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BAYESIAN APPROACH ANALYSIS TO IDENTIFY THE DETERMINANTS OF CESAREAN SECTION IN NORTHEASTERN STATES, INDIA

Surgery

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ABSTRACT

Objective: This study investigates the level, trend, and determinants of caesarean section rate in northeastern states of India. **Methods:** This study used a cross-sectional survey dataset from the fifth round of National Family Health Survey. In the NFH+S-5 (2019-21) survey, questions were asked from the mothers who delivered live births (n=34222) in the last five years of the survey (since 2016). We applied bivariate analysis and Bayesian logistic regression in this study. We checked the significant association between outcome and predictor variables using chi-square test. **Results:** We found cesarean section rate has increased from 1.60 (95%CI: 1.10-2.00) percent in 1992 to 17.50 (95%CI: 16.90-18.20) percent in 2021 in the northeastern states of India. Maternal age, mother's education level, social status, religion and wealth quintile were significant determinants of cesarean section. In addition, we found odds of cesarean section was higher among overweight (aOR: 1.78; CI: 1.68-1.91) and Obese (aOR: 2.66; CI: 2.49-2.89) mothers as compared to mothers who were thin (BMI<18). Moreover, likelihood of cesarean section was found to be higher among mothers of children of birth order first (aOR: 2.03; CI: 1.96-2.16) as compared to mothers of children of birth order third and above. **Conclusions:** The prevalence of cesarean section has increased to nearly nine times (2% to 18%) in last three decades (1992-2021). Socioeconomic and demographic characteristics of mothers are significantly associated with cesarean section. We suggest adequate healthcare interventions are needed for judicious use of cesarean section facilities in northeastern states of India.

KEYWORDS

Cesarean Section, Bayesian Logistic regression, Northeastern states

INTRODUCTION

Cesarean Section (CS) is a lifesaving obstetric intervention and one of the most common surgery performed across the world (Boerma et al., 2008). With the considerable increase in clinical obstetric care and safe surgical procedures, the choice of CS has increased at global level (Vogel et al., 2015). Based on the data from 154 countries covering 95 percent of live births, the trend analysis showed that the global average CS rate increased to 21 percent in 2018 from 7 percent in 1990 (Betran et al., 2021). Another study showed that South Asian region has the CS rate of 19 percent in 2018, which vary from 7 percent to 40 percent at the country level (Betran et al., 2021). India is not an exception to such trend; National Family Health Survey (NFHS) report shows that CS rate has increased from 17 percent (2015-16) to 22 percent (2019-21) at national level (IIPS & ICF, 2021).

WHO concludes that CS rate higher than 10 percent were not associated with decline in maternal and newborn mortality.(WHO, 2015) As with any surgery, CS is associated with immediate maternal and perinatal risks and may have implications for future pregnancy (Gregory et al., 2012). These risks are higher among women with limited access to comprehensive obstetric care, lack of facilities and capacities to conduct safe surgery or treat complications (WHO, 2018). In addition, high rates of CS are associated with substantial health-care costs (Lee et al., 2021; WHO, 2018).

The reasons for increase in the CS rate include multiple factors such as health professional's views, women's preferences, economic, social and cultural factors (Mi & Liu, 2014). Previous studies showed higher maternal age, high body mass index (BMI), pregnancies complications, and fear of pain are some of the maternal factors associated with increase in the CS rate.(Feng et al., 2014) Moreover, the higher CS rates are observed in the private health-care facilities (Kumar et al., 2023; Lee et al., 2021; WHO, 2018).

In India, nearly 22 percent of the live births delivered by the CS during 2019-21, 12 percent of those CS cases were decided before the onset of labor pain (IIPS & ICF, 2021). There are significant variation in CS rates across states of India. In addition, NFHS (2019-21) (IIPS & ICF, 2021) showed high prevalence of CS in northeastern states of India. It is challenging to achieve Sustainable Development Goals 3 (ensure healthy lives and promote well-being for all at all ages) when high rates of CS become public health concern. Monitoring both CS rates and outcomes is essential to ensure positive maternal and newborns' health outcomes. Therefore, this study assess the level and trend of CS rate in the northeastern states of India. In addition, this study further investigates the socioeconomic and demographic determinants of CS in northeastern states of India.

METHODS

Data source

We used the data from all five rounds of NFHS (NFHS 1-5), conducted between 1992-93 and 2019-21. The NFHS are conducted under the stewardship of Ministry of Health and Family Welfare, Government of India. It provides essential information on household populations, housing characteristics, basics demographic and socioeconomic characteristics of respondents, fertility, family planning, maternal and child mortality, nutrition, morbidity and adult health indicators at the national, state and district level.

Study design and population

The NFHS adopted a uniform sample design, which is representative at the national, state/union territory, and district levels. Two stage stratified random sampling approach was adopted. In first stage, primary sampling units (PSUs) (villages in rural areas and census enumeration blocks in urban areas) are selected using probability proportional to size. In the second stage, a fixed number of the households per cluster was selected with an equal probability systematic selection from listed households in the selected PSUs. A detailed description of sample design is documented elsewhere.(IIPS & ICF, 2021). In NFHS-5 (2019-21), information was collected from 94,510 households with a response rate of 98 percent in northeastern states. In the selected households, 103,433 women were interviewed. This study considered all live births (n=34,222) occurred in last five year of the NFHS-5 (2019-21) in northeastern states of India, consist of Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim and Tripura. The International Institute for Population Sciences Institutional Review Board and ICF Institutional Review Board approved the survey. In addition, U.S. Centers for Disease Control and Prevention (CDC) also approved the protocols of the survey. The survey took the informed consent from the

respondents.

Dependent variable

CS is the outcome variable of this study. In the survey, a question on CS was asked, "Was the baby delivered by CS, that is, did they cut your belly open to take the baby out?" The response category was binary (No, Yes) and coded as 1 for Yes and No for 0.

Independent variables

We included the independent variables based on previous studies.(Betrán et al., 2016; Lee et al., 2021; Rahman et al., 2018; Rajabi et al., 2015; Singh et al., 2020) We selected a list of maternal factors including maternal age (15-19, 20-24, 25-29, 30-34 and 35-49 years), educational level (illiterate, primary, secondary and higher), number of antenatal care (ANC) visit (less than four, four and above), place of residence (rural, urban), social status (scheduled caste (SC), scheduled tribes (ST), other backward classes (OBC), others) included as per the report of National Commission for Backward Classes (NCBC), Government of India (National Commission for Backward Classes [NCBC], 2022) and religion (Hindus, Muslims, Christian and others). In addition, lifestyle factors such as alcohol consumption (No, Yes) and smokeless tobacco consumption (No, Yes) were included. Moreover, we considered BMI (thin, normal, overweight and obese) and financial assistance received by women for delivery care (No, Yes) was analyzed. We selected birth order (first, second, third and above), sex of the child (male, female), baby size (smaller than average, average, larger than average), wealth quintile (lowest, second, middle, fourth, highest), and gender of head of the household (male, female) were considered in the study.

Analysis

We performed the level and trend analysis of CS rates during 1992 to 2021. Besides, we estimated CS rates by mothers, children and households characteristics. Chi-square test was used to check the association between CS and independent variables. The Bayesian logistic regression was applied to estimate adjusted odds ratios (aORs) and 95% credible interval (CI). The Bayesian logistic regression uses Bayesian statistics to estimate the unknown parameters of a model, given observed data. We adjusted for maternal, newborn and household level factors in the main multivariable model. In addition, choropleth map of prevalence of CS, Standardized Incidence Ratio (SIR) and Relative Risk (RR) were used to understand the spatial variation, relative risk and observed vs predicted CS rate. Besides, we presented the graphs of prevalence of CS by maternal age, education level and wealth quintile. Moreover, results were considered significant at $P<0.05$. Bayesian Information Criteria (BIC) was used for model selection. We preferred the Bayesian logistic regression model (BIC value, 18820) over simple logistic regression (BIC value, 23942). There were no missing values in the analyzed dataset. We incorporated the complex survey design weight and all the analysis were performed in R (version 4.3.1).

RESULTS

We found CS rate has increased from 1.60 (95%CI: 1.10-2.00) percent in 1992 to 17.50 (95%CI: 16.90-18.20) percent in 2021 in northeastern states (Fig 1). At the national level, we observed relative change of 19 percent in last three decades. In addition, the relative change of CS rate were highest in Sikkim (26%) followed by Manipur (25%), Tripura (22%), Assam (16%) and Arunachal Pradesh (14%) between 1992 and 2021. In 2019-21, the prevalence of CS was higher in Sikkim (33%), Manipur (26%), Tripura (25%) and Assam (18%). However, Meghalaya and Nagaland showed CS rates of lower than 10 percent in 2019-21 (Fig 1). Besides, we found all the northeastern states reveal an increasing pattern of CS.

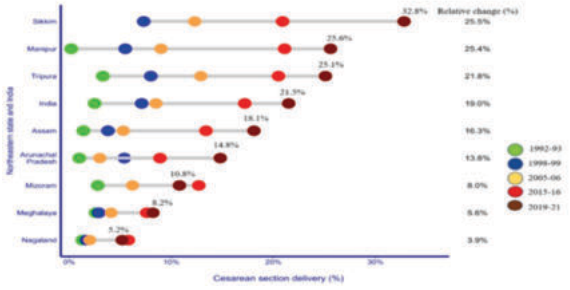

Fig 1: Level and trend of CS in northeastern states, 1992-2021

Data Source: Authors computation

Note: a) We presented relative change (%) between 1992 and 2021. For Sikkim, relative change is computed between 1998 and 2021 as the survey was not conducted in 1992.

b) Labels represent CS rate in 2019-21

Figure 2.a shows the CS rate (%) by 104 districts in northeastern states. Out of 104 districts, 35 districts showed CS rate lower than 10 percent. All four districts of Sikkim showed high CS rate (>27%). In Arunachal Pradesh, out of 20 districts, 17 districts showed CS rate higher than 10 percent. In Assam, out of 33 districts, 29 districts revealed CS rate higher than 10 percent. In Manipur, out of 9 districts, 6 districts showed CS rate higher than 10 percent. In Meghalaya, out of 11 districts, only East Khasi Hills showed CS rate of 14 percent. In Mizoram, out of 8 districts, 2 districts, Serchip and Aizwal exhibited CS rate of 14 percent and 18 percent, respectively. In Nagaland, out of 12 districts, two districts, Wokha and Dimapur showed CS rate of 10 percent and 15 percent, respectively. All districts of Tripura revealed CS rate higher than 10 percent.

Fig 2.b exhibits SIR by the districts and found that in Arunachal Pradesh, 6 districts showed SIR greater than 1, which means observed number of CS cases are higher than the predicted number of cases. In Manipur, five districts (Imphal West, Bishnupur, Imphal East, Thoubal, Chandel) showed SIR greater than 1. In Meghalaya, East Khasi Hill, East Jaintia Hills and Ri Bhoi showed SIR greater than 1. In Sikkim, north, east and south districts showed SIR greater than 1. In Tripura, all districts except Dhalai and Unakoti revealed SIR above 1.

Fig 2.c presents posterior mean of relative risk of CS in the districts in comparison to whole state. In Arunachal Pradesh, 10 districts showed higher risk of CS than the risk of CS in whole state. In Assam, out of 33 districts, 29 districts showed higher risk of CS than whole state with high probability. In Meghalaya, only East Khasi Hills district showed higher risk of CS than whole state. In Manipur, five districts (Imphal West, Bishnupur, Imphal East, Thoubal, Chandel) showed higher risk of CS than whole state. In Mizoram, only two districts (Aizwal and Serchip) showed higher risk of CS than whole state. In Nagaland, none of the districts showed a higher relative risk. It was found that all four districts of Sikkim showed high relative risk of CS. In Tripura, all districts except Dhalai and Unakoti exhibited higher risk than whole state.

Fig 2.d depicts increase in CS rate with increase in the education level of mothers. We found a higher CS rate (>60%) among mothers who completed seventeen and above years of formal education. Further, fig 2.e shows the pattern of CS rate by education level and wealth quintile of mothers does not seem linear. Prevalence of CS were higher among mothers of highest and fourth wealth quintile and mothers who completed seventeen and above years of formal schooling. Turning to maternal age, fig 2.f shows non-linear pattern of CS rate by maternal age (15-49 years) because the prevalence of CS were higher among maternal age between 28 and 39 years than younger and older mothers (CS rate>20%).

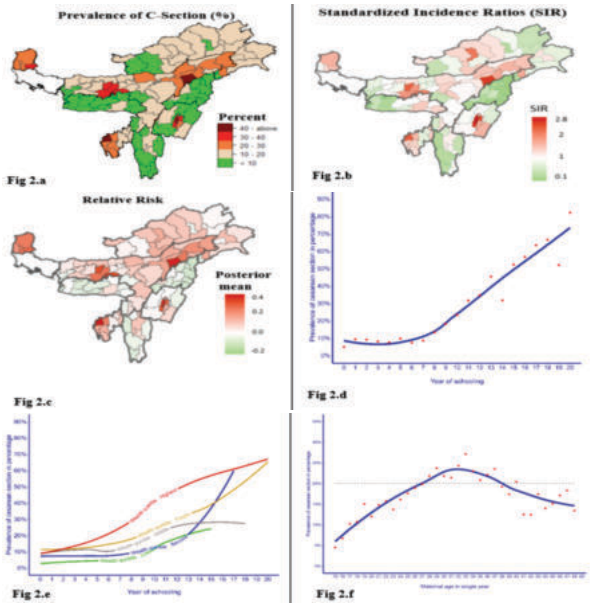

Fig 2 (a-f): Prevalence of CS, SIR, RR at district levels and prevalence

of CS by mothers' education level, age and wealth quintile in the northeastern states of India

Table 1 shows CS rate by mothers, newborns and households characteristics. We found that CS rate was highest among maternal age 30-34 years (22.12%; 95%CI: 20.12-24.13) followed by 35-49 years (21.05; 95%CI: 18.74-23.46). The CS rate was found more than two times in urban areas (35.93%; 95%CI: 32.36-37.67) as compared to rural areas (14.52%; 95%CI: 13.76-15.46). This study revealed CS rates was higher among first order birth (23.52%; 95%CI: 22.12-24.91) followed by second order birth (19.03%; 95%CI: 17.53-20.43). We found sex of the child and gender of the household head were not significantly associated with CS.

Furthermore, the proportion of CS was higher among higher educated mothers (47.43%; 95%CI: 44.45-50.92) as compared with illiterate mothers (4.83%; 95%CI: 3.72-6.05). CS rates were higher among other social status (29.15%; 95%CI: 26.24-32.16) followed by OBCs (25.72%; 95%CI: 23.56-27.95), SC (22.03%; 95%CI: 19.42-24.84) and ST (12.81%; 95%CI: 11.43-14.14). Further, CS rates were highest among mothers of highest (46.03%; 95%CI: 43.14-48.73) and fourth (23.62%; 95%CI: 21.56-25.75) wealth quintile as compared with mothers of lowest wealth quintile (5.23%; 95%CI: 4.34-6.25). In addition, we found higher CS rates among mothers with four and above ANC visits (25.49%; 95%CI: 23.94-26.15) as compared to mothers with less than four ANC visits (11.42%; 95%CI: 10.51-12.04). In addition, CS rates were higher among mothers who reported distance to health facility was not a problem for them (26.02%; 95%CI: 23.92-27.43). CS rates were found to be higher among others who did not receive financial assistance for delivery care (28.53%; 95%CI: 26.91-30.12) as compared to mothers who received financial assistance (17.64%; 95%CI: 15.65-18.44). Furthermore, we found lower CS rate among mothers who consume smokeless tobacco (12.83%; 95%CI: 11.02-14.84) as compared to mothers who did not consume smokeless tobacco (18.41%; 95%CI: 17.41-19.21). Mothers who were overweight showed higher CS rates (33.43%; 95%CI: 31.92-35.84) than mothers of normal BMI (15.12%: 95%CI: 14.42-15.97).

Furthermore, table 1 shows the results of Bayesian logistic regression by mothers, newborns and households characteristics. We found odds ratio of CS was higher among maternal age-group 30-34 years (aOR: 1.96; CI: 1.83-2.09) and 35-49 years (aOR: 2.70; CI: 2.56-2.87) as compared to mothers of age-group 15-19 years. Besides, likelihood of CS was higher among mothers of children of birth order first (aOR: 2.03; CI: 1.92-2.16) as compared to mothers of children of birth order three and above.

Mothers who completed higher education showed higher likelihood of CS (aOR: 1.96; CI: 1.82-2.11) as compared to mothers with no formal education. This study revealed religion is significantly associated with CS. Odds of CS was higher among mothers who practice Hindus religion (aOR: 1.47; CI: 1.36-1.62) as compared with mothers who practice Christian religion. In addition, likelihood of CS was found to be higher among mothers of fourth (aOR: 1.79; CI: 1.66-1.92) and highest (aOR: 2.52; CI: 2.30-2.82) wealth quintile as compared to mothers among lowest wealth quintile. Further, this study showed odds of CS was higher among mothers who were overweight (aOR: 1.78; CI: 1.68-1.91) and obese (aOR: 2.66; CI: 2.49-2.89) as compared with mothers who were thin.

Table 1: Results of bivariate and Bayesian logistic regression analysis of CS by mothers, newborns and households characteristics in northeastern states of India, 2019-21

Independent variables	% (95% CIa)	Chi-Sq2	N	aOR (95% CIb)
Maternal age at birth (in years)				
15-19	11.50 (8.72-12.31)	95.50***	1118	Reference
20-24	14.22 (12.82-15.61)		7856	1.25 (1.16-1.35)
25-29	16.93 (15.63-18.42)		11482	1.51 (1.41-1.62)
30-34	22.12 (20.12-24.13)		7726	1.96 (1.83-2.09)
35-49	21.05 (18.74-23.46)		6040	2.70 (2.56-2.87)
Place of residence				
Rural	14.52 (13.76-15.46)	5100.25***	29145	Reference
Urban	34.93 (32.36-37.67)		5077	1.06 (0.96-1.14)
Birth order				
First	23.52 (22.12-24.91)	740.41***	10061	2.03 (1.92-2.16)
Second	19.03 (17.53-20.43)		12629	1.58 (1.50-1.66)
Third and above	6.60 (5.79-7.78)		11532	Reference
Sex of the child				
Male	17.92 (16.82-19.13)	1.74	16810	Reference
Female	17.13 (16.81-19.12)		17412	1.03 (0.98-1.08)
Size of the child at birth				
Smaller	15.92 (13.83-18.34)	96.64***	4437	Reference
Average	17.64 (16.75-18.66)		23768	0.86 (0.80-0.92)
Larger	18.24 (16.3-20.1)		6017	1.14 (1.01-1.23)
Gender of the household's head				
Male	17.33 (16.4-18.2)	0.07	27705	Reference
Female	18.82 (16.8-20.9)		6517	1.16 (1.04-1.25)
Education level				
Illiterate	4.83 (3.72-6.05)		5484	Reference
Primary	8.71 (7.23-10.24)	1500.56***	5982	1.23 (1.13-1.44)
Secondary	19.12 (17.56-19.64)		19318	1.36 (1.29-1.44)
Higher	47.43 (44.45-50.92)		3438	1.96 (1.82-2.11)
Social groups				
ST	12.81 (11.43-14.14)	988.7***	2423	Reference
SC	22.03 (19.42-24.84)		20568	1.33 (1.21-1.44)
OBC	25.72 (23.56-27.95)		3667	1.53 (1.43-1.62)
Other	29.15 (26.24-32.16)		7564	1.64 (1.56-1.71)
Religion				
Christian	9.56 (8.16-11.08)	1200.32***	15958	Reference
Hindus	26.23 (24.71-27.53)		10136	1.47 (1.36-1.62)
Muslims	9.91 (8.82-11.13)		5007	0.76 (0.69-0.85)
Others	21.43 (16.71-26.92)		3121	1.27 (1.18-1.35)
Wealth quintile				
Lowest	5.23 (4.34-6.25)	2400.07***	9701	Reference
Second	9.81 (8.54-11.26)		7818	1.17 (1.10-1.23)
Middle	14.83 (13.12-16.54)		6723	1.41 (1.32-1.51)
Fourth	23.62 (21.56-25.75)		5723	1.79 (1.66-1.92)
Highest	46.03 (43.14-48.73)		4257	2.52 (2.30-2.82)
Number of ANC visit		298.09***		
Less than four	11.42 (10.51-12.04)		21063	Reference

Distance to health facility				
Four and above	25.49 (23.94-26.15)		13159	1.54 (1.43-1.67)
No problem	26.02 (23.92-27.43)	750.45***	9490	Reference
Problem	14.21 (13.32-15.11)		24732	0.94 (0.88-1.00)
Received financial assistance for delivery care				
No	28.53 (26.91-30.12)	143.05***	26030	Reference
Yes	16.94 (15.65-18.44)		8192	0.70 (0.65-0.75)
BMI				
Thin	13.83 (12.24-15.45)	843.02***	4139	Reference
Normal	15.12 (14.42-15.97)		24577	1.03 (0.96-1.11)
Overweight	33.43 (31.92-35.84)		4636	1.78 (1.68-1.91)
Obese	43.34 (38.23-48.73)		870	2.66 (2.49-2.89)
Alcohol consumption				
No	17.64 (16.85-18.52)	0.0012	32238	Reference
Yes	14.14 (10.72-18.34)		1984	0.98 (0.87-1.09)
Smokeless tobacco consumption				
No	18.41 (17.41-19.21)	79.500	27609	Reference
Yes	12.83 (11.02-14.84)		6613	1.23 (1.14-1.33)
Total	17.54 (16.91-18.22)		34222	

Data Source: Authors computations Note: aOR: adjusted odds ratio; CIa: confidence interval; CIb: credible interval "***" p<0.001; "**"p<0.01; "*"p<0.05

DISCUSSION

This study showed considerable increase in CS rate in the last three decades (1992-2021). The CS rate has increased to 18 percent in 2021 from 2 percent in 1992 in northeastern states of India. In addition, this study found significant variation of CS rate in northeastern states of India, range between 33 percent in Sikkim to 5 percent in Nagaland. Previous literature also showed that CS rate has increased by about 19 percent in last three decade at global, regional and national levels and become a serious concern for health programmes managers (Betran et al., 2021). Besides, considerable number of districts of northeastern states of India showed higher SIR of CS. Moreover, it is equally important to note that Nagaland and Meghalaya had lower (<10%) prevalence of CS. Low CS rate indicates lack of access to obstetric care, which needs urgent attentions (Lee et al., 2021).

This study revealed demographic, socioeconomic, healthcare and lifestyle variables are significant determinants of CS. A higher odd of CS rate was observed among maternal age 30-34 and 35-49 years. This study's findings is consistent with previous studies which documented obstetric and maternal complications are higher among older woman, therefore, obstetricians suggest CS delivery (Essex et al., 2013; Singh et al., 2020). In contrast, this study showed that the pattern of CS rate is nonlinear because prevalence of CS was higher among maternal age 28-39 years compared to their younger and elder mothers.

Moreover, we found CS rate were higher among urban areas, which is in line with previous studies (Kumar et al., 2023; Singh et al., 2020). A previous study showed urban residents have greater accessibility to healthcare facilities (Joe et al., 2015). Furthermore, this study found likelihood of CS is higher among mothers of first order birth. A study showed that little knowledge of pregnancy at first birth delivery, fear of uncontrolled labor pain and stress led women to opt for CS (Raven et al., 2015).

This study found high CS rate among higher educated mothers. Educated women have good knowledge about healthcare facilities and make their healthcare decisions (Kamal, 2009). A previous study also showed CS rate is higher among higher educated (Kamal, 2009). Consistent with the findings of previous studies, this study showed likelihood of CS is higher among mothers of highest and fourth wealth quintile (Boatin et al., 2018; Pandey et al., 2023).

We found CS rate were higher among mothers with four and above ANC visit. A higher number of ANC visit indicates fetal delivery complications, therefore, medical experts recommend CS in case of a medical emergency (Singh et al., 2020). A previous study also showed higher number of ANC visits are linked with high CS rate (Kumar et al., 2023). Further, consistent with the findings of another study (Xiong et al., 2016), this study found women who were overweight and obese have higher odds of CS.

Furthermore, this study showed lower odds of CS among women who received financial assistance for delivery care. In India, financial assistance are provided to women of below poverty level (BPL) households and these women mostly go to public hospitals for birth delivery. Previous studies showed that prevalence of CS was higher in private health facilities than public health facilities (Lee et al., 2021; Neuman et al., 2014). Therefore, adequate monitoring of CS in private hospitals is required to reduce the high cost associated with unnecessary CS among poor households. This study suggests a primary study can be conducted to further understand the contextual factors associated with the CS.

Strength and limitations

This study is based on a large-scale and representative dataset. Hence, the findings of this study is generalizable for all eligible population of northeastern states of India. In addition, this is the first study, which graphically presented the district-wise prevalence of CS (%), SIR and RR in northeastern states. Moreover, this study demonstrated the different level and pattern in the association between CS rate and maternal characteristics. On the other hand, this study has few limitations. First, we did not consider medical risk factors of CS, as this information were not collected in the survey. Therefore, special care should be taken to interpret the observed associations. Second, information on a few variables such as maternal BMI, consuming alcohol or smokeless tobacco were collected at the time of survey, not during the pregnancy period. These could be a source of bias if there was change in BMI and lifestyle for some women after birth delivery (Lee et al., 2021).

CONCLUSIONS

This study showed tremendous increased in CS rate in the last three decades. The CS rate has increased to 18 percent in 2021 from 2 percent in 1992. Northeastern states of India showed considerable variation in CS rate, range between 33 percent in Sikkim to 5 percent in Nagaland. In addition, this study revealed maternal age, education level, social status, wealth quintile and maternal BMI are significant predictors of CS. We suggest adequate healthcare interventions are needed for judicious use of CS facilities in six northeastern states of India.

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