Abstract

Introduction
The rate of cesarean delivery (C-section) has been increasing worldwide, including Bangladesh, and it has a negative impact on the mother and child’s health. Our aim was to examine the association between C-section and childhood diseases and to identify the key factors associated with childhood diseases.

Methods
We used four nationally representative data sets from multiple indicator cluster survey (MICS, 2012 and 2019) and Bangladesh Demographic and Health Survey (BDHS, 2011 and 2014) and analyzed 25,270 mother-child pairs. We used the frequency of common childhood diseases (fever, short or rapid breaths, cough, blood in stools, and diarrhea) as our outcome variable and C-section as exposure variable. We included mother’s age, place of residence, division, mother’s education, wealth index, child age, child sex, and child size at birth as confounding variables. Negative binomial regression model was used to analyze the data.

Results
In the BDHS data, the prevalence of C-section increased from 17.95% in 2011 to 23.33% in 2014. Also, in MICS, the prevalence almost doubled over an eight-year period (17.74% in 2012 to 35.41% in 2019). We did not observe any significant effect of C-section on childhood diseases in both surveys. Only in 2014 BDHS, we found that C-section increases the risk of childhood disease by 5% [Risk Ratio (RR): 1.05, 95% CI: 0.95, 1.17, p = 0.33]. However, the risk of childhood disease differed significantly in all survey years by division, child’s age, and child’s size at birth after adjusting for important confounding variables. For example, children living in Chittagong division had a higher risk [(2011 BDHS RR: 1.22, 95% CI: 1.08, 1.38)
and (2019 MICS RR: 1.21, 95% CI: 1.08, 1.35) of having disease compared to Dhaka division. Maternal age, education, and wealth status showed significant differences with the outcome in some survey years.

Conclusion

Our study shows that C-section in Bangladesh continued to increase over time, and we did not find significant association between C-section and early childhood diseases. High C-section rate has a greater impact on maternal and child health as well as the burden on the health care system. We recommend raising public awareness of the negative impact of unnecessary C-section in Bangladesh.

Introduction

Cesarean delivery (C-section) is a surgical procedure that is often performed or recommended when the life of the mother or child is at risk [1]. Recently, it has become a preferred choice as a mode of delivery among women because they believed that it is painless, comfortable, safer, and healthier than normal delivery [2]. This choice may have increased unnecessary C-section and could harm the mother and child health [3].

The prevalence of the C-section is expeditiously growing in many developed and developing countries [4, 5]. During the last decades, unnecessary C-section has increased rapidly [6]. It is rising significantly, as more than half of the women willingly undergo C-section [7]. A trend analysis based on data from 121 countries reported that, from 1990 to 2014, the average C-section rates increased by 12.4%, and it annually increased by 4.4% [8]. Moreover, a 2004–2008 World Health Organization (WHO) survey documented an average global rate of C-section was 25.7%, and the rate was 27.3% in Asia, 29.2% in Latin America, and 19.0% in Europe [8, 9]. In Bangladesh, the rate increased six times from 3.5% in 2004 to 23% in 2014 [10].

There are several risks associated with C-section for mothers and children [11, 12]. Babies born in C-section are at risk of developing asthma, obesity, type 1 diabetes, allergic diseases [11, 12], Crohn’s disease [13], and so on. Moreover, C-section babies may develop neurodevelopmental disorders, such as attention deficit hyperactivity disorder, autism spectrum disorder, learning disabilities, etc. [14–18].

In Bangladesh, young children, in general, are suffering from several common diseases such as fever, cough, short/ difficulty in breathing, diarrhea etc. [19]. Several studies investigated the impact of socio-demographic, maternal, or child characteristics on specific childhood diseases [16, 20–22]. For example, Imran et al. [22] investigated the potential risk factors for early childhood acute respiratory infections; Pathelaet et al. [16] studied the risk factors for the diarrheal disease of young children in Bangladesh. However, to the best of our knowledge, there is no published research on the association between C-section and early childhood diseases and/or identify potential risk factors that may influence the overall common childhood disease in Bangladesh. Therefore, our main objective was to study the association between C-section and common childhood diseases and to identify potential factors that may influence childhood diseases.

Materials and methods

Data source and study design

We used two different survey data sets of 2011, 2014 Bangladesh Demographic and Health Survey (BDHS) and 2012, 2019 Multiple Indicator Cluster Survey (MICS). The BDHS is a
large household survey produced by the Demographic and Health Surveys Program, and the MICS is also a large, multi-dimensional household survey conducted by UNICEF. Both surveys collects maternal and child health indicators. Details of the methodology and sampling procedure of both surveys were published elsewhere [23, 24]. We included women who gave birth three years prior to the survey. Children who died or did not live with their mother or who were over 3 years of age at the time of the survey were excluded from the analysis. The final analysis included 4748, 4527, 7248, and 8747 mother-child pairs from 2011 BDHS, 2014 BDHS, 2012 MICS, and 2019 MICS, respectively.

**Outcome variable**

For creating the outcome variable (childhood disease), we used several variables such as fever, short/ rapid breaths, cough, blood in stools, and diarrhea in the two weeks before or during the survey. We created a count variable that means the frequency of the diseases of the children. Here, the number of diseases for a child varies from 0 to 5. The zero means the child did not suffer any above-mentioned diseases in the two weeks before or during the survey.

**Exposure variable**

The exposure variable was the type of delivery (C-section vs. normal delivery), which is a binary variable.

**Potential confounding variables**

We considered important confounding variables and/or covariates are mothers age, place of residence, division, mother’s education, wealth index, religion, mother’s body mass index (BMI), breastfeeding status, child age, child sex, and child’s size at birth.

**Statistical analyses**

Descriptive statistics of each of the selected covariates and distribution of type of delivery were shown by adjusting the sampling weight of the survey. Similarly, weighted percentages were calculated to compare demographic and socioeconomic characteristics among the type of delivery. Pearson’s chi-squared test was used to determine the association between C-section (vs. normal delivery) and other covariates. As our outcome is a count variable, frequency of diseases, we first applied Poisson regression models. However, due to over- dispersion in the data, we then applied negative binomial (NB) regression models. We first fitted univariate models to estimate the effect of C-section on the outcome variable (disease count). Subsequently, we also fitted univariate models using all potential covariates. We used an arbitrary p —value of ≤ 0.20 as a criterion to include covariates in the multivariable models. We used stepwise procedures to select the best model. Therefore, in our final model, we had included all significant covariates and some key variables related to the outcome. To account for the complex survey design, we used the *svyset* command in Stata (StataCorp LP, College Station, Texas). The *svyset* command helps us to use design elements such as the primary sampling unit, strata, cluster, and sample weight.

**Ethics approval.** Our study was exempt from the ethical review approval because we used publicly available de-identified data.

**Results**

The prevalence of C-section increased over time in both surveys. In BDHS, the rate increased from 17.95% in 2011 to 23.33% in 2014. Also, in MICS, the prevalence almost doubled over an
eight-year period (17.74% in 2012 to 35.41% in 2019). Other than 2012 MICS, the distribution of common childhood diseases across survey years were fairly similar. More than half (48 to 52%) of the children had no diseases, followed by 15 to 19% had one disease in two weeks prior to the survey. The proportion of the disease counts by delivery type was approximately similar across survey years and between surveys (Fig 1).

Tables 1 and 2 outlines the maternal and child characteristics between C-section and normal delivery for BDHS and MICS surveys, respectively. The distribution of C-section by mother’s age increased over time in both surveys. For example, in BDHS, the rate of C-section among 25–29 year old mothers increased from 19.8% in 2011 to 26.53% in 2014; similarly in MICS the rate doubled (17.73% vs. 36.68%). In both surveys, women from Dhaka division, living in urban areas with higher education and higher wealth status, had a higher proportion of having C-section in recent surveys compared to the previous surveys. Among the child’s characteristics, the baby’s size at birth was one of the significant factors found to be associated with C-section. For example, one-third of the baby’s size larger than average was delivered by cesarean section in 2014 BDHS.

Tables 3 and 4 show the results of the multivariable negative binomial regression models for BDHS and MICS surveys estimating the effects of C-section (vs. normal delivery) on childhood diseases after adjusting for maternal and child’s characteristics. No statistically significant effects of C-section on childhood diseases were observed in both sets of surveys. However,
| Mother's Age | Normal Delivery | Caesarean Delivery | p-values | Normal Delivery | Caesarean Delivery | p-values |
|--------------|-----------------|--------------------|----------|-----------------|--------------------|----------|
| < 15–19      | 789 (86.8)      | 120 (13.2)         | <0.001   | 739 (79.55)     | 190 (20.45)        | 0.01     |
| 20–24        | 1439 (81.76)    | 321 (18.24)        |          | 1218 (77.93)    | 345 (22.07)        |          |
| 25–29        | 964 (80.2)      | 238 (19.8)         |          | 853 (73.47)     | 308 (26.53)        |          |
| 30–34        | 459 (78.73)     | 124 (21.27)        |          | 461 (76.2)      | 144 (23.8)         |          |
| 35+          | 229 (82.67)     | 48 (17.33)         |          | 199 (74.25)     | 69 (25.75)         |          |
| Place of Residence |       |                    | <0.001   |                 |                    | <0.001   |
| Urban        | 1070 (72.1)     | 414 (27.9)         |          | 917 (63.5)      | 527 (36.5)         |          |
| Rural        | 2821 (86.59)    | 437 (13.41)        |          | 2553 (82.84)    | 529 (17.16)        |          |
| Division     |                 |                    | <0.001   |                 |                    | <0.001   |
| Dhaka        | 431 (83.53)     | 85 (16.47)         |          | 540 (67.67)     | 258 (32.33)        |          |
| Barishal     | 843 (85.15)     | 147 (14.85)        |          | 432 (80.6)      | 104 (19.4)         |          |
| Chittagong   | 604 (78.85)     | 162 (21.15)        |          | 713 (80.84)     | 169 (19.16)        |          |
| Khulna       | 408 (73.12)     | 150 (26.88)        |          | 345 (65.59)     | 181 (34.41)        |          |
| Rajshahi     | 471 (79.7)      | 120 (20.3)         |          | 403 (73.14)     | 148 (26.86)        |          |
| Rangpur      | 507 (86.67)     | 78 (13.33)         |          | 435 (80.11)     | 108 (19.89)        |          |
| Sylhet       | 627 (85.19)     | 109 (14.81)        |          | 602 (87.25)     | 88 (12.75)         |          |
| Mothers Education |        |                    | <0.001   |                 |                    | <0.001   |
| No-education | 765 (95.86)     | 33 (4.14)          |          | 567 (92.95)     | 43 (7.05)          |          |
| Primary      | 1264 (91.26)    | 121 (8.74)         |          | 1103 (88.52)    | 143 (11.48)        |          |
| Secondary    | 1700 (79.4)     | 441 (20.6)         |          | 1570 (73.36)    | 570 (26.64)        |          |
| Higher       | 162 (38.76)     | 256 (61.24)        |          | 230 (43.4)      | 300 (56.6)         |          |
| Wealth Index |                 |                    | <0.001   |                 |                    | <0.001   |
| Poorest      | 990 (97.06)     | 30 (2.94)          |          | 908 (94.58)     | 52 (5.42)          |          |
| Poorer       | 825 (91.46)     | 77 (8.54)          |          | 759 (88.46)     | 99 (11.54)         |          |
| Middle       | 777 (86.24)     | 124 (13.76)        |          | 707 (81.17)     | 164 (18.83)        |          |
| Richer       | 750 (79.2)      | 197 (20.8)         |          | 662 (70.8)      | 273 (29.2)         |          |
| Richest      | 549 (56.48)     | 423 (43.52)        |          | 434 (48.12)     | 468 (51.88)        |          |
| Religion     |                |                    | 0.02     |                |                    | 0.35     |
| Non-Muslim   | 368 (76.83)     | 111 (23.17)        |          | 259 (72.14)     | 100 (27.86)        |          |
| Muslim       | 3523 (82.64)    | 740 (17.36)        |          | 3211 (77.06)    | 956 (22.94)        |          |
| Mothers BMI  |                 |                    | <0.001   |                 |                    | <0.001   |
| Underweight  | 1248 (90.37)    | 133 (9.63)         |          | 976 (87.46)     | 140 (12.54)        |          |
| Normal weight| 1917 (84.71)    | 346 (15.29)        |          | 1684 (80.73)    | 402 (19.27)        |          |
| Overweight   | 545 (69.78)     | 236 (30.22)        |          | 629 (64.65)     | 344 (35.35)        |          |
| Obese        | 181 (57.1)      | 136 (42.9)         |          | 181 (51.57)     | 170 (48.43)        |          |
| Breastfeeding|                |                    | 0.006    |                |                    | 0.071    |
| No           | 482 (78.12)     | 135 (21.88)        |          | 469 (73.86)     | 166 (26.14)        |          |
| Yes          | 3409 (82.64)    | 716 (17.36)        |          | 3001 (77.13)    | 890 (22.87)        |          |
| Child's Sex  |                |                    | 0.059    |                |                    | 0.036    |
| Male         | 1937 (81.01)    | 454 (18.99)        |          | 1755 (75.39)    | 573 (24.61)        |          |
| Female       | 1954 (83.11)    | 397 (16.89)        |          | 1715 (78.03)    | 483 (21.97)        |          |
| Child's age, years |      |                    | 0.030    |                |                    | 0.005    |
| 0            | 1337 (80.49)    | 324 (19.51)        |          | 1084 (74.5)     | 371 (25.5)         |          |
| 1            | 1258 (81.74)    | 281 (18.26)        |          | 1173 (76.02)    | 370 (23.98)        |          |

(Continued)
### Table 1. Sample characteristics of mother and children by delivery status, BDHS 2011 and 2014.

|                  | 2011 BDHS |          | 2014 BDHS |          |
|------------------|-----------|----------|-----------|----------|
|                  | Normal Delivery | Caesarean Delivery | p-values | Normal Delivery | Caesarean Delivery | p-values |
|                  | n (%)     | n (%)   |           | n (%)     | n (%)   |           |
| Childs size at Birth |           |          |           |           |          |           |
| Average          | 1296 (84.05) | 246 (15.95) |          | 1213 (79.38) | 315 (20.62) |          |
| Smaller than average | 717 (83.08) | 146 (16.92) |          | 704 (80.27) | 173 (19.73) |          |
| Larger than average | 515 (77.68) | 148 (22.32) |          | 403 (69.48) | 177 (30.52) |          |

Numbers in the parenthesis indicates row percentages. 

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### Table 2. Sample characteristics of mother and children by delivery status, MICS 2012 and 2019.

|                  | 2012 MICS |          | 2019 MICS |          |
|------------------|-----------|----------|-----------|----------|
|                  | Normal Delivery | Caesarean Delivery | p-values | Normal Delivery | Caesarean Delivery | p-values |
|                  | n (%)     | n (%)   |           | n (%)     | n (%)   |           |
| Mothers age      |           |          |           |           |          |           |
| < 15–19          | 730 (82.3) | 157 (17.7) |          | 803 (66.36) | 407 (33.64) |          |
| 20–24            | 2088 (81.25) | 482 (18.75) |          | 1849 (62.83) | 1094 (37.17) |          |
| 25–29            | 1810 (82.27) | 390 (17.73) |          | 1552 (63.32) | 899 (36.68) |          |
| 30–34            | 819 (81.74) | 183 (18.26) |          | 951 (64.39) | 526 (35.61) |          |
| 35+              | 515 (87.44) | 74 (12.56) |          | 495 (74.32) | 171 (25.68) |          |
| Place of Residence|          |          |           | <0.001    | <0.001    |          |
| Urban            | 851 (70.51) | 356 (29.49) |          | 886 (52.55) | 800 (47.45) |          |
| Rural            | 5111 (84.61) | 930 (15.39) |          | 4764 (67.47) | 2297 (32.53) |          |
| Division         |           |          |           | <0.001    | <0.001    |          |
| Dhaka            | 1421 (77.52) | 412 (22.48) | 1336 (59.59) | 906 (40.41) |          |
| Barishal         | 591 (89.14) | 72 (10.86) | 572 (72.41) | 218 (27.59) |          |
| Chittagong       | 1339 (88.5) | 174 (11.5) | 1331 (73.9) | 470 (26.1) |          |
| Khulna           | 679 (69.5) | 298 (30.5) | 568 (46.67) | 649 (53.33) |          |
| Rajshahi         | 504 (77.54) | 146 (22.46) | 513 (58.7) | 361 (41.3) |          |
| Rangpur          | 806 (88.47) | 105 (11.53) | 722 (67.54) | 347 (32.46) |          |
| Sylhet           | 622 (88.73) | 79 (11.27) | 608 (80.64) | 146 (19.36) |          |
| Mothers Education|           |          |           | <0.001    | <0.001    |          |
| No-education     | 1306 (94.98) | 69 (5.02) | 634 (87.81) | 88 (12.19) |          |
| Primary          | 1929 (91.25) | 185 (8.75) | 1593 (81.19) | 369 (18.81) |          |
| Secondary        | 2199 (78.65) | 597 (21.35) | 2801 (62.7) | 1666 (37.3) |          |
| Higher           | 528 (54.83) | 435 (45.17) | 622 (38.97) | 974 (61.03) |          |
| Wealth Index     |           |          |           | <0.001    | <0.001    |          |
| Poorest          | 1857 (94.89) | 100 (5.11) | 1759 (86.14) | 283 (13.86) |          |
| Poorer           | 1404 (90.87) | 141 (9.13) | 1319 (74.06) | 462 (25.94) |          |
| Middle           | 1166 (86.24) | 186 (13.76) | 1041 (62.79) | 617 (37.21) |          |
| Richer           | 917 (73.48) | 331 (26.52) | 926 (54.28) | 780 (45.72) |          |
| Richest          | 618 (53.93) | 528 (46.07) | 605 (38.78) | 955 (61.22) |          |
| Religion         |           |          |           |          | 0.237     |          |
| Non-Muslim       | 646 (80.75) | 154 (19.25) | 503 (60.46) | 329 (39.54) |          |
| Muslim           | 5316 (82.44) | 1132 (17.56) | 5147 (65.03) | 2768 (34.97) |          |

(Continued)
having a C-section appears to increase the risk of childhood disease by 5% (RR: 1.05, 95% CI: 0.95, 1.17, p = 0.33) only in 2014 BDHS. Overall, the risk of common childhood diseases differed significantly in all survey years by division, child’s age, and child’s size at birth. In both surveys, children living in Chittagong division had a higher risk [(2011 BDHS RR: 1.22, 95% CI: 1.08, 1.38) and (2019 MICS RR:1.21, 95% CI: 1.08, 1.35)] of having disease compared to Dhaka division. The risk of having common childhood diseases decreases as children grow. For example, one year old child had a 42% (RR: 1.42, 95% CI: 1.19, 1.71, p < 0.001) and 19% (RR: 1.19, 95% CI: 1.08, 1.31, p = 0.001) higher risk of having common childhood diseases in 2019 MICS and 2014 BDHS, respectively. There were significant differences in common childhood diseases among children born with smaller and larger than average sizes. Children born with either smaller or larger than average size had a higher likelihood of having common childhood diseases. Mothers’ age plays a key role in childhood disease, compared with younger mothers (15–19 years) children born to young adult mothers had a lower risk of having childhood diseases was observed in 2019 MICS, not other surveys. For example, children born to 30–34 years old mothers had 18% less risk of having childhood disease. There was a significant increase in childhood disease among the children who were born to mothers with lower levels of education. Similarly, children born to a lower socio-economic status family had a higher risk of having common childhood diseases.

Discussion

In this study, we investigated the relationship between C-section (vs. normal delivery) and early childhood diseases in Bangladesh using multiple nationally representative survey data-sets. We also investigated the factors associated with common childhood diseases. We observed that for BDHS (2011), MICS (2012), BDHS (2014), and MICS (2019), the prevalence of cesarean deliveries was 17.95%, 17.74%, 23.3%, and 35.41%, respectively. The distributions of childhood diseases were approximately similar in both cesarean and normal delivery in all survey datasets across the survey years.
In multivariable negative binomial regression models, there was no significant association between C-section and common childhood diseases. Similar results have been observed by Gondwe et al. in a similar population setting in India [25, 26]. However, there are other studies in both developed and developing countries that have found a significant association between C-section and childhood diseases, especially asthma and respiratory diseases. Moreover, among the key factors, division - geographical locations, age of the child, and child’s size at birth had a

**Table 3. Factors associated with cesarean vs normal delivery and common childhood diseases, BDHS 2011 and 2014.**

|                        | 2011 BDHS          |        | 2014 BDHS          |        |
|------------------------|--------------------|--------|--------------------|--------|
|                        | IRR (95% CI)       | p-value| IRR (95% CI)       | p-value|
| Cesarean delivery      |                    |        |                    |        |
| No                     | Reference          |        | Reference          |        |
| Yes                    | 0.92 (0.82, 1.02)  | 0.129  | 1.05 (0.95, 1.17)  | 0.33   |
| Mothers age            |                    |        |                    |        |
| 15–19                  | Reference          |        | Reference          |        |
| 20–24                  | 1.07 (0.97, 1.18)  | 0.195  | 1.02 (0.88, 1.19)  | 0.751  |
| 25–29                  | 0.97 (0.87, 1.09)  | 0.599  | 0.94 (0.83, 1.07)  | 0.356  |
| 30–34                  | 0.99 (0.86, 1.13)  | 0.826  | 0.95 (0.80, 1.12)  | 0.532  |
| 35+                    | 1.18 (0.99, 1.41)  | 0.064  | 0.84 (0.70, 1.01)  | 0.064  |
| Division               |                    |        |                    |        |
| Dhaka                  | Reference          |        | Reference          |        |
| Barishal               | 1.05 (0.91, 1.22)  | 0.485  | 1.11 (0.93, 1.32)  | 0.232  |
| Chittagong             | 1.22 (1.08, 1.38)  | 0.001  | 1.19 (1.04, 1.36)  | 0.011  |
| Khulna                 | 1.11 (0.95, 1.29)  | 0.177  | 0.97 (0.82, 1.14)  | 0.704  |
| Rajshahi               | 1.05 (0.92, 1.19)  | 0.50   | 1.08 (0.92, 1.27)  | 0.328  |
| Rangpur                | 1.06 (0.9, 1.25)   | 0.465  | 1.07 (0.89, 1.28)  | 0.474  |
| Sylhet                 | 1.11 (0.98, 1.25)  | 0.092  | 1.14 (0.99, 1.31)  | 0.07   |
| Education              |                    |        |                    |        |
| Higher                 | Reference          |        | Reference          |        |
| Secondary              | 1.14 (0.97, 1.35)  | 0.112  | 1.04 (0.88, 1.22)  | 0.65   |
| Primary                | 1.26 (1.05, 1.51)  | 0.012  | 1.13 (0.94, 1.35)  | 0.185  |
| No-education           | 1.09 (0.89, 1.35)  | 0.393  | 1.16 (0.96, 1.41)  | 0.125  |
| Wealth index           |                    |        |                    |        |
| Richest                | Reference          |        | Reference          |        |
| Richer                 | 1.07 (0.94, 1.22)  | 0.305  | 1.09 (0.94, 1.25)  | 0.245  |
| Middle                 | 1.06 (0.93, 1.2)   | 0.371  | 1.16 (0.99, 1.35)  | 0.064  |
| Poorer                 | 1.03 (0.9, 1.19)   | 0.647  | 1.08 (0.90, 1.28)  | 0.407  |
| Poorest                | 1.29 (1.13, 1.48)  | <0.001 | 1.10 (0.92, 1.32)  | 0.305  |
| Child’s sex            |                    |        |                    |        |
| Female                 | Reference          |        | Reference          |        |
| Male                   | 1.11 (1.03, 1.19)  | 0.007  | 1.05 (0.97, 1.14)  | 0.254  |
| Child’s age, years     |                    |        |                    |        |
| 2                      | Reference          |        | Reference          |        |
| 1                      | 1.18 (1.07, 1.29)  | 0.001  | 1.15 (1.04, 1.26)  | 0.006  |
| 0                      | 1.19 (1.08, 1.30)  | <0.001 | 1.19 (1.08, 1.31)  | 0.001  |
| Child’s size at birth  |                    |        |                    |        |
| Average                | Reference          |        | Reference          |        |
| Smaller than average   | 1.23 (1.12, 1.35)  | <0.001 | 1.13 (1.02, 1.25)  | 0.021  |
| Larger than average    | 1.23 (1.13, 1.35)  | <0.001 | 1.00 (0.86, 1.15)  | 0.961  |

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significant impact on the childhood disease in all surveys. Maternal age, education, wealth status, have also been found to be significant in some survey years. We also observed other factors such as division, child’s age, and size at birth were significantly associated with childhood disease in all surveys.

We have noticed that the delivery rate for the C-section was higher particularly in the Dhaka division compared with other geographical divisions in Bangladesh. An earlier study

### Table 4. Factors associated with cesarean vs normal delivery and common childhood diseases, MICS 2012–2019.

|                                    | 2012 MICS |          | 2019 MICS |          |
|------------------------------------|-----------|----------|-----------|----------|
|                                    | IRR (95% CI) | p-value | IRR (95% CI) | p-value |
| Cesarean delivery                   |           |         |           |         |
| No                                 | Reference |         | Reference |         |
| Yes                                | 0.98 (0.92, 1.04) | 0.492 | 0.95 (0.88, 1.03) | 0.209 |
| Mothers age                         |           |         |           |         |
| 15–19                              | Reference |         | Reference |         |
| 20–24                              | 0.98 (0.91, 1.05) | 0.511 | 0.92 (0.82, 1.03) | 0.146 |
| 25–29                              | 0.98 (0.91, 1.05) | 0.549 | 0.95 (0.84, 1.06) | 0.353 |
| 30–34                              | 0.97 (0.89, 1.05) | 0.458 | 0.82 (0.72, 0.94) | 0.005 |
| 35+                                | 0.95 (0.86, 1.05) | 0.307 | 0.71 (0.59, 0.84) | <0.001 |
| Division                            |           |         |           |         |
| Dhaka                              | Reference |         | Reference |         |
| Barishal                           | 1.12 (1.03, 1.22) | 0.006 | 1.17 (1.01, 1.34) | 0.036 |
| Chittagong                         | 0.93 (0.87, 1.00) | 0.053 | 1.21 (1.08, 1.35) | 0.001 |
| Khulna                             | 1.16 (1.09, 1.24) | <0.001 | 1.15 (1.02, 1.29) | 0.018 |
| Rajshahi                           | 1.14 (1.07, 1.22) | <0.001 | 1.18 (1.04, 1.33) | 0.008 |
| Rangpur                            | 1.05 (0.98, 1.12) | 0.176 | 1.07 (0.94, 1.23) | 0.311 |
| Sylhet                             | 1.01 (0.93, 1.09) | 0.85 | 0.6 (0.5, 0.72) | <0.001 |
| Education                           |           |         |           |         |
| Higher                             | Reference |         | Reference |         |
| Secondary                          | 1.07 (0.99, 1.15) | 0.099 | 0.99 (0.89, 1.1) | 0.835 |
| Primary                            | 1.04 (0.96, 1.13) | 0.329 | 1.05 (0.92, 1.19) | 0.499 |
| No-education                       | 1.07 (0.97, 1.17) | 0.163 | 0.84 (0.69, 1.01) | 0.068 |
| Wealth Index                        |           |         |           |         |
| Richest                            | Reference |         | Reference |         |
| Richer                             | 0.97 (0.89, 1.04) | 0.381 | 0.96 (0.84, 1.09) | 0.501 |
| Middle                             | 1.01 (0.93, 1.1) | 0.765 | 0.99 (0.88, 1.12) | 0.919 |
| Poorer                             | 1.01 (0.93, 1.11) | 0.749 | 1.17 (1.02, 1.33) | 0.023 |
| Poorest                            | 1.04 (0.96, 1.14) | 0.331 | 1.08 (0.94, 1.24) | 0.266 |
| Child’s sex                         |           |         |           |         |
| Female                             | Reference |         | Reference |         |
| Male                               | 1.00 (0.95, 1.04) | 0.83 | 1.12 (1.04, 1.19) | 0.002 |
| Child’s age, years                  |           |         |           |         |
| 2                                  | Reference |         | Reference |         |
| 1                                  | 1.19 (1.07, 1.31) | 0.001 | 1.42 (1.19, 1.71) | <0.001 |
| 0                                  | 1.12 (1.02, 1.24) | 0.023 | 1.40 (1.17, 1.68) | <0.001 |
| Child’s size at birth               |           |         |           |         |
| Average                            | Reference |         | Reference |         |
| Smaller than average               | 1.07 (1.01, 1.13) | 0.023 | 1.25 (1.14, 1.37) | <0.001 |
| Larger than average                | 1.01 (0.95, 1.08) | 0.717 | 1.22 (1.10, 1.36) | <0.001 |

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found that women in the division of Chittagong, Dhaka, Khulna and Rajshahi were more likely to go C-section [27]. For instance, the risk of disease was higher in the Khulna division in the MICS surveys. Most of the women in these areas are educated and they belong to middle-class and rich families and have access to and ability to undergo C-section delivery [28]. Nowadays, educated pregnant women want to avoid vaginal delivery in fear of labor pain and other conveniences. Perhaps these are the most important reasons for the increased rate of cesarean delivery in Bangladesh.

Our study findings also confirmed that the highest rate of C-section has occurred among secondary or higher educated females. Since education is directly linked to women’s autonomy, they are more economically solvent and mostly living in urban areas, can decide to give birth through the C-section. However, some studies show that women’s choice of C-Section has no visible link with their educational level [29, 30]. In terms of wealth, health facilities were higher for the rich families than for the mid- and poorer families. In comparison with the poorest or poorest families, the rates for C-section were higher among the rich families [31]. This might be due to financial issues since the wealthy family can pay C-section costs.

The analyses of this study confirmed that childhood disease is associated with maternal age, according to MICS data. An earlier study showed that children born to younger teenage mothers were found to have a relatively high risk of diarrhea, cough, and fever [32]. This is due to the fact that maternal age is linked with some adverse pregnancy outcomes and a higher risk of developing medical conditions such as hypertension, diabetes, or other causes. However, in the BDHS data, we did not observe any significant relationship between the ages of the mothers and the risk of short-term diseases.

Our study has several strengths: first, to our knowledge, this the first study to examine delivery-section and childhood diseases in Bangladesh; second, we used the latest available four data sets from two nationally representative surveys, third, we used proper data analyses methodology in which we accounted for all complex survey designs. However, there are some limitations of the study: first, we used cross-sectional survey data and the childhood disease changes over time and the reported association may change in the longitudinal studies, although our study exposure variable, C-section, was a time-independent variable; second, an important maternal factor complications during pregnancy that have a significant number of missing values and could not consider them in the analyses; third, data on reasons for C-section were not available to capture an understand of the choice.

Conclusions

Our study shows that cesarean delivery in Bangladesh has continued to increase rapidly over time, and we did not find any significant association between cesarean delivery and early childhood diseases. The study also confirmed that childhood disease is significantly related to maternal age, geographical division, maternal education and wealth index, age of the child, and birth size.

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References

1. Zakeriha Midi M, Roudsari RL, Khoei EM. Vaginal delivery vs. cesarean section: A focused ethnographic study of women’s perceptions in The North of Iran. International journal of community based nursing and midwifery. 2015; 3(1):39. PMID: 25553333

2. Lori JR, Boyle JS. Cultural childbirth practices, beliefs, and traditions in postconflict Liberia. Health care for women international. 2011; 32(6):454–73. https://doi.org/10.1080/07399332.2011.555631 PMID: 21547801

3. Haider MR, Rahman MM, Moinuddin M, Rahman AE, Ahmed S, Khan MM. Ever-increasing Caesarean section and its economic burden in Bangladesh. PloS one. 2018; 13(12):e0208623. https://doi.org/10.1371/journal.pone.0208623 PMID: 30532194

4. Farmer TW, Estell DB, Leung M-C, Trott H, Bishop J, Caims BD. Individual characteristics, early adolescent peer affiliations, and school dropout: An examination of aggressive and popular group types. Journal of School Psychology. 2003; 41(3):217–32.

5. Gomes UA, Silva AA, Bettiol H, Barbieri MA. Risk factors for the increasing caesarean section rate in Southeast Brazil: a comparison of two birth cohorts, 1978–1979 and 1994. International Journal of Epidemiology. 1999; 28(4):687–94. https://doi.org/10.1093/ije/28.4.687 PMID: 10480697

6. Magne F, Puchi Silva A, Carvalho B, Gotteland M. The elevated rate of cesarean section and its contribution to non-communicable chronic diseases in Latin America: the growing involvement of the microbiota. Frontiers in pediatrics. 2017; 5:192. https://doi.org/10.3389/fped.2017.00192 PMID: 28929093

7. Gibbs RS, Karlan BY, Haney AF, Nygaard IE. Danforth’s obstetrics and gynecology; Lippincott Williams & Wilkins Philadelphia, PA; 2008.

8. Betrán AP, Ye J, Moller A-B, Zhang J, Gülmezoglu AM, Torloni MR. The increasing trend in caesarean section rates: global, regional and national estimates: 1990–2014. PloS one. 2016; 11(2);e0148343. https://doi.org/10.1371/journal.pone.0148343 PMID: 26849801

9. Villar J, Valladares E, Wojdyła D, Zavaleta N, Carroli G, Velazco A, et al. Caesarean delivery rates and pregnancy outcomes: the 2005 WHO global survey on maternal and perinatal health in Latin America. The Lancet. 2006; 367(9525):1819–29.

10. Khan MN, Islam MM, Shariff AA, Alam MM, Rahman MM. Socio-demographic predictors and average annual rates of caesarean section in Bangladesh between 2004 and 2014. PloS one. 2017; 12(6): e0177579. https://doi.org/10.1371/journal.pone.0177579 PMID: 28493956

11. Ajslev TA, Andersen CS, Gamborg M, Sørensen TIA, Jess T. Childhood overweight after establishment of the gut microbiota: the role of delivery mode, pre-pregnancy weight and early administration of antibiotics. International journal of obesity. 2011; 35(4):522–9. https://doi.org/10.1038/ijo.2011.27 PMID: 21386800
12. Darmasseleane K, Hyde MJ, Santhakumar S, Gale C, Modi N. Mode of delivery and offspring body mass index, overweight and obesity in adult life: a systematic review and meta-analysis. PloS one. 2014; 9(2):e87896. https://doi.org/10.1371/journal.pone.0087896 PMID: 24586295

13. Begum T, Rahman A, Nababan H, Hoque DME, Khan AF, Ali T, et al. Indications and determinants of caesarean section delivery: evidence from a population-based study in Matlab, Bangladesh. PloS one. 2017; 12(11):e0188074. https://doi.org/10.1371/journal.pone.0188074 PMID: 29155840

14. Zhang T, Sidorchuk A, Sevilla-Cermeño L, Vilaplana-Pérez A, Chang Z, Larsson H, et al. Association of cesarean delivery with risk of neurodevelopmental and psychiatric disorders in the offspring: A systematic review and meta-analysis. JAMA network open. 2019;2(8):e1910236-e. https://doi.org/10.1001/jamanetworkopen.2019.10236 PMID: 31461150

15. Chen G, Chiang W-L, Shu B-C, Guo YL, Chiou S-T, Chiang T-l. Associations of cesarean delivery and the occurrence of neurodevelopmental disorders, asthma or obesity in childhood based on Taiwan birth cohort study. BMJ open. 2017; 7(9):e017086. https://doi.org/10.1136/bmjopen-2017-017086 PMID: 28963295

16. Pathela P, Zahid Hasan K, Roy E, Huq F, Kasem Siddique A, Bradley Sack R. Diarrhoeal illness in a cohort of children 0–2 years of age in rural Bangladesh: I. Incidence and risk factors. Acta paediatrica. 2006; 95(4):430–7. https://doi.org/10.1080/080352505004444875 PMID: 16720490

17. Tazinya AA, Halle-Ékane GE, Mbuagbaw LT, Abanda M, Atashili J, Obama MT. Risk factors for acute respiratory infections in children under five years attending the Bamenda Regional Hospital in Cameroon. BMC pulmonary medicine. 2018; 18(1):7. https://doi.org/10.1186/s12890-018-0579-7 PMID: 29338717

18. Ullah MB, Mridha MK, Arnold CD, Matias SL, Khan MSA, Siddiqui Z, et al. Factors associated with diarrhoea and acute respiratory infection in children under two years in rural Bangladesh. BMC pediatrics. 2019; 19(1):386. https://doi.org/10.1186/s12887-018-1378-4 PMID: 31651818

19. Yusuf A, Mamun A, Karmuzzaman M, Saw A, El-Fetoh NMA, Lestrel PE, et al. Factors influencing childhood anaemia in Bangladesh: a two level logistic regression analysis. BMC pediatrics. 2019; 19(1):1–9. https://doi.org/10.1186/s12887-018-1324-3 PMID: 30400845

20. Yun X-D, An L-P, Cheng P, Wu M, Xia Y-Y. Treatment of tibial intercondylar eminence fracture under arthroscopy through patellofemoral joint space. Zhongguo gu shang = China journal of orthopaedics and traumatology. 2013; 26(9):714–6. PMID: 24416898

21. Imran MIK, Inshafi MUA, Sheikh R, Chowdhury MAB, Uddin MJ. Risk factors for acute respiratory infection in children younger than five years in Bangladesh. Public health. 2019; 173:112–9. https://doi.org/10.1016/j.puhe.2019.05.011 PMID: 31271965

22. Pathey P. Bangladesh multiple indicator cluster survey 2012–2013 Key findings. Bangladesh Bur Stat UNICEF Bangladesh. 2014:2014.

23. Niport M. and ICF: Bangladesh demographic and health survey 2014. Technical report, National Institute of Population Research and Training . . . , 2016.

24. Gondwe T, Betha K, Kuseniwar GN, Bunker CH, Tang G, Simhan H, et al. Maternal Factors Associated with Mode of Delivery in a Population with a High Cesarean Section Rate. J Epidemiol Glob Health. 2019; 9(4):252–8. Epub 2019/12/20. https://doi.org/10.2991/jegh.k.191017.001 PMID: 31854166; PubMed Central PMCID: PMC7310794.

25. Kamal SMM. Preference for institutional delivery and caesarean sections in Bangladesh. Journal of health, population, and nutrition. 2013; 31(1):96. https://doi.org/10.3329/jhpn.v31i1.14754 PMID: 23617210

26. Hasan F, Alam MM, Hossain MG. Associated factors and their individual contributions to caesarean delivery among married women in Bangladesh: analysis of Bangladesh demographic and health survey data. BMC pregnancy and childbirth. 2019; 19(1):433. https://doi.org/10.1186/s12884-019-2588-9 PMID: 31752772

27. Angeja ACE, Washington AE, Vargas JE, Gomez R, Rojas I, Caughey AB. Chilean women’s preferences regarding mode of delivery: which do they prefer and why? BJOG: An International Journal of Obstetrics & Gynaecology. 2006; 113(11):1253–8. https://doi.org/10.1111/j.1471-0528.2006.01069.x PMID: 17014679
30. Chu K-H, Tai C-J, Hsu C-S, Yeh M-C, Chien L-Y. Women’s preference for cesarean delivery and differences between Taiwanese women undergoing different modes of delivery. BMC health services research. 2010; 10(1):138. https://doi.org/10.1186/1472-6963-10-138 PMID: 20504354

31. Shahabuddin ASM, Delvaux T, Utz B, Bardaji A, De Brouwere V. Determinants and trends in health facility-based deliveries and caesarean sections among married adolescent girls in Bangladesh. BMJ open. 2016;6(9). https://doi.org/10.1136/bmjopen-2016-012424 PMID: 27633641

32. Kandala NB. Bayesian geo-additive modelling of childhood morbidity in Malawi. Applied Stochastic Models in Business and Industry. 2006; 22(2):139–54.