116.90)
Birth order (ref: 2nd or above)						
First child	-42.35***	(-62.44 - -22.27)	-5.02	(-29.43 - 19.40)	-28.36***	(-43.90 - -12.82)
Gender (ref: Male)						
Female	-68.38***	(-81.62 - -55.14)	-74.37***	(-90.74 - -58.01)	-70.45***	(-80.66 - -60.23)
Constant	1,960***	(1,773 - 2,147)	1,503***	(1,265 - 1,741)	1,776***	(1,624 - 1,929)
Results from interaction effects of antenatal care (components of antenatal care) and male partner attendance on infant birth weight						
Interaction terms	**Model 1b**		**Model 2b**		**Model 3b**	
	Coeff	CI	Coeff	CI	Coeff	CI
Receipt of TT injection * MPA	8.90	(-63.81 - 81.60)	64.88	(-50.38 - 180.10)	27.80	(-33.30 - 88.89)
Constant	1,967***	(1,774 - 2,159)	1,550***	(1,296 - 1,804)	1,796***	(1,638 - 1,954)
	Model 1c		**Model 2c**		**Model 3c**	
ANC testing * MPA	24.35	(-55.37 - 104.10)	12.85	(-60.07 - 85.77)	12.14	(-42.62 - 66.90)
Constant	1,976***	(1,782 - 2,170)	1,510***	(1,270 - 1,750)	1,784***	(1,628 - 1,939)
	Model 1d		**Model 2d**		**Model 3d**	
ANC counselling * MPA	50.90**	(5.44 - 96.37)	1.25	(-43.51 - 46.00)	21.84	(-9.68 - 53.36)
Constant	1,990***	(1,801 - 2,180)	1,503***	(1,264 - 1,743)	1,787***	(1,634 - 1,941)

Supplementary Table 10. Results from multivariable logistic regression estimating the association between antenatal care (components of antenatal care **as a score**) and low infant birth weight

	Full sample including report based on medical record or recall (N = 90,680)		Full sample including report based on medical record or recall (N = 90,680)		Full sample including report based on medical records or recall (N = 90,680)	
	Model 1a		Model 2a		Model 3a	
	Odds ratio	CI	Odds ratio	CI	Odds ratio	CI
Antenatal care (score)	0.99	(0.97 - 1.02)	0.98**	(0.96 - 1.00)	0.98**	(0.97 – 1.00)
Male partner attendance (ref: Male partner not present)						
Male partner present	1.03	(0.93 - 1.14)	0.92	(0.84 - 1.02)	0.97	(0.91 - 1.04)
Educational level (ref: no formal education)						
Primary	1.02	(0.90 - 1.15)	1.12**	(1.00 - 1.26)	1.06	(0.98 - 1.16)
Secondary	0.95	(0.86 - 1.05)	0.94	(0.85 - 1.05)	0.94	(0.88 - 1.01)
Higher Secondary	0.78***	(0.66 - 0.92)	0.71***	(0.60 - 0.84)	0.75***	(0.66 - 0.84)
Caste (ref: General)						
Scheduled Caste (SC)	1.08	(0.96 - 1.21)	1.02	(0.90 - 1.16)	1.05	(0.96 - 1.15)
Scheduled Tribe (ST)	1.20**	(1.04 - 1.38)	0.98	(0.84 - 1.14)	1.09	(0.98 - 1.23)
Other Backward Classes (OBC)	1.02	(0.92 - 1.13)	0.93	(0.84 - 1.03)	0.98	(0.91 - 1.05)
Religion (ref: Hindu)						
Muslim	0.92	(0.80 - 1.05)	1.00	(0.89 - 1.14)	0.96	(0.88 - 1.05)
Others	0.92	(0.78 - 1.08)	1.04	(0.84 - 1.28)	0.96	(0.85 - 1.09)
Age at marriage (ref: Below 18 years)						
18 years and older	0.90**	(0.83 - 0.98)	0.91**	(0.83 - 0.98)	0.90***	(0.85 - 0.96)
Respondent's Age	1.02***	(1.00 - 1.03)	1.00	(0.98 - 1.01)	1.01**	(1.00 - 1.02)
Number of children	1.00	(0.95 - 1.06)	1.03	(0.98 - 1.08)	1.02	(0.98 - 1.06)
Parity	0.94**	(0.89 - 0.99)	0.97	(0.93 - 1.02)	0.96***	(0.92 - 0.99)
Smoking (ref: Does not smoke)						
Smokes cigarettes	1.36**	(1.06 - 1.74)	0.84	(0.62 - 1.12)	1.10	(0.90 - 1.33)
Biological characteristics						
Body Mass Index (BMI - kg/m2) (ref: <18.5)						
18.5-24.9	0.76***	(0.69 - 0.82)	0.84***	(0.77 - 0.92)	0.79***	(0.75 - 0.84)
>25	0.69***	(0.61 - 0.79)	0.79***	(0.69 - 0.90)	0.74***	(0.67 - 0.81)
Anemia (ref: Not anemic)						
Anemic	0.93	(0.87 - 1.00)	0.87***	(0.81 - 0.94)	0.91***	(0.86 - 0.96)

Pregnancy complications (ref: No complications)						
Yes	1.05	(0.97 - 1.13)	1.02	(0.95 - 1.11)	1.04	(0.98 - 1.09)
Labor Complications (ref: No complications)						
Yes	1.02	(0.94 - 1.10)	1.05	(0.98 - 1.14)	1.03	(0.97 - 1.08)
Household characteristics						
Household wealth index (ref: Poorest)						
Poorer	1.00	(0.89 - 1.13)	0.92	(0.82 - 1.02)	0.97	(0.89 - 1.05)
Middle	0.91	(0.80 - 1.04)	0.91	(0.80 - 1.04)	0.92	(0.84 - 1.01)
Richer	0.97	(0.84 - 1.14)	0.93	(0.79 - 1.08)	0.96	(0.86 - 1.08)
Richest	0.68***	(0.57 - 0.82)	0.73***	(0.59 - 0.89)	0.71***	(0.62 - 0.82)
Type of cooking fuel (ref: Polluting fuel)						
Use of non- polluting fuel	1.00	(0.90 - 1.11)	0.96	(0.86 - 1.08)	0.98	(0.91 - 1.06)
Place of residence (ref: Urban)						
Rural	0.91**	(0.83 – 1.00)	0.96	(0.87 - 1.07)	0.93**	(0.87 - 1.00)
Region (ref: South)						
North	1.32***	(1.18 - 1.49)	1.32***	(1.13 - 1.55)	1.32***	(1.20 - 1.44)
Central	0.95	(0.86 - 1.06)	1.25***	(1.08 - 1.46)	1.14***	(1.05 - 1.24)
East	0.86**	(0.77 - 0.97)	0.90	(0.76 - 1.07)	0.87***	(0.80 - 0.96)
North-East	0.70***	(0.61 - 0.81)	0.74***	(0.60 - 0.92)	0.72***	(0.64 - 0.81)
West	1.25***	(1.09 - 1.43)	1.17	(0.97 - 1.41)	1.21***	(1.09 - 1.34)
Infant characteristics						
Gestational age	0.64***	(0.59 - 0.69)	0.60***	(0.54 - 0.66)	0.62***	(0.58 - 0.67)
Birth order (ref: 2nd or above)						
First child	1.31***	(1.18 - 1.47)	1.09	(0.98 - 1.21)	1.23***	(1.14 - 1.32)
Gender (ref: Male)						
Female	1.19***	(1.11 - 1.27)	1.26***	(1.17 - 1.35)	1.22***	(1.16 - 1.28)
Constant	10.27***	(4.61 - 22.87)	35.79***	(13.64 - 93.94)	17.50***	(9.20 - 33.27)
Results from interaction effects of antenatal care (score) and male partner attendance on infant birth weight						
Interaction terms	**Model 1b**		**Model 2b**		**Model 3b**	
ANC score*MPA	0.91***	(0.87 - 0.96)	0.97	(0.93 - 1.00)	0.96***	(0.93 - 0.98)
Constant	5.92***	(2.50 - 14.02)	30.60***	(11.52 - 81.28)	13.68***	(7.08 - 26.44)

***p<0.001, ** p<0.01, *p<0.05

Supplementary table 11. Results from multivariable logistic regression estimating the association between antenatal care (timing, frequency, component of antenatal care) and low infant birth weight for full sample, removing outliers for infant birth weight

	Full sample including report based on medical records or recall (N = 83,413)		Full sample including report based on medical records or recall (N = 83,413)		Full sample including report based on medical records or recall (N = 83,413)	
	Model 1		Model 2		Model 3	
	Odds Ratio	CI	Odds Ratio	CI	Odds Ratio	CI
Timing of antenatal care (ref: Later than 12 weeks)						
At 12 weeks or less	0.92**	(0.87 - 0.99)				
Frequency of antenatal care contacts (ref: Less than 4 contacts)						
4-7 contacts			0.99	(0.93 - 1.06)		
8 or more contacts			0.98	(0.90 - 1.07)		
Components of ANC						
Receipt of TT injection (ref: No)						
Yes					0.86**	(0.76 - 0.98)
Antenatal Testing (Blood, urine sample, blood pressure) (ref: no)						
Yes					0.94	(0.81 - 1.10)
Antenatal Counselling (ref: no)						
Yes					1.01	(0.94 - 1.09)
Male partner attendance (ref: Male partner not present)						
Male partner present	0.99	(0.92 - 1.07)	0.99	(0.92 - 1.07)	1.00	(0.92 - 1.08)
Individual characteristics						
Educational level (ref: No formal education)						
Primary	1.10**	(1.00 - 1.21)	1.10**	(1.00 - 1.20)	1.10**	(1.00 - 1.21)
Secondary	0.95	(0.87 - 1.03)	0.95	(0.87 - 1.03)	0.95	(0.87 - 1.03)
Higher Secondary	0.78***	(0.69 - 0.89)	0.78***	(0.69 - 0.89)	0.78***	(0.69 - 0.89)
Caste (ref: General)						
Scheduled Caste (SC)	1.02	(0.93 - 1.13)	1.03	(0.93 - 1.13)	1.02	(0.93 - 1.13)
Scheduled Tribe (ST)	1.10	(0.97 - 1.24)	1.09	(0.97 - 1.23)	1.09	(0.97 - 1.23)
Other Backward Classes (OBC)	0.98	(0.91 - 1.06)	0.98	(0.90 - 1.06)	0.98	(0.90 - 1.06)
Religion (ref: Hindu)						
Muslim	0.97	(0.88 - 1.08)	0.97	(0.88 - 1.07)	0.97	(0.88 - 1.08)
Others	0.96	(0.84 - 1.09)	0.96	(0.84 - 1.09)	0.96	(0.84 - 1.09)
Age at marriage (ref: Below 18 years)						
18 years and older	0.91***	(0.85 - 0.97)	0.91***	(0.85 - 0.97)	0.91***	(0.85 - 0.97)
Respondent's Age	1.01**	(1.00 - 1.02)	1.01**	(1.00 - 1.02)	1.01**	(1.00 - 1.02)

Number of children	1.04	(0.99 - 1.08)	1.04	(1.00 - 1.08)	1.04	(1.00 - 1.08)
Parity	0.95**	(0.92 - 0.99)	0.96**	(0.92 - 0.99)	0.95**	(0.92 - 0.99)
Smoking (ref: Does not smoke)						
Smokes cigarettes	1.12	(0.91 - 1.37)	1.12	(0.91 - 1.38)	1.12	(0.91 - 1.38)
Biological characteristics						
Body Mass Index (BMI - kg/m2) (ref: <18.5)						
18.5-24.9	0.81***	(0.76 - 0.87)	0.81***	(0.76 - 0.87)	0.81***	(0.76 - 0.87)
>25	0.75***	(0.68 - 0.84)	0.76***	(0.68 - 0.84)	0.75***	(0.68 - 0.84)
Anemia (ref: Anemic)						
Not anemic	0.93**	(0.88 - 0.99)	0.93**	(0.88 - 0.99)	0.93**	(0.88 - 0.99)
Pregnancy complications (ref: No complications)						
Yes	1.03	(0.98 - 1.10)	1.04	(0.98 - 1.10)	1.04	(0.98 - 1.10)
Labor Complications (ref: No complications)						
Yes	1.02	(0.97 - 1.09)	1.03	(0.97 - 1.09)	1.02	(0.97 - 1.09)
Household characteristics						
Household wealth index (ref: Poorest)						
Poorer	0.95	(0.87 - 1.04)	0.95	(0.87 - 1.04)	0.95	(0.87 - 1.04)
Middle	0.95	(0.86 - 1.05)	0.95	(0.86 - 1.05)	0.95	(0.86 - 1.05)
Richer	0.99	(0.88 - 1.12)	0.98	(0.87 - 1.11)	0.98	(0.87 - 1.11)
Richest	0.76***	(0.66 - 0.89)	0.76***	(0.65 - 0.88)	0.76***	(0.65 - 0.88)
Type of cooking fuel (ref: Polluting fuel)						
Use of non- polluting fuel	0.99	(0.91 - 1.08)	0.99	(0.91 - 1.08)	0.99	(0.91 - 1.08)
Place of residence (ref: Urban)						
Rural	0.94	(0.87 - 1.02)	0.94	(0.87 - 1.02)	0.94	(0.87 - 1.02)
Region (ref: South)						
North	1.23***	(1.12 - 1.36)	1.23***	(1.11 - 1.36)	1.25***	(1.13 - 1.38)
Central	1.01	(0.92 - 1.11)	1.01	(0.92 - 1.11)	1.03	(0.94 - 1.13)
East	0.89**	(0.80 - 0.98)	0.89**	(0.80 - 0.99)	0.90*	(0.82 - 1.00)
North-East	0.76***	(0.67 - 0.86)	0.76***	(0.67 - 0.86)	0.77***	(0.68 - 0.87)
West	1.17***	(1.04 - 1.31)	1.17***	(1.04 - 1.31)	1.18***	(1.05 - 1.32)
Infant characteristics						
Gestational age	0.71***	(0.67 - 0.76)	0.71***	(0.67 - 0.76)	0.71***	(0.67 - 0.76)
Birth order (ref: 2nd or above)						
First child	1.18***	(1.09 - 1.28)	1.18***	(1.09 - 1.28)	1.18***	(1.09 - 1.28)
Gender (ref: Male)						
Female	1.19***	(1.12 - 1.26)	1.19***	(1.12 - 1.26)	1.19***	(1.12 - 1.26)
Constant	3.78***	(1.94 - 7.34)	3.64***	(1.88 - 7.08)	4.33***	(2.18 - 8.59)

***p<0.001, ** p<0.01, *p<0.05

Supplementary table 12. Results from multivariable logistic regression estimating the association between antenatal care (timing, frequency, component of antenatal care) and low infant birth weight for full sample, **including missing data on anemia and cooking fuels**, NFHS-4 (2015-16)

	Full sample including report based on medical record or recall (N = 119,300)		Full sample including report based on medical record or recall (N = 119,300)		Full sample including report based on medical record or recall (N = 119,300)	
	Model 1		Model 2		Model 3	
	OR	CI	OR	CI	OR	CI
Timing of antenatal care (ref: Later than 12 weeks)						
At 12 weeks or less	0.96	(0.91 - 1.02)				
Frequency of antenatal care contacts (ref: Less than 4 contacts)						
4-7 contacts			0.99	(0.94 - 1.05)		
8 or more contacts			0.95	(0.89 - 1.02)		
Components of ANC						
Receipt of TT injection (ref: No)						
Yes					0.80***	(0.72 - 0.88)
Antenatal Testing (Blood, urine sample, blood pressure) (ref: No)						
Yes					0.95	(0.84 - 1.07)
Antenatal Counselling about pregnancy complications (ref: No)						
Yes					0.95	(0.89 - 1.01)
Male partner attendance (ref: Male partner not present)						
Male partner present	0.96	(0.90 - 1.02)	0.96	(0.90 - 1.02)	0.97	(0.92 - 1.04)
Individual characteristics						
Educational level (ref: No formal education)						
Primary	1.03	(0.95 - 1.11)	1.03	(0.95 - 1.11)	1.03	(0.96 - 1.11)
Secondary	0.92**	(0.87 - 0.98)	0.92**	(0.87 - 0.98)	0.92**	(0.87 - 0.98)
Higher Secondary	0.70***	(0.63 - 0.77)	0.70***	(0.63 - 0.77)	0.70***	(0.63 - 0.77)
Caste (ref: General)						
Scheduled Caste (SC)	1.06	(0.98 - 1.14)	1.06	(0.98 - 1.14)	1.06	(0.98 - 1.14)
Scheduled Tribe (ST)	1.07	(0.97 - 1.18)	1.07	(0.97 - 1.18)	1.07	(0.97 - 1.18)
Other Backward Classes (OBC)	1.00	(0.94 - 1.07)	1.00	(0.94 - 1.07)	1.00	(0.94 - 1.07)
Religion (ref: Hindu)						
Muslim	0.94	(0.87 - 1.02)	0.94	(0.87 - 1.02)	0.94	(0.87 - 1.01)
Others	0.95	(0.84 - 1.06)	0.95	(0.85 - 1.06)	0.95	(0.85 - 1.06)
Age at marriage (ref: Below 18 years)						
18 years and older	0.92***	(0.88 - 0.97)	0.92***	(0.88 - 0.97)	0.92***	(0.88 - 0.97)
Respondent's Age	1.01	(1.00 - 1.01)	1.01	(1.00 - 1.01)	1.01	(1.00 - 1.01)
Number of children	0.98	(0.95 - 1.02)	0.98	(0.95 - 1.02)	0.98	(0.95 - 1.02)
Parity	0.98	(0.95 - 1.01)	0.98	(0.95 - 1.01)	0.98	(0.95 - 1.00)

Smoking (ref: Does not smoke)						
Smokes cigarettes	1.10	(0.90 - 1.34)	1.10	(0.90 - 1.34)	1.10	(0.90 - 1.34)
Biological characteristics						
Body Mass Index (BMI - kg/m2) (ref: <18.5)						
18.5-24.9	0.77***	(0.73 - 0.82)	0.77***	(0.73 - 0.82)	0.77***	(0.73 - 0.81)
>25	0.72***	(0.66 - 0.78)	0.72***	(0.67 - 0.78)	0.72***	(0.66 - 0.78)
Anemia (ref: Anemic)						
Not anemic	0.91***	(0.87 - 0.96)	0.91***	(0.87 - 0.96)	0.91***	(0.87 - 0.96)
Missing data	1.09***	(1.03 - 1.16)	1.09***	(1.03 - 1.16)	1.09***	(1.03 - 1.16)
Pregnancy complications (ref: No complications)						
Yes	1.03	(0.98 - 1.08)	1.03	(0.98 - 1.08)	1.03	(0.99 - 1.08)
Labor Complications (ref: No complications)						
Yes	1.01	(0.97 - 1.06)	1.01	(0.97 - 1.06)	1.02	(0.97 - 1.07)
Household characteristics						
Household wealth index (ref: Poorest)	0.94	(0.88 - 1.01)	0.94	(0.88 - 1.01)	0.94	(0.88 - 1.01)
Poorer	0.91**	(0.84 - 0.98)	0.90**	(0.84 - 0.98)	0.91**	(0.84 - 0.98)
Middle	0.92	(0.84 - 1.01)	0.92	(0.84 - 1.01)	0.92	(0.84 - 1.01)
Richer	0.70***	(0.62 - 0.79)	0.70***	(0.62 - 0.79)	0.70***	(0.63 - 0.79)
Richest						
Type of cooking fuel (ref: Polluting fuel)	0.97	(0.90 - 1.03)	0.97	(0.90 - 1.03)	0.97	(0.91 - 1.03)
Other/missing	1.01	(0.91 - 1.12)	1.01	(0.91 - 1.12)	1.02	(0.92 - 1.13)
Place of residence (ref: Urban)						
Rural	0.94**	(0.88 – 1.00)	0.94**	(0.88 - 1.00)	0.94	(0.88 - 1.00)
Region (ref: South)						
North	1.35***	(1.24 - 1.47)	1.33***	(1.22 - 1.45)	1.37***	(1.26 - 1.49)
Central	1.14***	(1.06 - 1.22)	1.12***	(1.04 - 1.21)	1.16***	(1.08 - 1.24)
East	0.85***	(0.78 - 0.92)	0.84***	(0.77 - 0.92)	0.86***	(0.80 - 0.94)
North-East	0.77***	(0.69 - 0.85)	0.76***	(0.68 - 0.84)	0.78***	(0.70 - 0.86)
West	1.21***	(1.10 - 1.33)	1.21***	(1.10 - 1.33)	1.22***	(1.12 - 1.34)
Infant characteristics						
Gestational age	0.60***	(0.57 - 0.64)	0.60***	(0.57 - 0.64)	0.60***	(0.57 - 0.64)
Birth order (ref: 2nd or above)						
First child	1.22***	(1.14 - 1.30)	1.22***	(1.14 - 1.30)	1.21***	(1.14 - 1.30)
Gender (ref: Male)						
Female	1.21***	(1.16 - 1.27)	1.21***	(1.16 - 1.27)	1.21***	(1.16 - 1.27)
Constant	23.87***	(13.28 - 42.91)	23.53***	(13.10 - 42.27)	30.61***	(16.82 - 55.69)

***p<0.001, ** p<0.01, *p<0.05

Supplementary table 13. Multivariable logistic regression predicting exclusion (missing data as outcome): Adjusted Odds Ratios (AOR) (95% Confidence Interval)

	Missing data Model 1 (N=180,136)	
	Odds ratio	CI
Individual level variables		
Education (ref: No education)		
Primary	0.75***	(0.72 - 0.79)
Secondary	0.68***	(0.65 - 0.71)
Higher	0.79***	(0.74 - 0.84)
Caste (ref: General)		
Scheduled Caste (SC)	1.00	(0.94 - 1.05)
Scheduled Tribe (ST)	1.00	(0.94 - 1.08)
Other Backward Classes (OBC)	1.02	(0.98 - 1.07)
Religion (ref: Hindu)		
Muslim	1.44***	(1.37 - 1.52)
Others	1.06	(0.98 - 1.14)
Age at Marriage (ref: Below 18 years)		
18 years and older	0.90***	(0.86 - 0.93)
Respondent's age	1.01***	
Number of children	0.79***	(0.78 - 0.81)
Parity (Number of live births)	1.14***	(1.06 - 1.10)
Household level variables		
Wealth Quintile (ref: Poorest quintile)		
Poorer	0.75***	(0.72 - 0.78)
Middle	0.64***	(0.61 - 0.67)
Richer	0.56***	(0.53 - 0.59)
Richest	0.50***	(0.46 - 0.53)
Place of residence (ref: Urban)		
Rural	1.07***	(1.02 - 1.12)
Region (ref: South)		
North	1.26***	(1.19 - 1.34)
Central	1.88***	(1.79 - 1.98)
East	1.16***	(1.09 - 1.23)
Northeast	1.35***	(1.26 - 1.45)
West	0.96	(0.89 - 1.03)
Constant	1.06	(0.96 - 1.16)

***p<0.001, ** p<0.01, *p<0.05

Chapter V. Conclusion

This three-paper dissertation assessed the levels of male partner attendance in antenatal care in India. It also examined if male partner attendance influenced maternal health service utilization and infant birth weight. For the conceptual framework, the dissertation relied on the *Social Ecological Model*, *Connell's Theory of Gender and Power*, and a *Gender-Transformative Approach*. The findings contribute to the growing body of literature on the importance of male partner attendance in antenatal care. In particular, it adds to the evidence-base of studies in India that have examined various aspects of male partner involvement in maternal care. In the discussion that follows, I highlight some of the key findings of each paper, and potential implications for policy, practice and further research. I also discuss the overall limitations of this dissertation and its implications for public health and perinatal social work.

Paper I documented the levels of male partner attendance in antenatal care in India, overall and by state. I also examined the factors that influence male partner attendance. Based on the results from the most recent round of the NFHS (NFHS-4, 2015-16), among women who reported having at least one antenatal care contact, about 85% said that their male partner accompanied them for antenatal care, with women from the Southern and Eastern regions reporting higher levels of male partner attendance as compared to the other regions. It is also interesting to note that there was an observed increase in levels of male partner attendance from 2005-6 to 2015-16. Furthermore, the study results revealed that higher levels of education, higher household wealth, increased knowledge of pregnancy complications, and older age at marriage were positively associated with male partner attendance in antenatal care. Additionally, in comparison to

the Southern region, North, Central, West and North-Eastern regions had lower odds of male partner attendance. The *Social Ecological Model* was used as a theoretical framework to contextualize this study and interpret the study findings. The results from the study are congruent with the main premise of the Social Ecological Model which highlights the importance of multiple levels of influence on individual behavior. These results are also consistent with previous research from India on male involvement in maternal care (Barua et al., 2004; Jungari & Paswan, 2019a, 2019b; Singh & Ram, 2009), and highlights the overall impact of socio-economic status in determining men's choice to be involved, particularly drawing attention to the role of education and awareness. The findings also suggest that interventions aimed at increasing male partner attendance in antenatal care should focus on education and information dissemination on maternal care as one of its primary components. Another important implication of this paper is that it draws attention to early and child marriage as a key factor influencing male partner attendance in antenatal care. There is a need for further in-depth research to understand how child marriage as a practice among boys and young men can shape their attitudes towards involvement in maternal care and their perceived responsibility as partners and fathers. Additionally, a key contribution of this study has been in examining the association between male partner attendance in antenatal care and women's level of autonomy. The significant and positive association between male partner attendance and women's autonomy as suggested by this study indicates that policies aimed at women's empowerment can have a crucial impact on women's decision-making and bargaining power within the household, which in turn can shape their access to health services as well as their partner's decision to be involved in overall maternal care. Future qualitative

research could provide a more nuanced understanding of the intersection between the different aspects of autonomy and male partner attendance in antenatal care. In contrast to previous research (Jungari & Paswan, 2019a; Singh & Ram, 2009), this dissertation's results did not find an effect of family type (nuclear/joint) and work status on male partner attendance. Further research should explore how male partners navigate shared decision-making and responsibility in maternal care within varying household contexts and provide a more in-depth understanding of the socio-cultural aspects of male involvement in maternal care. Based on the framework of the *Social Ecological Model*, the overall findings of this paper suggest the need for a multi-pronged approach to encouraging male partner attendance in antenatal care. Such an approach should take into consideration both individual and household level factors, as well as broader regional and cultural influences.

Paper II examined the association between male partner attendance in antenatal care and maternal health service utilization (timing and frequency of antenatal care contacts, institutional delivery). This paper also showed how these associations varied by residence (rural/urban) and region. The study findings support previous evidence demonstrating a statistically significant and positive association between male partner attendance in antenatal care and women's maternal health service utilization (Chattopadhyay, 2012; Mohammed et al., 2019; Rahman et al., 2018; Suandi et al., 2019; Teklesilasie & Deressa, 2018; Yargawa & Leonardi-Bee, 2015). Only one prior study from India has used nationally representative data to examine the effect of male partner attendance on maternal health service utilization, including data from three India states (Uttar Pradesh, West Bengal and Maharashtra) (Chattopadhyay, 2012). This dissertation

utilized data from the most recent round of the NFHS (NFHS-4, 2015-16). It included data on all twenty-nine states and seven union territories to provide a complete picture of the effect of male partner attendance on maternal health service utilization. Further, the findings show variations in the association between male partner attendance and maternal health service utilization by region. In comparison to the Southern region, the effect of male partner attendance on maternal health service utilization (specifically, frequency of antenatal care contacts) was higher in the Central, Eastern and North-Eastern regions. Taken together, these results provide support for policies and interventions that are aimed at engaging with male partners as an important strategy to improve maternal health service utilization. The importance of male partner attendance in antenatal care can be viewed from differing perspectives. While on one hand, male partners can be thought of as gatekeepers or key decision-makers, conversely, they may also be viewed as responsible and equal partners in maternal care. Interpreting the findings of this paper from a Gender-Transformative lens lends support to the latter viewpoint, and promotes a rights-based approach to maternal and neonatal health that challenges existing gender norms and patriarchal structures. Moreover, the region-specific differences in the effect of male partner attendance on antenatal care indicate the need for interventions and programs tailored to specific cultural and social contexts. Another critical finding of this study was that although the report of intimate partner violence was negatively associated with maternal health service utilization, the correlation between male partner attendance in antenatal care and maternal health service utilization remained significant even when controlling for report of intimate partner violence. While these results provide additional support to interventions that involve men in maternal care, it also calls for a need to be

cognizant of contexts where women do not desire male involvement or where inclusion of male partners may compromise women's safety.

Finally, Paper III assessed the effect of antenatal care on infant birth weight, and examined how this association varied based on women's report of male partner attendance at antenatal care. This is one of the first studies in India which has examined the role of early initiation of antenatal care, and the results indicate that commencing antenatal care contacts early on within the first trimester is associated with reduced odds of having a low birth weight infant. Contrary to previous studies (Khan, Mozumdar, & Kaur, 2019; Zaveri et al., 2020), this study however, found no association between frequency of antenatal care contacts and infant birth weight. This inconsistency in results may be explained by differences in comparison groups. The main assumption within this study is that all women have had at least one antenatal care contact; and thus, the findings highlight that among women who have at least had one contact with the health system during pregnancy, there may be no statistically significant effect on birth outcomes based on number of contacts. This is an important issue for future research aiming to understand the effect of frequency of antenatal care contacts on infant birth outcomes for diverse groups of women. The study results also bring into focus the role of components of antenatal care. In particular, the findings indicate that while women who received tetanus toxoid injection were less likely to deliver a low birth weight infant, testing/screening and counseling showed no association with infant birth weight. Overall, the effect of antenatal care on infant birth weight showed no variation based on women's report of male partner attendance in antenatal care. Despite these findings, there is abundant room for further research examining the effect of male partner attendance in

antenatal care on neonatal and infant health. Future investigations should examine the role of varying aspects of male involvement, such as involvement in nutrition care, household chores, and improved knowledge levels regarding pregnancy care, and its effect on infant birth weight.

Limitations

One of the major limitations of this dissertation is related to the construction of the survey questions that capture male partner attendance in antenatal care. Within the NFHS survey, the variable measuring male partner attendance in antenatal care has been asked in the form of a yes/no question for women who have had at least one antenatal care contact. Thus, one of the main limitations is that I could not account for male partners' sustained involvement throughout the pregnancy period. Due to a lack of information on the timing of male partner attendance, I was also unable to assess whether male partner attendance was initiated early on during the pregnancy. Further, only the previous two rounds of the NFHS survey (NFHS-4, 2015-16 and NFHS-3, 2005-05) included questions on male partner attendance in antenatal care, and hence I could examine the changing trends in male partner attendance only for 2005 and 2015. While examining women's reports of male partner attendance, it is also important to acknowledge the potential for social desirability bias which can lead to an overestimation of report of male partner attendance.

Secondly, there are limitations concerning variables measuring maternal health service utilization. For instance, the survey asks questions on maternal health service utilization based on women's last pregnancy in the past 5 years, and as a result the responses could suffer from recall bias. Further, due to the lack of available data, I was

unable to control for the spacing of antenatal care contacts, quality of health services and the number of pregnancies (gravida) within the model. Additionally, due to a lack of information on mental health within the NFHS survey, I could not account for maternal depression as a potential confounder. Another crucial limitation of this study is that to account for male partner attendance in antenatal care, I excluded women who have had zero antenatal care contacts, thus eliminating an important subpopulation of women who had no contact with the health system during pregnancy. Women who have never received antenatal care often constitute some of the most vulnerable populations. Due to this limitation, the results cannot be generalized to this sub-population. Additionally, the dissertation uses cross-sectional data, and hence it is not possible to establish a causal relationship between male partner attendance in antenatal care and maternal health service utilization.

Third, the data on infant birth weight is based both on written records as well as recall. Due to these inconsistencies and the possible bias associated with recalling infant birth weight, I chose to conduct the analysis stratified by the method of report and interpreted findings for the sub-sample based only on medical records. Further, while gestational age is included as a control variable in the analyses, this is measured in months; hence, I could not include gestational age in weeks which would have been a more precise measure.

Finally, due to data limitations, I could not account for the influence of prevalent cultural norms and practices. This also extends to the perceptions of health providers. Prior research has documented that health workers' attitude and harsh treatment by health providers is an important factor influencing male partner attendance in antenatal care

(Barua et al., 2004; Gibore, Bali, & Kibusi, 2019); however, I was unable to account for these health system-level factors that might impede maternal health service utilization as well as male partner attendance. Further, as a result of how the survey is designed and operationalized, it includes data on understanding partner involvement only among partners of a specific gender. The survey questions also focus on women as the primary childbearing individuals, excluding persons of other genders who may be childbearing individuals (trans men).

Implications for policy

This dissertation's findings contribute to the literature by constructing a comprehensive understanding of male partner attendance in antenatal care in India. This dissertation documents the levels of male partner attendance, its effect on maternal health service utilization and infant birth weight, and also examines the factors that shape male partner attendance in antenatal care. As one of the first studies to examine male partner attendance in India at a national level and regional level, this study also serves as a primer for similar research in India and other low- and middle-income countries. In particular, it sheds light on how women's level of autonomy and cultural practices, such as child marriage, not only affect women's health behavior but also influence men's desire to be involved in maternal care. Further research can provide a more in-depth understanding of the regional variations in male partner attendance and can explore the cultural and region-specific factors that might shape this.

These findings are particularly useful to inform policy and health interventions in India and provide support for introducing inclusive and gender-transformative strategies aimed at improving maternal and neonatal health outcomes. Engaging with male partners

and encouraging male partner attendance in antenatal care can be a crucial strategy leading to improvements in knowledge levels among the couple, increased support for women accessing services during pregnancy, birth preparedness, and complication readiness, and an uptake in both institutional delivery and antenatal care utilization. As suggested by the findings of this study, educating male partners and increasing awareness regarding maternal care, birth preparedness and complication readiness should be the basis of any intervention aimed at harnessing the positive effect of male partner attendance in antenatal care. Provision of education materials, mass media campaigns and awareness-generation workshops for men separately as well as couples can be some key strategies in this direction. Another important aspect is the role of community based outreach in engaging with male partners on maternal and child care. Home-visits and group counseling sessions within the community can be an essential strategy for improving male partner attendance. Particularly within this context, male community health workers/ Male Health Activists can be an important pathway for engaging with male partners (Fotso, Higgins-Steele & Mohanty, 2015), especially for populations living in rural and tribal areas. This study also highlights the regional variations in levels of male partner attendance and differences in its effect on maternal health service utilization. Thus, community-based participatory approaches to designing, implementing and monitoring, and engaging in dialogue with the community can greatly assist in the development of culturally-appropriate and inclusive interventions.

Encouraging male partner attendance in antenatal care can be an immense leap forward in the direction of gender-transformative interventions in maternal and child health. However, it is vital to consider the need for implementing such interventions in a

manner that respects and promotes women's choices and decision-making autonomy. Women's access to quality maternal health services should not in any way be conditional on male partner attendance, and programs and policies should be mindful of avoiding the reinforcement of gendered stereotypes. In contexts of intimate partner violence, strategies should be implemented in a manner that does not compromise women's safety. In this regard, further qualitative research can provide a nuanced understanding of the diversity in women's preferences and cultural values. Additionally, future investigations in India should also examine men's perspectives towards attendance in antenatal care and other aspects of maternal care, and how male partner involvement intersects with and influences intra-household dynamics. Further, research should also examine how health provider attitudes towards male involvement, unequal treatment or discrimination based on caste, religion or class could influence the uptake of services. Finally, although this dissertation did not find an association between male partner attendance in antenatal care and infant birth weight, future research should continue to explore if male involvement influences neonatal and infant health outcomes.

Implications for perinatal social work

Social workers have an essential role to play in providing support to women, families and communities during the perinatal period. At the individual level, perinatal social workers form an essential link with the health system, and can help women address some of the barriers to accessing services, as well additional challenges faced during the pregnancy and postpartum period. The findings of this study relate to the Systems perspective of social work, and indicate the need for an integrated approach that takes into consideration the entire social ecological environment of individuals. More

specifically, within the context of India, social workers also have a key role to play in the community setting and can partner with community-based Non-Governmental Organizations (NGOs) to design and implement gender-transformative programs aimed at increasing male partner attendance in antenatal care. These interventions should not only be limited to male partners of women, and can extend to other male members within the community, such as community leaders, religious or village heads. Furthermore, an important finding of this study is the role of women's autonomy in positively influencing maternal health service utilization as well as male partner attendance. This is an essential area of advocacy within social work, and has implications for improvements in women's empowerment and well-being.

Currently, perinatal social work within the Indian context is in its nascent stages. Perinatal social workers in India need to be closely integrated within health systems, wherein they may work alongside a team of medical and health professionals to provide support and quality care to women. Further, there is also a need to expand social work interventions in the field of perinatal mental health in India; particularly, the role of social workers in assisting both women as well as their partners in dealing with grief and loss during the perinatal period.

Conclusion

Prioritizing maternal and neonatal health, and ensuring that all women have access to comprehensive reproductive healthcare is crucial both from a rights-based and global health perspective. With the launch of the Sustainable Development Goals (SDG) in 2016, there is a global call to action for countries to bring about a significant reduction in maternal and infant mortality by 2030 (global maternal mortality should be reduced to

70 per 100,000 live births and neonatal mortality to 12 per 1000 live births). According to projections in a study by McArthur, Rasmussen and Yamey (2018), about 1.6 million women's lives are at stake through to 2030, with about 67% of these women residing in developing countries. With less than a decade remaining to the SDG targets, accelerating the rate of progress towards reducing maternal morbidities and mortalities in India takes on utmost priority. According to research, one of the key strategies to meeting this goal is to create substantial improvements in women's access to adequate and quality antenatal care, as well as ensuring safety and well-being of women during child-birth and in the postpartum period (Campbell et al., 2006). This three-paper dissertation examines factors influencing maternal health service utilization and infant birth weight. Taken together, the findings of this dissertation suggest the need for multi-pronged interventions that account for the entire social ecology of the individual. There is a need to broaden the scope of interventions beyond an exclusive focus on women, and to take into consideration the role of the partner, family and communities. Most importantly, these results provide support for interventions that aim at a more inclusive or gender-transformative approach to maternal health. As a gender-transformative strategy, male partner attendance in antenatal care has the potential not only to improve maternal health service utilization, but also to serve as a meaningful step towards creating sustainable social change and health equity for all.

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Appendix 1

Supplementary Table 14. Description and coding for variables used within the dissertation.

Dissertation variables and NFHS Survey questions from women's questionnaire	**NFHS response categories**	**Recoded response categories**
Primary variables		
Male attendance in antenatal care "Was the child's father present at any antenatal care contact for your most recent child?"	Responses categories: Yes; No	0 = No 1 = Yes
Number of antenatal care contacts ***(4 or more contacts)*** "How many antenatal care contacts did you go for?" (continuous variable)	Number/Don't know	0= Less than 4 visits; 1= 4 or more visits
Number of antenatal care contacts ***(8 or more contacts)*** "How many antenatal care contacts did you go for?" (continuous variable)	Number/Don't know	0= Less than 8 visits; 1= 8 or more visits
Timing of antenatal care "When did you go for your first antenatal care contact?" (continuous variable)	Number/Don't know	0= Post 12 weeks of pregnancy 1= At or before 12 weeks of pregnancy
Institutional Delivery "What was place of delivery for your last pregnancy?"		0= Home 1= Health facility
Components of ANC - *Receipt of tetanus toxoid injection* - *ANC testing (weight, blood and urine sample and blood pressure, abdomen examined)*	*Receipt of tetanus toxoid injection: Did you at least one tetanus toxoid injection during antenatal care contact?* *ANC testing: Was your weight checked, abdomen examined, urine and blood sample, and blood pressure taken during antenatal care contact?* *ANC counselling: Were you told about pregnancy*	Each component was constructed as a binary variable.

- *ANC counselling (on pregnancy complications*	*complications and where to access care for complications during antenatal care contact?*	
Control variables		
Men's questionnaire		
Male Respondent's Education	This variable included five categories: no education, primary education (pre-primary to the completion of 5th grade of schooling), secondary education (6th grade to the completion of 10th grade); Higher secondary and above higher secondary (beyond 10th grade). No education was used as the reference category.	1= no education, 2= primary education 3= secondary education 4 =Higher secondary and above higher secondary (beyond 10th grade).
Male Respondent's Caste	This variable included five categories: scheduled caste, scheduled tribe, other backward classes, none of them/General, don't know. General was used as the reference category.	1= scheduled caste 2= scheduled tribe 3= other backward classes 4= none of them/General (will drop 'don't know' while recoding due to limited number of cases.)
Male Respondent's Religion	This variable included nine categories: Hindu, Muslim, Christian, Sikh, Buddhist, Jain, Jewish, No religion, other. Hindu was used as the reference category.	1= Hindu 2= Muslim 3= Christian 4= Sikh 5= Buddhist 6= Jain 7= No religion (will drop 'Jewish' while recoding due to limited number of cases.)
Male Respondent's age	Continuous variable representing respondent's age.	0 = 15 – 24 years' old 1 = 25 and above
Male respondent's Age at marriage	Continuous variable representing respondent's age at marriage.	0 = Men married below 18 years of age 1= Men married at 18 years of age and older were coded as 1;

Family type	Based on the question, what is your relationship to the household head.	0 = Joint family (those who reported any other relationship to household head) 1= Nuclear family (those who reported themselves or wife as household head);
Male Respondent's Work status		0 = No work 1 = Currently employed
Male respondents Knowledge of pregnancy-related complications and maternal care	Score was created based on whether the male respondent was told of (Chattopadhyay, 2012): - Signs of pregnancy complications (bleeding, convulsion, prolonged labor, abdominal pain, blood pressure); - Delivery advice during pregnancy; - Nutritional advice during pregnancy - Cord care explained - Need to breastfeed - Need to keep baby warm after birth - Family planning or delaying next child	The index will include 7 questions, and the score will range from 0 to 7.
Women's questionnaire		
Respondent's Education	This variable included five categories: no education, primary education (pre-primary to the completion of 5th grade of schooling), secondary education (6th grade to the completion of 10th grade); Higher secondary and above higher secondary (beyond 10th grade). No education was used as the reference category.	1= no education, 2= primary education 3= secondary education 4 =Higher secondary and above higher secondary (beyond 10th grade).
Caste	This variable included five categories: scheduled caste, scheduled tribe, other backward classes, none of them/General, don't know. General was used as the reference category.	1= scheduled caste 2= scheduled tribe 3= other backward classes 4= none of them/General
Religion	This variable included nine categories: Hindu, Muslim, Christian, Sikh, Buddhist, Jain, Jewish, No religion, other. Hindu was used as the reference category.	1= Hindu 2= Muslim 3= Others

Respondent's age	Continuous variable representing respondent's age.	No recoding
Age at marriage	Continuous variable representing woman's age at marriage.	1= Women married at 18 years of age or older were coded as 1; 0 = Women married below 18 years of age
Number of children	Continuous variable representing number of children born.	No recoding
Parity	Continuous variable representing number of births (including live birth and stillbirths)	No recoding
Visited by Health worker	This variable included two categories: Yes, no	0 = No 1 = Yes
Women's Autonomy	Adapted from Thapa et al. (2013)* ● Whether the woman has money set aside that they alone can use, whether the woman has a bank account. ● Whether woman has to ask permission to go to health facility, to the market, to go outside the village/community. ● Whether women make decisions regarding healthcare, major household purchases and the decision to visit family or relatives.	The index will range from 0 to 4.
Intimate Partner Violence	Adapted from Raj et al. (2010) Respondent was classified as having experienced physical, sexual or emotional violence based on whether they reported "yes" to any of the following yes/no survey questions: • Have you ever been slapped; twisted arm or hair; shaken, pushed or thrown; kicked or dragged; punched with fist or something else; strangled or burned; threatened or attacked with a knife or gun, by husband/partner	0 = No 1 = Yes

	• Have you experienced any emotional violence from husband/partner • Have you experienced any sexual violence from husband/partner	
Household level Characteristics		
Wealth quintile[a]	This variable includes five categories: Poorest, Poorer, Middle, Richer, Richest. Richest was used as the reference category.	1= Poorest 2= Poorer 3= Middle 4= Richer 5= Richest
Place of residence	This variable included two categories: Rural, Urban	0= Rural 1= Urban
Region	State variable was recoded into regions based on categorization of National Family and Health Survey-4 (IIPS, 2017). South was used as the reference category.	1=North (Chandigarh, Delhi, Haryana, Himachal Pradesh, Jammu & Kashmir, Punjab, Rajasthan, Uttarakhand) 2=Central (Chattisgarh, Madhya Pradesh, Uttar Pradesh) 3=East (Bihar, Jharkhand, Odisha, West Bengal) 4=North East (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Tripura) 5= West (Dadar & Nagar Haveli, Daman & Diu, Goa, Gujarat, Maharashtra) 6= South (Andaman & Nicobar Islands, Andhra Pradesh, Karnataka, Kerala, Lakshadweep, Puducherry, Tamil Nadu, Telangana)
Distance to health facility	This variable included three categories: no problem, big problem, not a big problem	This was recoded into two categories: Not a problem, Big problem
Use of polluting fuels	Electricity, Liquefied Petroleum Gas (LPG), Biogas, Kerosene, Coal, Charcoal, Wood, Straw, Agricultural crop, Animal Dung, Others.	0= Use of non-polluting fuels (electricity, LPG, biogas); 1= Use of polluting fuels

	Respondents who reported "Others" and "No food cooked in the house" were excluded from analysis.	
Biological characteristics		
Maternal Body Mass Index (BMI)	Continuous variable	1= <18.5 (Underweight); 2= 18.5 – 23.0 (Normal); 3= >23.0 (Overweight) (Reference category is Underweight)
Anemia during pregnancy	This variable included two categories: Yes, No	0 = No; 1 = Yes
Pregnancy complications	Variable created based on response (yes/no) to any one of the following survey questions: During pregnancy, had difficulty with daylight vision; during pregnancy had swelling on legs, body, face; had convulsions not from fever. Respondents who answered yes to any of these questions were coded as 1, otherwise as 0.	0 = No; 1 = Yes
Labor complications	Variable created based on response (yes/no) to any one of the following survey questions: During delivery, did you experience prolonged labor, excessive bleeding had massive vaginal bleeding after delivery. Respondents who answered yes to any of these questions were coded as 1, otherwise as 0.	0 = No; 1 = Yes
Infant characteristics		
Gestational Age	Continuous variable based on number of months of pregnancy	No recoding.
Infant sex	This variable included two categories: Male, female	0 = Male; 1 = Female
Birth Order	Continuous variable	0= 2 or more births; 1= 1st birth

**Note. Women's autonomy is measured at the individual level.*
[a]The wealth index is calculated at the household level based on assessments of housing characteristics and household assets as observed by the interviewer (https://dhsprogram.com/topics/wealth-index/)