

Sex differences in the care of the fetus in the mother's womb and the neonate on her lap: Evidence from demographic surveillance and survey data from Bangladesh

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ABSTRACT

Valuation of sons over daughters introduces sex-biased health, economic, and socio-demographic inequalities in many societies. This study aims to examine fetus-sex differences in maternity services and sex differences in medical care for terminally ill neonates in Bangladesh, using secondary data from the Matlab Health and Demographic Surveillance System (HDSS), maintained by icddr,b since 1966 along with data from the Bangladesh Maternal Mortality and Health Care Survey (BMMS) 2016. The HDSS follows a well-defined rural population (0.24 million in 2018) to register vital events and migrations and records the use of maternity services for the index birth and medical care-seeking during the terminal illness of each death in verbal autopsy. The BMMS 2016 recorded maternity care and maternal complications for the last live birth of mothers in the same population (weighted $n = 27,133$; unweighted $n = 26,939$). Bivariate analyses estimated the use (in %) of maternity services for the index live births and medical services for terminally ill neonates for each socio-demographic variable. Logistic regression models estimated odds ratios (AORs) adjusted for socio-demographic variables and clustering of births to the same mothers. The HDSS registered 49,827 live births and 1,049 neonatal deaths during 2009–2018. We found similar prenatal care-seeking for male and female fetuses but higher facility delivery (AOR = 1.17, 95% CI: 1.12–1.23) and C-sections (AOR = 1.20, 95% CI: 1.15–1.25) for male fetus pregnancies, differences that remain after adjusting for maternal complications. Sex differences persisted in seeking care for terminally ill neonates. Trained provider consultation (AOR = 1.46, CI: 1.00–2.12); hospital admissions (AOR = 1.43, CI: 1.01–2.03); and dying in hospital (AOR = 1.91, CI: 1.31–2.78) were all higher for male neonates. Other variables positively associated with delivery care and medical care-seeking were lower birth order of the child, higher maternal education, and higher household wealth status. Policy and decision-makers need to be aware of gender disparities in maternity care and care of sick neonates and plan remedial actions.

1. Introduction

Parental son preference and valuation of sons over daughters are common phenomena in many cultures worldwide, introducing sex-biased economic and demographic inequalities in some societies (Ahmed et al., 2021; Barot, 2012; Vlassoff, 2007). The adverse effects of overvaluing sons include sex differences in immunization coverage, perceptions of illness and need for care, quality of medical care-seeking, medical-care expenditure, and female-biased infant and child mortality in South Asian countries (Chowdhury et al., 2003; Hanifi et al., 2018;

Ismail et al., 2019; Najnin et al., 2011; Shah et al., 2014; Subedi et al., 2022; Willis et al., 2009). Socioeconomic development, expansion of preventive and curative health services, and gender policies to address gender-related barriers have contributed to lower maternal and childhood morbidity and mortality, lower fertility, and reduced gender inequalities in many indicators (e.g., education) in these countries. Despite this, fertility decline in a son-preferring society may increase the manifestation of sex bias in some contexts (Das Gupta & Mari Bhat, 1997).

With the decline in fertility, couples started having fewer children.

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Thus many couples may not have a son (Chao et al., 2019; Cleland, 2001). The sex composition of the current children in the family shapes the couples' subsequent fertility decisions and behavior (Asadullah, 2021). Some may adopt son-targeting fertility behavior to fulfill a desire for a son in the context of a smaller family size. That may increase sex bias in prenatal care use or, in extreme cases, sex-selective abortion or neglect of child care for daughters after birth. Advancements in medical technologies and increasing availability and accessibility of sex-identification technologies (e.g., ultrasonography) in low and middle-income countries (LMICs) allow couples to know fetal sex and thus adopt sex-biased prenatal care. For example, in India, prenatal health services (such as antenatal care, tetanus vaccinations, and iron and folic acid supplementation) were more used among women pregnant with boys than women pregnant with girls – evidence of sex bias in maternity care (Bharadwaj & Lakdawala, 2013). Such sex biases may persist in delivery care, but this question is less explored in LMICs, including Bangladesh.

Estimates of gender disparities in maternity care can be biased due to a lack of good statistical control for sex bias in pregnancy and obstetric complications. This is because women pregnant with male fetuses experience more complications (i.e., gestational hypertension, eclampsia, placental abruption, and hemorrhage) during pregnancy, labor, and delivery (Eogan et al., 2003; Funaki et al., 2020; Lieberman et al., 1997). Thus they get more or better quality care for more complications than women pregnant with female fetuses. Yet no study, to our knowledge, has explored sex differences in maternity care (e.g., quality antenatal care, nutritional supplements, delivery in health facilities, caesarian section, etc.) in Bangladesh, controlling for pregnancy and obstetric complications. This study aims to address this knowledge gap, estimating sex differences in maternity care using recent health and demographic surveillance and large-scale national survey data.

As mentioned, the worst consequence of prenatal son-targeting fertility behavior is sex-selective abortion, which remains illegal in all countries. Still, limited indirect evidence suggests that it has been prevalent in some regions since the 1970s when fertility started falling and prenatal sex diagnostics started to become available (Chao et al., 2019). Analysis of worldwide population data found an unnatural excess of boys in 12 countries (Chao et al., 2019). Abnormally high ratios of boys to girls at birth in India and Nepal were possibly due to sex-selective abortions to achieve both desired small family size and ideal sex composition, including at least one son, among children (Abbamonte, 2019; Das Gupta & Mari Bhat, 1997). Indeed, an estimated 4.1% of all live female births since the 1990s have been prevented by the practice of sex-selective abortion in India (Abbamonte, 2019).

In Bangladesh, moderate son preference persists, fertility is low (at 2.3 births per woman since 2011 as opposed to 7 births per woman in the 1970s), and the use of ultrasounds scan as a quality component of antenatal care is high and rising (ICF, 2012). Some couples in such an enabling situation may have adopted (or may adopt) son-targeting fertility behavior to fulfill their desire for a son despite a small family size. Yet analysis of national and local survey data collected in 1994–2011 found no significant rise in sex ratio at birth – a marker of sex-selective abortion (BBS, 2014, 2015; icddr,b, 2021; Shenk et al., 2014; Talukder et al., 2014). Still, couples do show evidence of son preference as those without a son among their first two children do have another child at a higher rate than couples with son(s) among their first two children (Asadullah, 2021). While thus far, there is little evidence of sex-selective abortion in Bangladesh, ongoing analysis of recent surveillance and national survey data is needed to monitor changes (if any) in the sex ratio at birth and thus any emerging trend toward sex-selective feticide.

The adverse consequences of couples' son-preferring behaviors may also continue after birth, affecting essential newborn care and patterns of care-seeking for sick neonates, which remained understudied in Bangladesh. There is evidence that parents perceive, recognize, and respond to the illness of male and female newborns differently.

Caregivers' perceptions and recognition of and care-seeking for illnesses of newborns were lower for female newborns than male newborns in rural Uttar Pradesh, India (Willis et al., 2009). They were more vigilant to the health of their sons, perceiving girls as less likely to be ill and neglected girls in care seeking often because they 'did not think the care was necessary' (Willis et al., 2009). In Nepal, ill male neonates were more frequently taken for care than female neonates (Rosenstock et al., 2015). As a result of this gender-based discrimination, higher mortality of boys in the first week was followed by no difference in weeks 2 and 3, which reversed to girls dying in week 4 at more than twice the rate of boys (Subedi et al., 2022). This is strikingly different than the expected pattern in which boys generally have higher mortality throughout the first month of life.

In Bangladesh, the balanced sex ratio at birth and excess mortality of male neonates (icddr,b, 2021; Shenk et al., 2014; Talukder et al., 2014) mark the absence of female feticide and gross neglect but do not demonstrate an absence of subtle neglect in the caring and nursing of girls after birth. In South Asia, data on neonatal care seeking are limited, and seeking care for newborn illness from health care facilities and medically trained providers is low (Herbert et al., 2012). Limited societal knowledge about the importance of care-seeking and recognition of newborn danger signs contribute to inadequate care seeking (Aruldas et al., 2017; Khadduri et al., 2008; Syed et al., 2008). The need-feeling drives the individual to seek or refrain from care-seeking. In Bangladesh, around one-third of sick neonates are treated by medically trained providers (Nu et al., 2020). Care-seeking from either unqualified or qualified providers was significantly lower for female preterm babies than for male preterm babies (Shah et al., 2014). Education, an important aspect of one's social position, endows the taste for modern health care (Stein, 1997). Care-seeking was higher for newborns of mothers who have higher education and higher socioeconomic status (Nu et al., 2020; Shah et al., 2014). Care-seeking for the newborns of young mothers with limited decision-making power in the family and access to household resources may be limited.

Gender differences in care-seeking are understudied; relevant indicators include the consultation of medically trained providers, admission to hospital during the illness of neonates prior to death, and finally, dying in hospital. Therefore, we aim to examine fetal sex differences (if any) in seeking maternity care using recent surveillance and national survey data, as well as medical care-seeking for terminally ill neonates in Bangladesh using recent surveillance data only.

2. Material and methods

2.1. Study design, data, and participants

This study used secondary data from the Matlab Health and Demographic Surveillance System (HDSS), maintained by icddr,b since 1966 (Alam et al., 2017) and the Bangladesh Maternal Mortality and Health Care Survey (BMMS) 2016 (National Institute of Population Research and Training (NIPORT) et al., 2019b) for two specific reasons. The first is to examine whether observed gender disparities in care-seeking are explained by higher pregnancy rates and obstetric complications among women pregnant with male fetuses. The second is to estimate spatial variation (if any) in gender disparities in maternity care and examine the comparability of the findings derived from the prospectively collected Matlab HDSS data and the retrospective national survey data.

Matlab is one of 495 sub-districts of Bangladesh, where HDSS follows a well-defined population (0.24 million in 2018) to record demographic events (births, deaths, migrations, marriages, and divorces) in standard forms. Birth forms record any pregnancy outcome with the result and date, including antenatal care received in each trimester of pregnancy and the place and mode of delivery. In addition, verbal autopsy data is collected for all deaths, including data on medical care-seeking during the terminal illness preceding each death (Appendix A).

The relational database of Matlab HDSS allowed the matching of individual-level information regarding births, deaths, and periodic household socioeconomic information to create a merged data file containing births alongside and mother’s background socio-demographic variables. The merged data were used to estimate fetal sex disparities in maternity care, neonates’ survival status, and care-seeking during terminal illness by different socio-demographic variables.

Since Matlab HDSS does not have data on maternal (pregnancy and delivery) complications, which are influenced by fetal sex, we used BMMS 2016 data to determine fetal sex disparities in maternity care, controlling for maternal complications. The BMMS 2016 is a recent large-scale nationally representative sample survey conducted to estimate maternal mortality ratio and health care use (Appendix B). The survey recorded women’s pregnancy and obstetric complications, as well as the mode and place of delivery of the last live births born three years preceding the survey (BMMS 2016).

2.2. Outcome measures

The outcome measures used in this study are the uses of different maternity services for the index births, the sex ratio at birth (a marker of sex-selective feticide), and medical care-seeking for terminally ill neonates. Maternity services include utilization of antenatal care (ANC) (in 2nd and 3rd trimesters as opposed to any other in the HDSS and four or more visits as opposed to fewer in BMMS 2016), delivery in a health facility, and delivery through cesarean section. Medical care-seeking prior to death includes consultation with trained providers, admission to a hospital during terminal illness and dying in a hospital.

2.3. Covariates from Matlab HDSS and BMMS 2016

The main explanatory variable of interest was the sex of the fetus, resulted in a live birth. The background socio-demographic variables that may influence ANC uptake, facility birth, mode of delivery, and neonatal care-seeking were selected based on earlier literature (Begum et al., 2017; Herbert et al., 2012; Islam & Masud, 2018; Rahman et al., 2021). The births and mothers in these two data sets are the same, except for: an ongoing MCH-FP (the maternal and child health and family planning) service provisions in one-half of the HDSS area, four self-reported complications during pregnancy and delivery, and place of residence in BMMS 2016 data. The socio-demographic variables are categorized as follows:

Mother’s age at birth: <20 years, 20–24 years, 25–29 years, ≥30 years; birth order of the fetus/infant: 1st, 2nd, 3rd or higher; mother’s education (grade passed): ≤5 (none or up to primary), 6–9 (secondary incomplete), ≥10 (secondary complete and higher); religious affiliation: Muslim, Non-Muslim; household asset quintiles: bottom two, middle, top two, unknown. Recent periodic household socioeconomic status (SES) updates in Matlab HDSS happened in 2005 and 2014. Thus, SES remained unknown for births that occurred to new households formed after the 2005 Matlab Household Socioeconomic Survey (MHSS) but before 2014 MHSS. Similarly, SES for births that occurred to new households formed after the 2014 MHSS were unknown.

The MCH-FP services provision in the area is categorized into icddr,b referring to enhanced quality of care versus government to refer to standard care as in other rural areas. The self-reported maternal complications were symptoms of preeclampsia (severe headache with blurred vision, high blood pressure or edema), leaking membrane and no labor pain for 6 hours or more, malpresentation, or prolonged labor of more than 12 hours (symptoms of prolonged labor), convulsion/fits. Place of residence was categorized into rural and urban areas.

2.4. Statistical analysis

Analysis included all pregnancy outcomes that resulted in live births.

Table 1
Distribution of live births and neonatal deaths by socio-demographic variables, Matlab HDSS 2009–2018.

Label of the variable	Live births		Neonatal deaths	
	Percentage	Number	Percentage	Number
Total	100.0	49,827	100.0	1049
Sex of the child				
Male	51.0	25,401	60.4	634
Female	49.0	24,426	39.6	415
Mother’s age at birth (years)				
<20	15.6	7758	18.0	189
20-24	32.9	16,373	32.9	344
25-29	26.7	13,305	21.9	226
30 and above	24.9	12,391	27.3	286
Mean age (± SE)	25.6 (± 0.03)	-	25.8 (± 0.20)	-
Mother’s years of schooling				
≤ 5	26.5	13,213	32.9	345
6–9	53.0	26,409	49.7	521
≥10	20.5	10,205	17.5	183
Household asset quintiles				
Bottom two	31.3	15,625	35.5	372
Middle	17.6	8786	17.5	184
Top two	40.3	20,096	35.4	371
Unknown	10.7	5320	11.6	122
Religious groups				
Muslim	90.1	44,894	90.7	951
Non-Muslim	9.9	4933	9.3	98
Local MCH-FP ^a service delivery				
icddr,b	52.6	26,234	42.0	441
Government	47.3	23,593	58.0	608
ANC ^b in trimesters 2 & 3				
Yes	66.1	32,930	15.9	167
No	33.9	16,897	84.1	882
Place of delivery				
Home	34.3	17,086	37.7	396
Facility	65.7	32,741	62.2	653
Mode of delivery				
Normal vaginal delivery	64.3	32,045	72.1	756
C-section	35.7	17,782	27.9	293

^a Maternal and child health and family planning.

^b Antenatal care.

The main explanatory variable of interest is the sex of the fetus, which resulted in a live birth. The confounders are maternal age, parity, years of schooling, household asset quintiles, and religion. The other two confounders are MCH-FP service provision in Matlab HDSS data and reported maternal complications in the BMMS 2016 data.

The BMMS 2016 adopted a two-stage stratified cluster sampling approach (National Institute of Population Research and Training (NIPORT) et al., 2019a). All the analyses were carried out by adjusting the survey weight (provided in the dataset) that accounts for the complex survey design characteristics of BMMS 2016. Sampling weight does not apply to Matlab HDSS data analysis as surveillance covers the entire population in a well-defined area.

Bivariate analyses estimated the use (in %) of maternity services for the index live births and medical services for terminally ill neonates for each socio-demographic variable. Chi-square (χ^2) test is used to test the difference in service use between categories of the socio-demographic variables for statistical significance at $p < 0.05$ with 0.80 power of the test. Finally, logistic regression models estimated the net relationships of the socio-demographic variables to the outcome variables, shown as adjusted odds ratios (AOR) with 95% confidence interval.

3. Results

3.1. Descriptive statistics

Matlab HDSS recorded 49,827 (male = 25,401, female = 24,426) live births born to 36,961 mothers and 1,049 neonatal deaths during

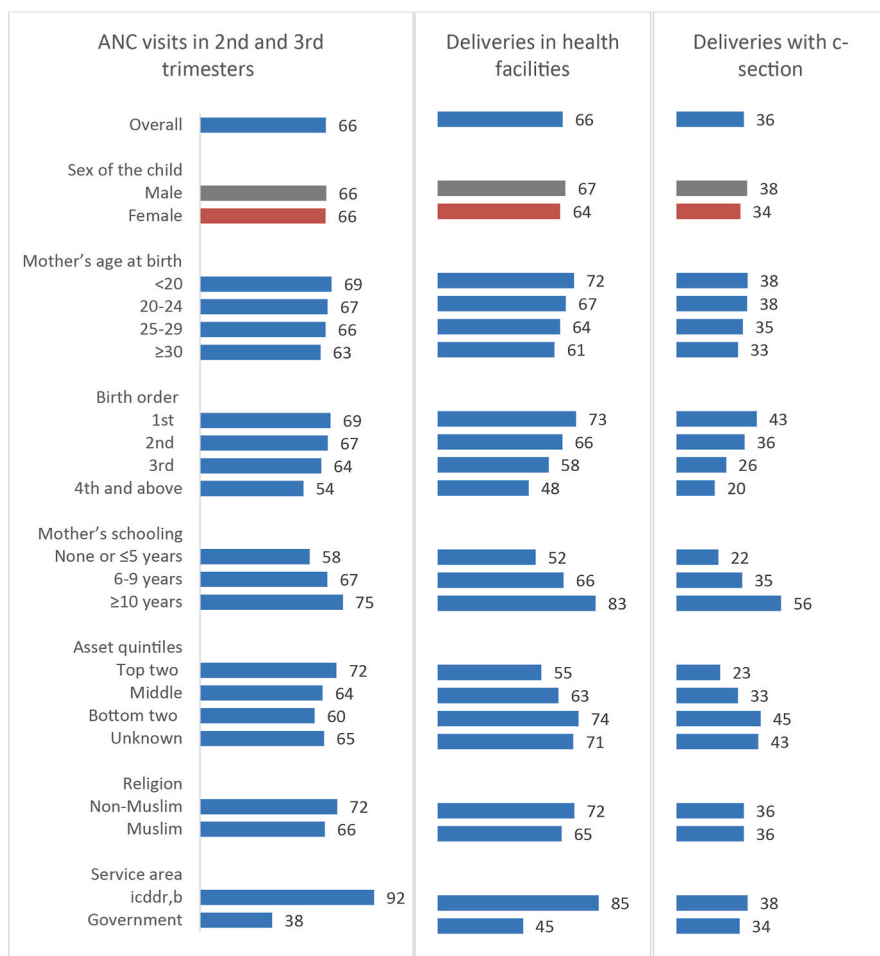


Fig. 1. Utilization (%) of ANC uptake, facility birth, and C-section birth by sex of the fetus and mothers' socio-demographic variables, Matlab HDSS 2009–2018 (n = 49,827 live births).

Note: Only 16% of the mothers sought prenatal care from trained providers in the first trimester. We have not further disaggregated this finding by socio-demographic characteristics.

2009–2018, yielding a sex ratio of 104 males per 100 female births and a rate of 21 deaths per 1,000 live births (Appendix A). The death rate at birth was higher among males than females (25 vs. 17). The fraction of births to mothers aged below 20 years was 15.6%, and to mothers aged 30 years and above was 24.9% (Table 1). The majority (53%) of births were to mothers who have passed grade 6-9, and 20.5% were to mothers who have passed grade 10 and above. One in eleven births was to Non-Muslim (mostly Hindu) mothers. Two in three births (65.7%) occurred in health facilities, and 35.7% were through C-sections.

3.2. Gender difference in prenatal care and delivery care

3.2.1. Uses of maternity services in Matlab HDSS population

The percentage of mothers seeking prenatal care from trained providers in the first trimester for the index birth was very low (16%), while seeking care in both the second and third trimesters was 66.1% and comparable between male and female births. Seeking prenatal care was higher for lower order births and for births to mothers who have at least some secondary education or more, and to those who belong to higher asset quintiles. Prenatal care was particularly higher for births to Non-Muslim mothers and births to mothers in the icddr,b service area. (Fig. 1).

The rate of deliveries in health facilities was not high, but it was significantly higher for live male than live female births (AOR = 1.17, CI: 1.12, 1.23), as was also true for cesarean section deliveries (AOR = 1.20, CI: 1.15–1.25). Other socio-demographic variables significantly associated with higher odds ratios of delivering in a health facility and undergoing a cesarean section delivery were mother's higher education, higher household asset quintiles, religious belief in Hinduism (most

Non-Muslims are Hindu), and residence in the icddr,b service area. (Table 2).

3.2.2. Uses of maternity services in BMMS 2016 population

A total of 26,939 (weighted n = 27,133) women who experienced their last live births three years preceding the survey were included in the present study. Like the Matlab HDSS results, analyses of the BMMS 2016 data yielded no difference in ANC visits, but significant differences in rates of deliveries in health facilities and cesarean sections in favor of male live birth pregnancies (Table 3). Utilization (%) of maternity care by mothers' socio-demographic variables from BMMS 2016 is presented in appendix Table C1.

Higher rates of facility deliveries and C-sections may be confounded to a lack of control for complications women experienced during pregnancy and delivery. 37.5% of the women reported one or more complications during pregnancy, and 25.9% reported one or more complications during delivery (Table 4). The most common complications reported by women during pregnancy and delivery were edema (in the face, feet, or body), followed by headache and high blood pressure. Preeclampsia symptoms (headache with blurred vision, blood pressure, or edema) were prevalent in 31.5% of women during pregnancy and 14.4% during delivery. Mothers experienced complications (individually or as a group) equally during the pregnancies of male and female births, yet complications during delivery and symptoms of preeclampsia were higher for male births (Table 4).

Lack of control for complications during delivery, which tend to be higher in women pregnant with male fetuses, may confound associations between gender and the use of maternity care. Both bivariate and logistic regression (controlling for pregnancy and obstetric complications)

Table 2

Adjusted odds ratios (AOR) with 95% confidence interval (CI) for maternity care, Matlab HDSS 2009–2018 (n = 49,827 live births).

Label of the variable	ANC in 2nd and 3rd trimesters		Deliveries in health facilities		Mode of deliveries with cesarean section	
	AOR ^a	95% CI	AOR ^a	95% CI	AOR ^a	95% CI
Sex of the child						
Female	Ref.	–	Ref.	–	Ref.	–
Male	1.02	(0.98,1.07)	1.17**	(1.12,1.23)	1.20**	(1.15,1.25)
Mother's age at birth (years)						
<20	0.85**	(0.76,0.94)	0.56**	(0.50,0.62)	0.43**	(0.34,0.47)
20-24	0.90*	(0.82,0.97)	0.63**	(0.58,0.68)	0.55**	(0.51,0.59)
25-29	0.96	(0.90,1.03)	0.78**	(0.73,0.84)	0.72**	(0.68,0.77)
≥30	Ref.	–	Ref.	–	Ref.	–
Birth order						
1st	Ref.	–	Ref.	–	Ref.	–
2nd	0.87**	(0.81,0.93)	0.57**	(0.53,0.60)	0.59**	(0.56,0.62)
3rd	0.74***	(0.68,0.81)	0.37**	(0.34,0.40)	0.32**	(0.29,0.34)
4th and above	0.56**	(0.50,0.63)	0.29**	(0.26,0.32)	0.26**	(0.23,0.29)
Mother's years of schooling						
≤5	Ref.	–	Ref.	–	Ref.	–
6-9	1.31**	(1.23,1.39)	1.46**	(1.37,1.55)	1.40**	(1.31–1.48)
≥10	1.67**	(1.54,1.81)	2.80**	(2.57,3.04)	2.32**	(2.16–2.50)
Asset quintiles						
Bottom two	Ref.	–	Ref.	–	Ref.	–
Middle	1.25**	(1.17,1.34)	1.39**	(1.29,1.49)	1.39**	(1.29–1.49)
Top two	1.66**	(1.57,1.77)	2.10**	(1.97,2.23)	2.15**	(2.02–2.28)
Unknown	0.92	(0.83,1.01)	1.18**	(1.08,1.29)	1.35**	(1.25–1.47)
Religious groups						
Muslim	Ref.	–	Ref.	–	Ref.	–
Non-Muslim	1.11**	(1.02,1.21)	1.30**	(1.19,1.42)	1.08	(0.99–1.16)
Service delivery						
Government	Ref.	–	Ref.	–	Ref.	–
icddr,b	18.54**	(17.55,19.58)	8.25	(7.82,8.69)	1.17**	(1.12–1.22)

*p < 0.05, **p < 0.01.

^a Adjusted for clustering of births to the same mother.

Table 3

Gender differences in place and mode of delivery of women's last live births born in the three years preceding the BMMS 2016 (n = 27,133).

ANC visits, place and mode of delivery	Male (%)	Female (%)	p-value of male and female comparison
ANC visits			
No or below 4	62.5	63.1	0.340
4+	37.6	36.9	
Place of delivery			
Home	50.8	53.3	<0.001
Health facility	49.2	46.7	
Mode of delivery			
Vaginal delivery	67.5	70.2	<0.001
C-section	32.6	29.8	
Number of births	13,831	13,302	

Compared between male and females using Chi-square (χ^2) test.

Table 4

Women's self-reported complications during pregnancy and delivery by sex of the last live birth born in the three years preceding the BMMS 2016.

Complications	During Pregnancy				During Delivery			
	Percentage			p-value ^c	Percentage			p-value ^c
	All births	Male	Female		All births	Male	Female	
Symptoms of preeclampsia^a	31.5	31.9	31.1	0.25	14.4	14.9	13.9	0.08
- Headache with blurred vision	13.6	13.7	13.4	0.47	3.6	3.6	3.6	0.96
- High blood pressure	3.8	4.1	3.6	0.14	3.1	3.4	2.7	0.03
- Edema	20.2	20.6	19.9	0.29	9.7	10.1	9.3	0.07
Convulsion/fits	2.1	2.1	2.1	0.80	1.5	1.6	1.5	0.29
Bleeding	1.3	1.3	1.3	0.97	2.2	2.2	2.1	0.66
Obstructed/prolonged labor ^b	8.1	8.3	7.9	0.35	11.4	11.6	11.2	0.34
At least one of above	37.5	38.1	37.0	0.16	25.9	26.5	25.3	0.05
More than one of the above	9.7	9.9	9.3	0.14	5.3	5.6	4.9	0.08
Number of live births	27,133	13,831	13,302	–	27,133	13,831	13,302	–

^a Headache with blurred vision, high blood pressure, or edema.

^b Leaking membrane and no labor pain for 6 h or more, malpresentation, or prolonged labor (>12 h).

^c Compared between males and females using Chi-square (χ^2) test.

analyses revealed no difference in the likelihood of having 4 or more prenatal care visits between male and female births, but a significant difference in the likelihood of delivery in health facilities (AOR = 1.14, 95% CI: 1.07–1.22) and the rate of C-sections (AOR = 1.17, 95% CI: 1.10–1.25) in favor of male birth pregnancies. Reported complications during delivery were associated with delivery in health facilities and C-sections. (Table 4, Table 5).

3.2.3. Sex ratio at birth

Son targeting fertility behavior (if any) may result in an abnormally high ratio of boys to girls at birth. Matlab HDSS during 2009–2018 recorded 49,827 live births, yielding a ratio of 104 males per 100 female births and 941 stillbirths (gestational age ≥ 28 weeks), yielding a sex ratio of 120 ((=514/427). In the BMMS 2016, the sex ratio of last live birth in the three years preceding the survey was also 104 (n = 27,133 live births). These sex ratios at birth are within the range of the global

Table 5

Utilization of maternity care by sex of the fetus, maternity complications and mothers' socio-demographic variables using adjusted odds ratios (AOR) with 95% confidence interval, BMMS 2016 (n = 27,133 live births).

Maternity complications	Model 1: At least 4 visit for ANC		Model 2: Health facility delivery		Model 3: C-sections	
Panel A: Pregnancy/delivery complications adjusted models						
	AOR	95% CI	AOR ²	95% CI	AOR ²	95% CI
Sex of the child (ref: Female)	1.04	[0.98, 1.11]	1.14**	[1.07, 1.22]	1.17**	[1.10,1.25]
Symptoms of preeclampsia ^a (ref: No)	1.17**	[1.10, 1.26]	1.76**	[1.60, 1.92]	1.81**	[1.66,1.98]
Convulsion ^a (ref: No)	1.35**	[1.11, 1.65]	1.96**	[1.51, 2.64]	2.07**	[1.57,2.72]
Bleeding ^a (ref: No)	1.39*	[1.08,1.81]	1.05	[0.84,1.30]	0.62**	[0.49,0.80]
Prolonged labor (ref: No)	–	–	1.69**	[1.53, 1.87]	0.96	[0.86,1.07]
Panel B: Pregnancy/delivery complications not adjusted models						
	AOR	95% CI	AOR	95% CI	AOR	95% CI
Sex of the child (ref: Female)	1.04	[0.98, 1.11]	1.15**	[1.08, 1.23]	1.18**	[1.10,1.25]

*p < 0.05, **p < 0.01.

Notes for Panel A: Models are adjusted for mother's age at birth, child's birth order, mother's education, household asset quintiles, urban/rural residence, and religious affiliation (see full model in Appendix Table C2).

Note for Panel B: Full models are shown in Appendix Table C3.

^a Panel A: Model 1 uses symptoms of preeclampsia, convulsion and bleeding during pregnancy. Model 2 and Model 3 uses symptoms of preeclampsia, convulsion and bleeding during delivery.

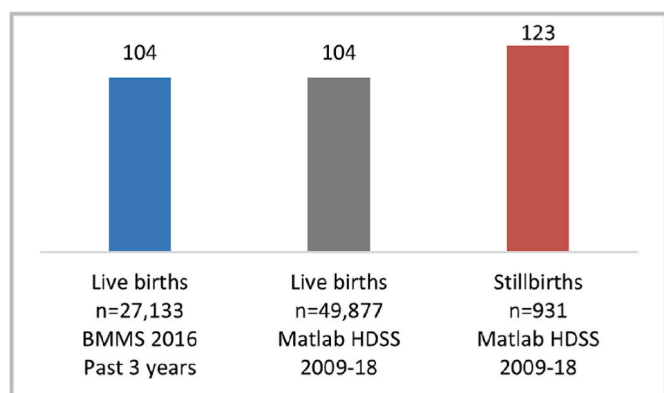


Fig. 2. Sex ratio (100 × Males/Females) at birth for live and stillbirths in Matlab HDSS and BMMS 2016.

Note: Sex of 10 stillbirths was unknown and they were thus dropped from the analysis.

Table 6

Number of live births and death rates/1000 by sex of the child, HDSS 2009–2018.

Age period	Number of male births	Number of female births	Rate for males	Rate for females	Chi-square & p-value
0–6 days	25,346	24,373	20.3	13.9	30.3, p < 0.001
7–27 days	24,726	23,930	4.9	3.2	8.1, p = 0.005
0–27 days	25,240	24,268	25.1	17.1	36.4, p < 0.001

Births lost to follow-up for mother's outmigration were excluded from denominators in specific age periods.

estimate of the 'natural' sex ratio from 103 to 107 boys per 100 girls. (Fig. 2), and the higher sex ratio for stillbirths is consistent with the reported elevated risk (~10% higher) of stillbirths in males in several countries (Mondal et al., 2014).

3.3. Gender differences in mortality and seeking medical care for terminally ill neonates

Globally, male babies are biologically less fit and born early. In the Matlab HDSS area, the prematurity (gestational age <37 weeks), a risk factor of morbidity and mortality, is higher (11.5% vs. 10.6%) among

male births in 2009–2018. Analyses included all live births and all neonatal deaths (i.e., died in 0–27 days after birth), which occurred in the surveillance area from 2009 to 2018. Higher mortality (25 vs. 17) of male neonates is evidenced in the study population (Table 6).

Sex-biased differences in health care persisted in seeking medical care during terminal illnesses of 1049 neonates in the HDSS area from 2009 to 2018. Deaths are heavily concentrated in the very early days of life; 330 (31%) died on the day of birth. A significantly lower proportion (41.5%, p < 0.001) of neonates who died on the same day as their birth received medical care from formally trained providers compared to 75.8% of the infants who died on days 1–27; the latter showed a gender difference in favor of male neonates. Medical care-seeking, particularly (a) consultation with well-trained providers, (b) hospital admission during terminal illness or (c) death outside the home (in transition or in hospital) were lower among deaths on the day of birth with no gender difference than among deaths aged 1–27 days which again were higher for male neonates (Fig. 3). The percentages of families consulting medically trained providers, infants admitted to hospitals during a terminal illness, and neonates dying in hospital by socio-demographic variables are presented in appendix Figure C1.

Results presented in Table 7 reveal higher odds ratios of care-seeking from trained medical providers (AOR = 1.49, CI: 1.01, 2.19), admission into a hospital (AOR = 1.41, CI: 0.99, 2.01) during terminal illnesses, and dying in a hospital (AOR = 2.01, CI: 1.37, 2.96) for male infants. The other variables associated with greater odds of medical care-seeking, hospital admission and dying in a hospital was higher maternal education (secondary or higher) and residence in icddr,b MCH-FP service area. Particularly, terminally ill neonates were admitted to a hospital and died in hospital at higher rates if mothers have higher education (grades 6-9 and 10 and higher) than if mothers had primary education or below.

4. Discussion

Very few studies have examined maternity care by fetal sex in LMICs. Our results from analyses of individual pregnancy outcomes data from a rigorous demographic surveillance area and a large-scale nationally representative BMMS 2016 reveal that while women visited health facilities for prenatal care equally with respect to the sex of the pregnancy, institutional deliveries and C-section deliveries were more likely for male births. This finding reveals fetal sex-selective delivery care as a new channel via which couples practice a sex-selective pattern of delivery care, as has been reported in Jordan, Japan, and Ireland (Al-Qaraghoul & Fang, 2017; Broere-Brown et al., 2020; Eogan et al., 2003; Funaki et al., 2020). While sex bias in the use of delivery care is a likely explanation for this disparity, it is also possible that the pattern could be explained by a better recall of maternal complications and care

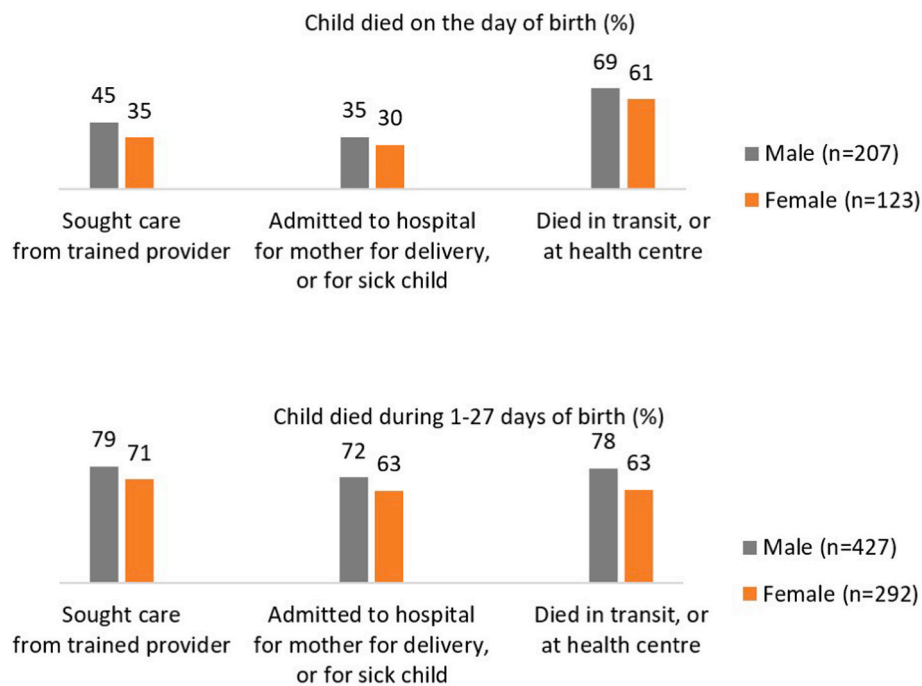


Fig. 3. Sex difference in healthcare seeking pattern during terminal illness among neonates died on the day of birth or during 1–27 days, HDSS 2009–2018.

seeking among women when pregnant with a boy due to preference for a son.

Despite sex bias in delivery care, sex ratios at birth in both the surveillance and survey data sets are balanced and comparable to the global estimate of the ‘natural’ sex ratio at birth of 105 (ranging from around 103 to 107 boys to 100 girls) (Ritchie & Roser, 2019). Moreover, analyses of sex distributions of live births reported in different rounds of the Bangladesh Demographic and Health Surveys during 1994–2011 and demographic surveillance data also found balanced sex ratios at birth (BBS, 2014, 2015; icddr,b, 2021; Shenk et al., 2014; Talukder et al., 2014) - indirect but compelling evidence of the near absence of sex-selective abortion in a culture of the overwhelming Muslim majority in Bangladesh. Couples with no son after their first two children are more likely to desire a third birth, yet do not abort the undesired fetus. In India, Muslims have similar levels of son preference but oppose abortion more than Hindus (Bhalotra et al., 2021).

Parents’ seeking of medical care for terminally ill neonates is found to be sex biased in the study population, which might be the continuation of parents’ sex bias in delivery care. The odds of seeking medical care, hospital admission during a terminal illness, and dying in a hospital were higher for male than female neonatal deaths aged 1–27 days. This finding corroborates that boys were consistently more often taken to trained providers for care in the early stages of illness, and parents spent more on health care for boys than girls in India (Saikia & Bora, 2016). The sex difference in medical care-seeking for terminally ill neonates reflects gender-biased ways of treating and raising boys and girls. Consequently, neonatal mortality of girls is higher than normally would be the case. Had care-seeking for terminally ill neonates been similar by sex, female neonates would typically have lower mortality rates than male neonates do (Osmani & Sen, 2003), but this was not the case in our data suggesting a mortality consequence of sex-selective medical care-seeking.

Expectedly, better maternal education and residence in icddr,b MCH-FP service area were also associated with improved healthcare-seeking for terminally ill neonates. Education is a proxy for many positive attributes; empowerment, health literacy, ability to judge the severity of illness, and access to health facilities which lead to a better care-seeking of neonates of educated mothers (Begum et al., 2017; Islam & Masud,

2018; Nu et al., 2020; Rahman et al., 2021).

4.1. Strengths and limitations of the study

Our study has some strengths; prospectively collected vital events and migration data from a well-defined rural population for a decade exhibit typical patterns of sex-biased differences in maternity care and newborn care-seeking. The second strength is the use of recent retrospectively collected data from a large-scale national survey on maternal complications during pregnancy, delivery and after delivery, and mode and place of delivery, along with care-seeking behavior for complications. The third strength is the consistency of our finding of fetal sex biases in the use of maternal and newborn care derived from prospective surveillance and retrospective survey data.

Yet our study has some limitations for using secondary data that were not collected to study gender differences in maternity care around delivery and medical care-seeking for terminally ill neonates. Child health conditions in the study birth cohorts at birth and in the neonatal period were unknown, which limits the scope of examining endogeneity at child-level. Data are not equipped to answer specific questions regarding whether sex-selective delivery and medical care patterns for sick neonates are natural (due to higher rates of complications among pregnancies with male fetuses) or shaped by a hidden preference for a son. Maternity complications are self-reported and thus may underestimate the true burden of ill health. However, they still give an estimate of what mothers consider complications and when they seek care.

4.2. Policy implications

In Bangladesh’s strongly patrilineal and patriarchal society, social norms and cultural and religious traditions shape parents’ minds to treat and raise sons and daughters differently. Our results reveal that care-seeking for girls in both the prenatal and neonatal periods is of lower quality and less frequent than for boys, initiating a gender gap in care starting from the mother’s womb. Reducing the gender gap and promoting a more gender-egalitarian society would require changing social norms and cultural traditions that shape parents’ mindsets. Ensuring equal treatment for boys and girls is part of Goal 5: Gender Equality of

Table 7

Adjusted odds ratios (AOR) of consulting medically trained providers, hospital admission during a terminal illness, and neonates dying in a hospital (n = 719 deaths aged 1–27 days).

Variables	Consult medical doctors		Admitted in hospital		Died in a hospital	
	AOR	95% CI	AOR	95% CI	AOR	95% CI
Sex of the birth						
Female	1		1		1	
Male	1.49*	[1.01,2.19]	1.41	[0.99,2.01]	2.01**	[1.37,2.96]
Mother's age at birth						
<20	0.68	[0.32,1.45]	0.95	[0.48,1.87]	0.6	[0.29,1.25]
20-24	0.74	[0.37,1.50]	1.02	[0.55,1.88]	0.9	[0.45,1.80]
25-29	0.54	[0.28,1.02]	0.55*	[0.31,0.98]	0.55	[0.30,1.04]
30+	1		1		1	
Birth order						
1st birth	1		1		1	
2nd birth	1.13	[0.66,1.93]	1.06	[0.65,1.74]	1.45	[0.86,2.45]
3rd birth	0.72	[0.38,1.38]	0.71	[0.39,1.29]	0.8	[0.42,1.52]
4th + birth	0.93	[0.42,2.07]	0.79	[0.37,1.70]	0.89	[0.40,1.97]
Mother's schooling						
0- ≤5 (up to primary)	1		1		1	
6-9 (secondary incomplete)	1.66*	[1.07,2.58]	1.84**	[1.21,2.78]	1.57*	[1.02,2.42]
≥10 (secondary or higher)	1.7	[0.90,3.20]	2.04*	[1.15,3.60]	3.16**	[1.61,6.21]
Household head education						
0- ≤5 (up to primary)	1		1		1	
6-9 (secondary incomplete)	0.94	[0.55,1.61]	0.97	[0.58,1.62]	0.86	[0.50,1.48]
≥10 (secondary or higher)	0.67	[0.32,1.43]	0.45*	[0.24,0.87]	1.63	[0.69,3.83]
Unknown	1.15	[0.54,2.46]	1.18	[0.60,2.32]	0.74	[0.37,1.49]
Asset quintiles						
Bottom two	1		1		1	
Middle	1.12	[0.66,1.89]	1.04	[0.64,1.70]	1.11	[0.66,1.87]
Top two	1.53	[0.94,2.48]	1.26	[0.80,1.97]	1.27	[0.78,2.07]
Unknown	0.72	[0.35,1.50]	0.99	[0.50,1.98]	0.83	[0.39,1.73]
Household size						
≤5	1		1		1	
6-8	0.61	[0.37,1.01]	0.64	[0.40,1.02]	1.18	[0.72,1.94]
9+	0.67	[0.31,1.47]	1.47	[0.67,3.21]	1.27	[0.53,3.04]
Unknown	1.26	[0.71,2.24]	1.07	[0.64,1.80]	1.91*	[1.09,3.35]
Religion						
Muslim	1		1		1	
Non-Muslim	1.24	[0.65,2.37]	0.82	[0.45,1.51]	1.13	[0.56,2.27]
Birth year	1.14**	[1.06,1.22]	1.04	[0.98,1.11]	1.06	[0.99,1.13]
Area of residence						
Government	1		1		1	
icddr,b	4.24**	[2.70,6.64]	4.15**	[2.81,6.11]	5.93**	[3.81,9.25]

Note: *p < 0.05, **p < 0.01.

the United Nations Sustainable Development Goals and needs to be pursued by the government and development partners. More research is needed to understand better what enhances which aspects of equal treatment for undertaking gender-sensitive development programs.

5. Conclusion

Male-biased gender differences in health care, both before and after babies are born, are a reality in Bangladesh society as in many other parts of the world. Policy and decision-makers need to be aware of these gender disparities and plan community-based behavior change communications for promoting a gender-egalitarian mindset in care-seeking behavior.

Ethics statement

This study used secondary data from Matlab Health and Demographic Surveillance System (HDSS) data and Bangladesh Maternal Mortality and Health Care Survey (BMMS) 2016. Institutional Review Board of icddr,b, Bangladesh approved the HDSS and Bangladesh Medical Research Council approved the BMMS 2016.

Submission declaration

This research article has not been published or accepted for

publication, and is not under consideration for publication in another journal or book. Its publication is approved by all authors. If accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright holder.

Data sharing statement

The HDSS data is sharable on request and only for the purposes related to this study. The BMMS 2016 data is publicly available at: <https://dataverse.unc.edu/dataset.xhtml?persistentId=doi:10.15139/S3/X33NIZ>.

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Author contributions

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 Ali Ahmed: Data Curation, Formal analysis.

Taslim Ali: Writing - Review & Editing.

M. Moinuddin Haider: Formal analysis, Visualization, Writing - Review & Editing.

Declaration of competing interest

None.

Data availability

The HDSS data is sharable on request and only for the purposes related to this study. The BMMS 2016 data is publicly available.

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Abbreviations

AOR	Adjusted odds ratio
BMMS	Bangladesh Maternal Mortality and Health Care Surveys
HDSS	Health and Demographic Surveillance System
LMIC	Low- and middle-income countries
SR _{at birth}	Sex ratio at birth

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ssmph.2022.101261>.

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