**Association between cesarean delivery and early childhood diseases in Bangladesh**

Mohammad Nayeem Hasan1, Jenifar Jahan1, Sumyea Jahan1, Muhammad Abdul Baker Chowdhury2, Nasar U. Ahmed3, Md Jamal Uddin1\*

1. Department of Statistics, Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh
2. Department of Emergency Medicine, University of Florida College of Medicine, Gainesville, FL, USA.
3. Department of Epidemiology, Florida International University, Miami, FL

\* corresponding author

**Abstract**

***Introduction*:** The rate of cesarean delivery (C-section) has increased worldwide including Bangladesh. Since the C-section is major surgery, it has a negative impact on the health of mother and child. However, research on this area in ​​Bangladesh is scarce. Our objective was to examine the association between C-section (vs normal delivery) and childhood diseases in Bangladesh.

***Methods:*** We used the latest available nationally representative data from a multiple indicator cluster survey (MICS, 2012), (MICS, 2019) and Bangladesh Demographic and Health Survey (BDHS, 2014). In total, 7921, 9183 and 4557 children were eligible for final analysis from MICS 2012, MICS 2019 and BDHS, respectively. The outcome variable was created using childhood diseases such as fever, short, rapid breaths, cough, blood in stools and diarrhea. Important confounding factors such as the age and sex of the child, child ever been breastfed, size of child at birth and weight at birth during the survey, geographical location, mother's age, and education, body mass index, the religion of household head, and wealth index quintile were considered. We estimated crude and adjusted risk ratio (RR) using different count data analysis models (e.g. negative binomial).

***Results:*** We found 19.1%, 36.0% and 23.3% of children were born in the C-section in MICS 2012, MICS 2019 and BDHS surveys, respectively. The crude RR for the C-section was 1.05 (95% confidence interval (CI): 1.02-1.08), 1.16 (CI: 1.14-1.18) and 1.08 (CI: 0.97-1.19) for MICS 2012, MICS 2019 and BDHS, respectively. The adjusted RR was 1.01 (95% CI: 0.97-1.04), 1.14 (CI: 1.11-1.17) for MICS 2012 and MICS 2019, respectively. For BDHS, the adjusted RR was 1.15 (CI:1.05-1.27). In the adjusted PS model, the RR was slightly increased in MICS 2012, 1.02 (CI: 0.90-1.14) and BDHS 1.17 (CI: 1.05-1.29), decreased in MICS 2019, 1.01 (CI: 0.98-1.03).

***Conclusion:*** We found that there has an increased risk for developing childhood diseases in both surveys and the results from the BDHS data showed a significant association between C-section (vs normal delivery) and childhood diseases in Bangladesh. We recommend increasing public awareness of the negative impact of unnecessary cesarean delivery in Bangladesh.

**Keywords:** Caesarean section; normal delivery; childhood disease; survey, MICS, BDHS

**1. 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 (Zakerihamidi et al., 2015). Recently, it has become a preferred choice as a mode of delivery among women because they believed that it is painless, easy, safer, and healthier than normal delivery (Lori & Boyle, 2011). This choice may increase unnecessary C-section and has a negative impact on the mother and child health (Haider et al., 2018).

The C-section is rapidly increasing in many developed and developing countries (Farmer et al., 2003; Gomes et al., 1999). During the last decades, unnecessary C-section has increased rapidly (Magne et al., 2017). It is increasing significantly as evident more than half of the women voluntarily undergo C-section (Danforth & Gibbs, 2008). This choice is influenced by several factors, including ways to prevent labor pain, it is safer, healthier than normal delivery (Tatar et al., 2000), fear of normal delivery (Latifnejad-Roudsari et al., 2014), incorrect cultural assumptions (Aziken et al., 2007), and closure of the uterine tubes (Kasai et al., 2010). In contrast, most women prefer natural birth due to personal beliefs, cultural customs, and values (Latifnejad-Roudsari et al., 2014), faster recovery after delivery (Kasai et al., 2010), financial shortage (Zakerihamidi et al., 2014).

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% (Betrán et al., 2016). Moreover, a 2004-2008 world health organization (WHO) survey recorded an average global rate of C-section was 25.7% in which 27.3% in Asia, 29.2% in Latin America, and 19.0% in Europe (Lumbiganon et al., 2010; Villar et al., 2006). As stated by WHO, there is no justification for any region to have a cesarean rate higher than 10 -15%, which weighs a serious reason for worry in most of the countries worldwide (Rahman et al., 2015). In Bangladesh, the C-section rate increased from 3.5% in 2004 to 23% in 2014 (Khan et al., 2017).

There are several risks associated with the C-section for mother and those risk of health conditions including cardiac arrest, hysterectomy, puerperal infection, thromboembolism, wound hematoma, anesthetics complications. (Yuan et al., 2016). In addition, babies born in C-section are at risk of developing asthma, type 1 diabetes, allergic diseases (Ajslev et al., 2011; Darmasseelane et al., 2014), Crohn's disease (Yuan et al., 2016), immune deficiencies, and leukemia. A study was conducted to examine the distribution of C-section and its correlates in the northern part of Bangladesh (Rahman et al., 2015). Rahman and colleagues showed that previous C-section, prolonged labor, higher maternal education level, mother age of 25 years or more, the lower order of birth, baby length greater than 45 cm, and unbalanced diet were some factors that were significantly associated with C-section. Another study found that higher the age of mother, lower birth order, higher education of parents, higher socioeconomic status, poor maternal history, and three or more antenatal cares was significantly associated with C-section delivery (Begum et al., 2017).

In Bangladesh, young children are generally suffering from several common diseases such as fever, the difficulty of breathing, blood in stools and diarrhea (Ferdous et al., 2018). However, to the best of our knowledge, there is no published record that any research has been conducted to determine the association between C-section and such early childhood diseases in Bangladesh. Therefore, it is important to study the consequence of C-section delivery on child health particularly on early childhood diseases applying an appropriate statistical method. To fill this gap in knowledge, we aimed to investigate the association between C-section delivery and childhood diseases. We also explore key factors associated with childhood diseases.

**2. Methods**

***Data source and study design***

We used the latest available dataset from the Bangladesh Demographic and Health Survey (BDHS, 2014) for our study. To compare and strengthen the association between C-section delivery and childhood diseases, we also used another parallel survey data, the multiple indicator cluster survey (MICS, 2012) and (MICS, 2019) in Bangladesh (MICS, 2015). 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 highlighted on identical measures of fertility and child health, mortality, and indicators of access to maternal and child health interventions, illness, treatment, and nutritional status. Both surveys represent the seven administrative divisions (Dhaka, Chittagong, Sylhet, Rajshahi, Rangpur, Barisal, and Khulna) of Bangladesh. These administrative divisions are taken as the main sampling strata for the sample (DHS Bangladesh, 2014; MICS, 2015). Both data-sets are fully open-access (Corsi et al., 2017).

In BDHS 2014, information on 7886 mother-child pairs was collected. Out of the mother-child pairs, 1236 children were excluded because they were not living with their mother. Moreover, as the BDHS data did not contain C-section information of greater than 3 years, 2093 children were omitted from the analysis. Hence, 4557 children were selected as a final sample for analysis (Figure 1).

Similarly, in MICS 2012, information on 59599 women was collected. Out of this number, 36197 women have not had a child and 15481 babies greater than 24 months were excluded from the analysis. Therefore, the sample included 7921 mother-child pairs for analysis (Figure 2).

In MICS 2019, information on 24453 mother-child pairs was collected. Out of the mother-child pairs, 13819 children were excluded because they were not living with their mother and some child were death after birth. Moreover, as the MICS 2019 data did not contain C-section information of greater than 3 years, 1451 children were omitted from the analysis. Hence, 9183 children were selected as a final sample for analysis (Figure 3).

**Outcome variable**

For creating the outcome variables, childhood disease, we used several variables such as develops a fever, short, rapid breaths, cough, blood in stools and diarrhea in the two weeks before or during the survey. Two types of outcome variables were considered. First, a count variable that means the frequency of the diseases of the children (figure 4,5 and 6); second, a binary outcome in which 0 means children were suffered from <3 diseases (as 3 was the median of the count of diseases) and 1 means greater than ≥3 diseases in MICS 2012 data, 0 means children were suffered from <2 diseases (as 2 was the median of the count of diseases) and 1 means greater than ≥2 diseases in MICS 2019 data and 0 means children were suffered from 0 (no) diseases (as 0 was the median of the count of diseases) and 1 means greater than >0 diseases in BDHS data, respectively.

**Exposure variable**

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

**Potential confounding variables**

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

**Statistical analyses**

**Descriptive statistics:** Descriptive statistics of each of the selected confounding variables 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 whether differences in demographic and socioeconomic characteristics between C-section and normal delivery were statistically significant.

**Poisson regression models:**As our main outcome is a count variable, frequency of diseases,Poisson regression models were applied. However, this model often displays overdispersion, for that reason, negative binomial (NB) regression models are perhaps the most convenient too with and have been used by various authors (Lawless, 1987). Hence, we also applied the NB regression method with a log link. In the analyses, we reported crude (only exposure and outcome in the model) and adjusted (exposure and other confounding variables in the model) exposure effects.

**Model assessment:** We used the AIC and BIC values to compare the models (Poisson regression versus NB regression); the lowest value of AIC and BIC indicates a better fit of the data after accounting for model complexity (i.e. the number of model parameters). Using the best model, we reviewed the variability of the results from the models.

**Propensity score models:** As a sensitivity, we also applied a propensity score (PS) method for the second outcome (binary) variable. The propensity score method is the probability of exposure (C-section versus normal delivery) assignment conditional on possible confounding variables. This approach helps us to design and analyze our observational survey data so that it mimics some of the characteristics (covariates) of a randomized controlled trial (Austin, 2011). The detailed practical explanations of the PS method can be found elsewhere (Ali et al., 2016; Austin, 2011).

All statistical analyses were performed by SAS and SPSS (IBM SPSS 25). In SAS, the survey analysis procedures command (e.g. PROC SURVEYFREQ, SURVEYLOGISTIC) were used to allow for the adjustments of the complex sampling design.

***Ethics approval***

Our study was wholly based on an analysis of existing public domain health survey datasets obtained from the BDHS 2014 and MICS 2012, 2019 which is freely available online with all personal identifying information removed. The BDHS 2014 data were reviewed and approved by the ICF Macro Institutional Review Board and the National Research Ethics Committee of the Bangladesh Medical Research Council. The MICS procedures were reviewed and approved by the Bangladesh Bureau of Statistics (BBS) and UNICEF. Informed consent was obtained from participants while interviewing them. Because this study involved the analysis with secondary data thus, it did not require the ethical approval of the respective institution.

**3. Results**

Table 1 outlines the participant characteristics as well as differences between participants with C-section versus normal delivery for both the data sources. The proportion of cesarean deliveries were 19.1%, 36.0% and 23.3% in MICS (2012), MICS (2019) and BDHS (2014) data, respectively (figure 7, 8 and 9).

The women who had undergone a C-section had a lower prevalence (6.1% and 5.5%) in the highest age groups (35+ years) for the both MICS data and they were significant. The prevalence of C-section was significantly higher in Muslim than non-Muslim with the figures being 88.9% for Muslims and 11.1% for non-Muslim in MICS 2012, 89.8% for Muslims and 10.2% for non-Muslim in MICS 2019, this prevalence is almost similar but insignificant in BDHS, 90.5% for Muslim and 9.5% for non-Muslim. Mothers living in rural areas being delivered by C-section were highest and the prevalence is 63.7% in MICS 2012 and it increased in MICS 2019 (71.1%), in BDHS, it is almost similar (50%). The highest percentages of C-section were delivered in Dhaka 40% in MICS 2012 and C-section delivery was also highest in BDHS (24.7%). But, in 2019 MICS shows highest prevalence in Chattogram (24.0%). The prevalence was higher among the children of mothers with higher education. In MICS, the prevalence of C-section among the children whose mothers have secondary incomplete education was highest (44.0%) and in BDHS, this prevalence is also reported high (53.9%) in the same group as MICS 2012. There was a significant rural-urban difference in the prevalence of C-section in both data. In addition, both models showed similar results e.g. wealth index, BMI, breastfeeding status, size at birth also has significant differences with respect to type of delivery.

Table 2 demonstrates the goodness of fit of two models Poisson and NB regression model. The NB model has the smallest AIC and BIC in both data sets and therefore it was chosen as a final model.

Table 3 shows the results from crude and adjusted estimates obtained from the NB regression model. The analyses showed that the risk ratio (RR) for the C-section (vs normal delivery) was 1.05 (95% confidence interval (CI): 1.02-1.08) for MICS 2012, 1.16 (CI: 1.14-1.18) for MICS 2019 and 1.08 (CI: 0.97-1.19) for BDHS, respectively, which indicates that children were born in C-section compared with the normal delivery were at increased risk for developing childhood disease. The association was statistically significant for both MICS data (p-value=0.001) but for BDHS, this was not significant (p-value=0.159) in crude model. Similarly, after adjusting for possible confounding factors in the adjusted model, the RR was 1.01 (95% CI: 0.97-1.04) for MICS 2012, 1.14 (CI: 1.11-1.17) for MICS 2019 and 1.15 (CI: 1.05-1.27) for BDHS, respectively. Here, the association between C-section and childhood disease was statistically significant (P=0.004) only for MICS 2019 and BDHS data (Table 3).

Similarly, for the binary outcome, the crude estimates from the PS method were 1.12 (95% CI: 0.94-1.31), 1.02 (CI:0.87-1.20) and 1.11 (95% CI: 1.01-1.23) for MICS 2012, 2019 and BDHS, respectively. The RR from adjusted (type of delivery and propensity scores) model was 1.02 (CI: 0.90-1.14) for MICS 2012, 1.01 (CI: 98-1.03) for MICS 2019 and 1.17 (1.05-1.29) for BDHS, respectively. Like NB binomial model, the association between C-section and childhood disease was statistically significant for BDHS data in both models (Table 4).

**Risk factors for childhood diseases related to C-section delivery**

NB regression analysis for the status of childhood diseases reveals that the Type of delivery, age of mother, division, BMI and size at birth were the contributing factors to childhood diseases in MICS data. Type of delivery, BMI, sex of child and child age were the contributing factors to childhood diseases according to BDHS data (S1 and S2 Table).

Table 5 shows the association between type of delivery and early childhood diseases when models adjusted for selected confounding factors. For instance, after adjusting all other factors, C-section delivered babies were more likely to be affected by diseases 1.15 times (CI: 1.05-1.27) in BDHS, however, they did not reach a statistically significant level in MICS 2012. The risk of the children getting affected by diseases whose mothers aged between 15-19 years were 1.04 (CI: 0.97-1.12) more likely and aged between 20-34 years were 0.93 (CI: 0.88-0.97) less likely than those aged above years, respectively in MICS 2012. Both MICS and BDHS explained similar conclusions, in BDHS, the mothers aged between 15-19 years were 1.05 (CI: 0.95-1.15) more likely and aged between 20-34 years were 0.96 (CI: 0.87-1.06) less likely to affected by diseases than those aged above, respectively. Children who were born to underweight and overweight mothers were more likely to have the disease, ARR 1.11 (CI: 1.04-1.19) and ARR 1.12 (95 % CI: 1.03-1.21) in MICS and ARR 1.13 (CI: 1.01-1.26) and ARR 1.17 (CI: 1.03-1.32) in BDHS, due to C-section. Age of the children is recognized as an important factor for childhood diseases in BDHS but not in MICS according to 95% level of significance, and results showed that children with age between 0-11 months and 12-23 months were more at risk of suffering from diseases than 24–35 months aged children, ARR 1.15 (CI: 1.04-1.27) and ARR 1.14 (CI: 1.04-1.26).

**4. Discussion**

The aim of this study was to examine the association between C-section delivery (versus normal delivery) and early childhood diseases in Bangladesh. The PS method and NB regression methods showed that the odds of having childhood diseases were higher for the C-section child as compared to the normal delivery child. A similar study observed that C-section is associated with an increased risk for immune development, and increase the probability of allergy, atopy, and asthma and decreases intestinal microbiome diversity (Sandall et al., 2018). A meta-analysis, conducted with the delivery of C-section baby, was associated with a moderately increased risk of developing type 1 diabetes (Cardwell et al., 2008). Similar results have been reported by Marcotte et al, where they have shown increase risk of acute lymphoblastic leukemia in young infants born with cesarean delivery (Marcotte et al., 2016). There is evidence of short-term health effects of the baby after cesarean delivery, such as hypothermia, impaired lung function, altered metabolism, altered blood pressure, and altered feeding, which is consistent with our findings (Bodner et al., 2011; Hyde et al., 2012; Peters et al., 2018). Although the risk is higher, after adjusting for all possible confounding variables, we did not identify any significant association between C-section and childhood diseases in BDHS data for crude estimates and in MICS data for adjusted estimates. The reason behind the contrasts of the results might be, both surveys on the same objective with the same variable often use different questions in a different household. There might be many other factors that give us a different result, differences between these survey time and the inclusion-exclusion criteria (as MICS provides information about C-section delivery under 2 years of child’s, on the other side, BDHS provides same information of 3 years of child’s), this does suggest the possibility that much of the research findings cannot be similar. In our study, the C-section rate was 23.3% in BDHS and also similar to the prevalence with the report (DHS Bangladesh, 2014). Considering the previous BDHS round, it is continued to increase gradually to 8% in 2007 to 23% in 2014, and to 33% in 2017 (DHS Bangladesh, 2019) and by MICS, it is increased 19.1% in 2012 to 36% in 2019. However, this study was generated with recently available data but during the current study, DHS published the report of key indicators with update data which is not publicly available.

The analyses of this study confirmed that childhood disease is associated with maternal age according to MICS data. In earlier studies, children born to younger mothers (aged <20 years) were found to have a relatively high risk of diarrhea, cough, and fever in their young children (Kandala, 2006), probably because the relationship between maternal age is associated with some adverse pregnancy outcomes and a higher risk of medical conditions such as hypertension, diabetes or other causes. In the present study, there was no clear and consistent relationship between the ages of the mothers and the risk of short-term diseases in BDHS data.

From our findings, we have seen that the rate of C-section delivery was higher particularly in the Dhaka division compared to other divisions of Bangladesh according to MICS data and it is also similar in the BDHS survey. A previous study has demonstrated that the women of Chittagong, Dhaka, Khulna, and Rajshahi division were more likely to avail of institutional delivery and C-section. For instance, the risk of disease was higher in Khulna in the MICS survey. It indicates that the availability of midwives and stuff in Barisal, Chittagong, and Sylhet divisions were low, and access to maternity care services is quite less. Dhaka, Khulna, and Rajshahi division have many more healthcare providers (Kamal, 2013). Lower number midwifery services might be the reason for the high occurrences of C-section as well as high occurrences of diseases on those divisions.

The findings of our study also confirmed that among the educated women, the highest rate of C-section has occurred among secondary completed or higher educated women. We also observed that lower risk of diseases occurred for C-section babies than children born by normal delivery in all other education levels of mother compared to this group. Since education is directly related to the autonomy of women, they are economically more solvent and mostly living in urban areas, may decide to give birth through a C-section. However, some studies reported no visible link between women's preference for C-section and their level of education (Angeja et al., 2006; Chu et al., 2010).

By wealth status, health care facilities were higher for the richest family than the middle and poorer family. Rates of C-section were also higher among the richest family compared to those belonging to the poorest or poorer families (Shahabuddin et al., 2016). This might be a reason for the high risk of diseases in the richest group in our study. However, economic anxiety is strongly associated with malnutrition of children, poor mental development and weakness of the immune system, so it can increase the vulnerability to infectious diseases. Children from financially well-off families may enjoy a healthier and safer lifestyle, with greater access to health-promoting conditions compared to poorer families in later life (Yaya & Bishwajit, 2019).

**Conclusion**

In conclusion, this study demonstrated a positive association between C-section and childhood diseases in areas with different SES in Bangladesh and according to MICS and BDHS, this trend is growing rapidly. An increase in the rates of cesarean section delivery is a burden on the health system and childhood diseases. The results also showed that C-section is associated with an increased risk of childhood diseases than normal delivery child. The analysis of this study confirmed that childhood disease is associated with maternal age. The rate of C-section delivery was higher particularly in the Khulna division compared to other divisions of Bangladesh according to MICS data and is similar in the BDHS survey. Among the educated women, the highest rate of C-section has occurred among secondary completed or higher educated women. Rates of C-section were also higher among the richest family compared to those belonging to the poorest or poorer families. Improving maternal health requires regular monitoring and evaluation of the provision of emergency obstetric services to combat under-utilization of Caesarean section in poor and rural areas and excessive use in rich and urban areas. Unnecessary cesarean delivery can also be a stress on the family and can complicate maternal and child health. Thus, the decision to perform a C-section delivery must be carefully chosen and not aimed at profit.

**Recommendations**:

To reduce unnecessary C-sections and encourage normal birth, various strategies must be taken, such as the implementation of standardized protocols, requests of a second medical opinion prior to surgery, improving maternal empowerment during pregnancy and delivery, maternal and medical collaboration on birth plans. The use of partographs is important in emergency obstetric care, in addition, training of hospital staff, health officers, midwives, and health extension workers, as well as the decision to adopt a neonatal resuscitation skill and C-section, are critical. Prior to delivery, all available birthing procedures and its merit and demerit should be explained to the pregnant women during the antenatal care period. Further studies are needed to enrich our knowledge on the negative impact of C-section delivery and its association with the development of childhood disease, the incidence of the chronic immune system and metabolic disorders in developing countries including Bangladesh. However, we recommend increasing public awareness of the negative impact of unnecessary cesarean delivery in Bangladesh.

**References**

Ajslev, T. A., Andersen, C. S., Gamborg, M., Sørensen, T. I. A., & Jess, T. (2011). 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*, *35*(4), 522–529. https://doi.org/10.1038/ijo.2011.27

Ali, M. S., Groenwold, R. H., & Klungel, O. H. (2016). Best (but oft-forgotten) practices: propensity score methods in clinical nutrition research. *The American Journal of Clinical Nutrition*, *104*(2), 247–258. https://doi.org/10.3945/ajcn.115.125914

Angeja, A. C. E., Washington, A. E., Vargas, J. E., Gomez, R., Rojas, I., & Caughey, A. B. (2006). Chilean women’s preferences regarding mode of delivery: which do they prefer and why? *BJOG : An International Journal of Obstetrics and Gynaecology*, *113*(11), 1253–1258. https://doi.org/10.1111/j.1471-0528.2006.01069.x

Austin, P. C. (2011). An introduction to propensity score methods for reducing the effects of confounding in observational studies. *Multivariate Behavioral Research*, *46*(3), 399–424. https://doi.org/10.1080/00273171.2011.568786

Aziken, M., Omo-Aghoja, L., & Okonofua, F. (2007). Perceptions and attitudes of pregnant women towards caesarean section in urban Nigeria. *Acta Obstetricia et Gynecologica Scandinavica*, *86*(1), 42–47. https://doi.org/10.1080/00016340600994950

Begum, T., Rahman, A., Nababan, H., Emdadul Hoque, D. M., Khan, A. F., Ali, T., & Anwar, I. (2017). Indications and determinants of caesarean section delivery: Evidence from a population-based study in Matlab, Bangladesh. *PLoS ONE*, *12*(11). https://doi.org/10.1371/journal.pone.0188074

Betrán, A. P., Ye, J., Moller, A. B., Zhang, J., Gülmezoglu, A. M., & Torloni, M. R. (2016). The increasing trend in caesarean section rates: Global, regional and national estimates: 1990-2014. *PLoS ONE*, *11*(2). https://doi.org/10.1371/journal.pone.0148343

Bodner, K., Wierrani, F., Grünberger, W., & Bodner-Adler, B. (2011). Influence of the mode of delivery on maternal and neonatal outcomes: A comparison between elective cesarean section and planned vaginal delivery in a low-risk obstetric population. *Archives of Gynecology and Obstetrics*, *283*(6), 1193–1198. https://doi.org/10.1007/s00404-010-1525-y

Cardwell, C. R., Stene, L. C., Joner, G., Cinek, O., Svensson, J., Goldacre, M. J., Parslow, R. C., Pozzilli, P., Brigis, G., Stoyanov, D., Urbonaitė, B., Šipetić, S., Schober, E., Ionescu-Tirgoviste, C., Devoti, G., De Beaufort, C. E., Buschard, K., & Patterson, C. C. (2008). Caesarean section is associated with an increased risk of childhood-onset type 1 diabetes mellitus: A meta-analysis of observational studies. *Diabetologia*, *51*(5), 726–735. https://doi.org/10.1007/s00125-008-0941-z

Chu, K. H., Tai, C. J., Hsu, C. Sen, Yeh, M. C., & Chien, L. Y. (2010). Women’s preference for cesarean delivery and differences between Taiwanese women undergoing different modes of delivery. *BMC Health Services Research*, *10*. https://doi.org/10.1186/1472-6963-10-138

Corsi, D. J., Perkins, J. M., & Subramanian, S. V. (2017). Child anthropometry data quality from Demographic and Health Surveys, Multiple Indicator Cluster Surveys, and National Nutrition Surveys in the West Central Africa region: are we comparing apples and oranges? *Global Health Action*, *10*(1), 1328185. https://doi.org/10.1080/16549716.2017.1328185

Danforth, D. N. (David N., & Gibbs, R. S. (2008). *Danforth’s obstetrics and gynecology.* Lippincott Williams & Wilkins.

Darmasseelane, K., Hyde, M. J., Santhakumaran, S., Gale, C., & Modi, N. (2014). Mode of delivery and offspring body mass index, overweight and obesity in adult life: a systematic review and meta-analysis. *PloS One*, *9*(2), e87896. https://doi.org/10.1371/journal.pone.0087896

DHS Bangladesh. (2014). *Bangladesh Demographic and Health Survey 2014*.

DHS Bangladesh. (2019). *Bangladesh Demographic and Health Survey 2017-18*.

Farmer, T. W., Estell, D. B., Leung, M. C., Trott, H., Bishop, J., & Cairns, B. D. (2003). Individual characteristics, early adolescent peer affiliations, and school dropout: An examination of aggressive and popular group types. *Journal of School Psychology*, *41*(3), 217–232. https://doi.org/10.1016/S0022-4405(03)00046-3

Ferdous, F., Ahmed, S., Das, S. K., Chisti, M. J., Nasrin, D., Kotloff, K. L., Levine, M. M., Nataro, J. P., Ma, E., Muhsen, K., Wagatsuma, Y., Ahmed, T., & Faruque, A. S. G. (2018). Pneumonia mortality and healthcare utilization in young children in rural Bangladesh: A prospective verbal autopsy study. *Tropical Medicine and Health*, *46*(1), 17. https://doi.org/10.1186/s41182-018-0099-4

Gomes, U. A., Silva, A. A. M., Bettiol, H., & Barbieri, M. A. (1999). 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*, *28*(4), 687–694. https://doi.org/10.1093/ije/28.4.687

Haider, M. R., Rahman, M. M., Moinuddin, M., Rahman, A. E., Ahmed, S., & Khan, M. M. (2018). Ever-increasing Caesarean section and its economic burden in Bangladesh. *PLOS ONE*, *13*(12), e0208623. https://doi.org/10.1371/journal.pone.0208623

Hyde, M. J., Mostyn, A., Modi, N., & Kemp, P. R. (2012). The health implications of birth by Caesarean section. In *Biological Reviews* (Vol. 87, Issue 1, pp. 229–243). https://doi.org/10.1111/j.1469-185X.2011.00195.x

Kamal, S. M. (2013). Preference for Institutional Delivery and Caesarean Sections in Bangladesh. *Journal of Health, Population and Nutrition*, *31*(1). https://doi.org/10.3329/jhpn.v31i1.14754

Kandala, N.-B. (2006). Bayesian geo-additive modelling of childhood morbidity in Malawi. *Applied Stochastic Models in Business and Industry*, *22*(2), 139–154. https://doi.org/10.1002/asmb.624

Kasai, K. E., Nomura, R. M. Y., Benute, G. R. G., de Lucia, M. C. S., & Zugaib, M. (2010). Women’s opinions about mode of birth in Brazil: A qualitative study in a public teaching hospital. *Midwifery*, *26*(3), 319–326. https://doi.org/10.1016/j.midw.2008.08.001

Khan, M. N., Islam, M. M., Shariff, A. A., Alam, M. M., & Rahman, M. M. (2017). Socio-demographic predictors and average annual rates of caesarean section in Bangladesh between 2004 and 2014. *PLoS ONE*, *12*(5). https://doi.org/10.1371/journal.pone.0177579

Latifnejad-Roudsari, R., Zakerihamidi, M., Merghati-Khoei, E., & Kazemnejad, A. (2014). Cultural perceptions and preferences of Iranian women regarding cesarean delivery. *Iranian Journal of Nursing and Midwifery Research*, *19*(7 Suppl 1), S28-36. http://www.ncbi.nlm.nih.gov/pubmed/25949249

Lawless, J. F. (1987). Negative binomial and mixed poisson regression. *Canadian Journal of Statistics*, *15*(3), 209–225. https://doi.org/10.2307/3314912

Lori, J. R., & Boyle, J. S. (2011). Cultural childbirth practices, beliefs, and traditions in postconflict liberia. *Health Care for Women International*, *32*(6), 454–473. https://doi.org/10.1080/07399332.2011.555831

Lumbiganon, P., Laopaiboon, M., Gülmezoglu, A. M., Souza, J. P., Taneepanichskul, S., Ruyan, P., Attygalle, D. E., Shrestha, N., Mori, R., Nguyen, D. H., Hoang, T. B., Rathavy, T., Chuyun, K., Cheang, K., Festin, M., Udomprasertgul, V., Germar, M. J. V, Yanqiu, G., Roy, M., … World Health Organization Global Survey on Maternal and Perinatal Health Research Group. (2010). Method of delivery and pregnancy outcomes in Asia: the WHO global survey on maternal and perinatal health 2007-08. *Lancet (London, England)*, *375*(9713), 490–499. https://doi.org/10.1016/S0140-6736(09)61870-5

Magne, F., Silva, A. P., Carvajal, B., & Gotteland, M. (2017). The elevated rate of cesarean section and its contribution to non-communicable chronic diseases in Latin America: The growing involvement of the microbiota. In *Frontiers in Pediatrics* (Vol. 5). Frontiers Media S.A. https://doi.org/10.3389/fped.2017.00192

Marcotte, E. L., Thomopoulos, T. P., Infante-Rivard, C., Clavel, J., Petridou, E. T., Schüz, J., Ezzat, S., Dockerty, J. D., Metayer, C., Magnani, C., Scheurer, M. E., Mueller, B. A., Mora, A. M., Wesseling, C., Skalkidou, A., Rashed, W. M., Francis, S. S., Ajrouche, R., Erdmann, F., … Spector, L. G. (2016). Caesarean delivery and risk of childhood leukaemia: A pooled analysis from the Childhood Leukemia International Consortium (CLIC). *The Lancet Haematology*, *3*(4), e176–e185. https://doi.org/10.1016/S2352-3026(16)00002-8

MICS. (2015). *BANGLADESH 2012-13 MICS FINAL REPORT RELEASED - UNICEF MICS*. https://mics.unicef.org/news\_entries/15

Peters, L. L., Thornton, C., de Jonge, A., Khashan, A., Tracy, M., Downe, S., Feijen-de Jong, E. I., & Dahlen, H. G. (2018). The effect of medical and operative birth interventions on child health outcomes in the first 28 days and up to 5 years of age: A linked data population-based cohort study. *Birth*, *45*(4), 347–357. https://doi.org/10.1111/birt.12348

Rahman, M., Shariff, A. A., Shafie, A., Saaid, R., & Tahir, R. M. (2015). Caesarean delivery and its correlates in Northern Region of Bangladesh: application of logistic regression and cox proportional hazard model. *Journal of Health, Population, and Nutrition*, *33*, 8. https://doi.org/10.1186/s41043-015-0020-2

Sandall, J., Tribe, R. M., Avery, L., Mola, G., Visser, G. H., Homer, C. S., Gibbons, D., Kelly, N. M., Kennedy, H. P., Kidanto, H., Taylor, P., & Temmerman, M. (2018). Short-term and long-term effects of caesarean section on the health of women and children. In *The Lancet* (Vol. 392, Issue 10155, pp. 1349–1357). Lancet Publishing Group. https://doi.org/10.1016/S0140-6736(18)31930-5

Shahabuddin, A. S. M., Delvaux, T., Utz, B., Bardaji, A., & De Brouwere, V. (2016). Determinants and trends in health facility-based deliveries and caesarean sections among married adolescent girls in Bangladesh. *BMJ Open*, *6*(9). https://doi.org/10.1136/bmjopen-2016-012424

Tatar, M., Günalp, S., Somunoglu, S., & Demirol, A. (2000). Women’s perceptions of caesarean section: Reflections from a Turkish teaching hospital. *Social Science and Medicine*, *50*(9), 1227–1233. https://doi.org/10.1016/S0277-9536(99)00315-9

Villar, J., Valladares, E., Wojdyla, D., Zavaleta, N., Carroli, G., Velazco, A., Shah, A., Campodónico, L., Bataglia, V., Faundes, A., Langer, A., Narváez, A., Donner, A., Romero, M., Reynoso, S., Simônia de Pádua, K., Giordano, D., Kublickas, M., & Acosta, A. (2006). Caesarean delivery rates and pregnancy outcomes: the 2005 WHO global survey on maternal and perinatal health in Latin America. *Lancet*, *367*(9525), 1819–1829. https://doi.org/10.1016/S0140-6736(06)68704-7

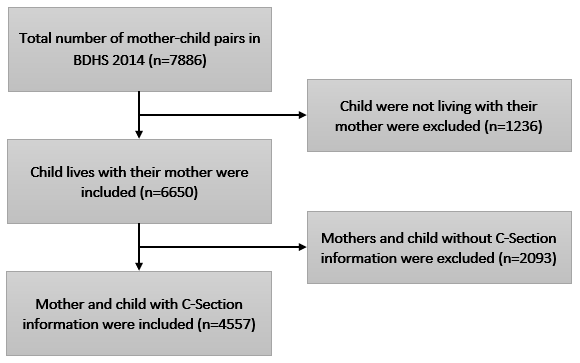
Yaya, S., & Bishwajit, G. (2019). Burden of acute respiratory infections among under-five children in relation to household wealth and socioeconomic status in Bangladesh. *Tropical Medicine and Infectious Disease*, *4*(1). https://doi.org/10.3390/tropicalmed4010036

Yuan, C., Gaskins, A. J., Blaine, A. I., Zhang, C., Gillman, M. W., Missmer, S. A., Field, A. E., & Chavarro, J. E. (2016). Association between cesarean birth and risk of obesity in offspring in childhood, adolescence, and early adulthood. In *JAMA Pediatrics* (Vol. 170, Issue 11). https://doi.org/10.1001/jamapediatrics.2016.2385

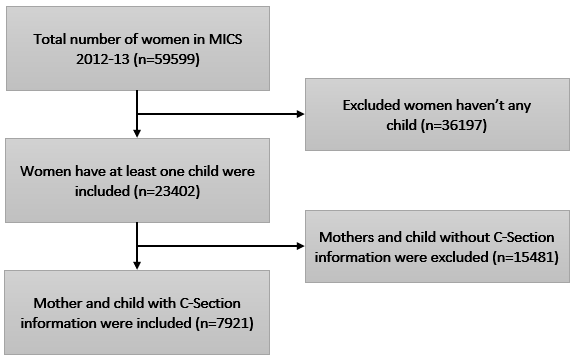
Zakerihamidi, M., Roudsari, R. L., & Khoei, E. M. (2015). Vaginal delivery vs. cesarean section: A focused ethnographic study of women’s perceptions in the north of Iran. *International Journal of Community Based Nursing and Midwifery*, *3*(1), 39–50.

Zakerihamidi, M., Roudsari, R. L., Khoei, E. M., & Kazemnejad, A. (2014). Decision-making for vaginal delivery in the North of Iran: A focused ethnography. *Iranian Journal of Nursing and Midwifery Research*, *19*(7 Suppl 1), S37-44. http://www.ncbi.nlm.nih.gov/pubmed/25949250

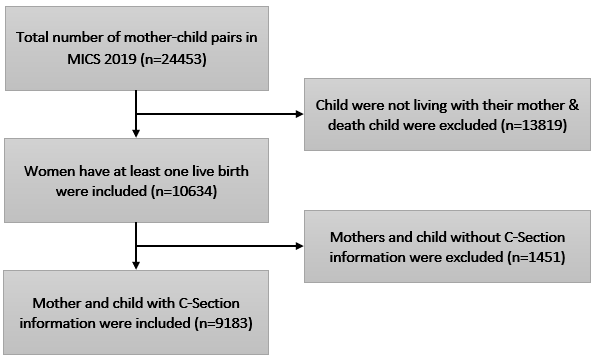
**TABLES AND FIGURES**



**Figure 1: Flow Chart of BDHS data for the study population**



**Figure 2: Flow Chart of MICS 2012 data for the study population**

****

**Figure 3: Flow Chart of MICS 2019 data for the study population**

|  |  |  |
| --- | --- | --- |
|  |  |  |
| **Figure 4: Count (diseases) variable in MICS (2012)** | **Figure 5: Count (diseases) variable in MICS (2019)** | **Figure 6: Count (diseases) variable in BDHS (2014)** |

|  |  |  |
| --- | --- | --- |
|  |  |  |
| **Figure 7: C-section delivery in MICS (2012)** | **Figure 8: C-section delivery in MICS (2019)** | **Figure 9: C-section delivery in BDHS (2014)** |

**Table 1: Distribution of maternal and child characteristics with the type of delivery**

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **MICS 2012** | | | **MICS 2019** | | | **BDHS 2014** | | |
|  | **Type of Delivery** | | | **Type of Delivery** | | | **Type of Delivery** | | |
| **Sources** | **Caesarean**  **N (%)** | **Normal**  **N (%)** | **p-value** | **Caesarean**  **N (%)** | **Normal**  **N (%)** | **p-value** | **Caesarean**  **N (%)** | **Normal**  **N (%)** | **p-value** |
| **Mother’s age group in years at birth** | | | | | | | | | |
| Mean (SD) | 25.4 (5.2) | 25.9 (6.0) | <0.001 | 25.4 (5.3) | 25.7 (5.7) | <0.009 | 24.9 (5.5) | 24.5 (5.8) | 0.038 |
| 15-19 | 171 (11.4) | 740 (11.6) | <0.001 | 427 (13.0) | 812 (14.0) | <0.001 | 191 (18.0) | 745 (21.3) | 0.402 |
| 20-34 | 1241(82.5) | 4952 (77.5) |  | 2682 (81.5) | 4481 (77.4) |  | 802 (75.5) | 2550 (73.0) |  |
| 35+ | 93 (6.1) | 700 (10.9) |  | 180 (5.5) | 497 (8.6) |  | 69 (6.5) | 200 (5.7) |  |
| **Religion** | | | | | | | | | |
| Islam | 1343 (88.9) | 5894 (92.2) | <0.001 | 2955 (89.8) | 5373 (92.8) | <0.001 | 961 (90.5) | 3236 (92.6) | 0.705 |
| Other\* | 167 (11.1) | 497 (7.8) |  | 334 (10.2) | 416 (7.2) |  | 101 (9.5) | 259 (7.4) |  |
| **Place of residence** | | | | | | | | | |
| Urban | 548 (36.3) | 1110 (17.4) | <0.001 | 952 (28.9) | 1029 (17.8) | <0.001 | 532 (50.1) | 925 (26.5) | <0.001 |
| Rural | 962 (63.7) | 5282 (82.6) |  | 2337 (71.1) | 4760 (82.2) |  | 530 (49.9) | 2570 (73.5) |  |
| **Geographical location** | | | | | | | | | |
| Barishal | 50 (3.3) | 428 (6.7) | <0.001 | 374 (6.5) | 134 (4.1) | <0.001 | 105 (9.9) | 435 (12.4) | <0.001 |
| Chattogram | 267 (17.7) | 1577 (24.7) |  | 1391 (24.0) | 589 (17.9) |  | 169 (15.9) | 716 (20.5) |  |
| Dhaka | 604 (40.0) | 1872 (29.3) |  | 1157 (20.0) | 1027 (31.2) |  | 262 (24.7) | 548 (15.7) |  |
| Khulna | 230 (15.2) | 524 (8.2) |  | 429 (7.4) | 480 (14.6) |  | 182 (17.1) | 346 (9.9) |  |
| Mymenshing | - | - |  | 543 (9.4) | 158 (4.8) |  | - | - |  |
| Rajshahi | 189 (12.5) | 656 (10.3) |  | 610 (10.5) | 429 (13.0) |  | 148 (13.9) | 406 (11.6) |  |
| Rangpur | 104 (6.9) | 788 (12.3) |  | 650 (11.2) | 319 (9.7) |  | 108 (10.2) | 440 (12.6) |  |
| Sylhet | 66 (4.4) | 547 (8.6) |  | 636 (11.0) | 153 (4.7) |  | 88 (8.3) | 604 (17.3) |  |
| **Mother’s education** | | | | | | | | | |
| None | 80 (5.3) | 1378 (21.6) | <0.001 | 102 (3.1) | 673 (11.6) | <0.001 | 43 (4.0) | 571 (16.4) | <0.001 |
| Primary incomplete | 78 (5.2) | 964 (15.1) |  | - | - |  |
| Primary | 142 (9.5) | 1096 (17.1) |  | 419 (12.7) | 1646 (28.4) | 145 (13.7) | 1112 (31.8) |  |
| Secondary incomplete | 660 (44.0) | 2360 (36.9) |  | - | - | 572 (53.9) | 1580 (45.2) |  |
| Secondary complete/ higher | 539 (36.0) | 594 (9.3) |  | 2768 (84.2) | 3471 (60.0) | 302 (28.4) | 232 (6.6) |  |
| **Wealth index** | | | | | | | | | |
| Richest | 735 (48.6) | 847 (13.3) | <0.001 | 1172 (35.6) | 1654 (28.6) | <0.001 | 471 (44.4) | 437 (12.5) | <0.001 |
| Richer | 351 (23.2) | 1046 (16.5) |  | 800 (24.3) | 1275 (22.0) |  | 275 (25.9) | 673 (19.3) |  |
| Middle | 192 (12.7) | 1308 (20.6) |  | 622 (18.9) | 1094 (18.9) |  | 165 (15.5) | 709 (20.3) |  |
| Poorer | 136 (9.0) | 1436 (22.6) |  | 438 (13.3) | 996 (17.2) |  | 99 (9.3) | 763 (21.8) |  |
| Poorest | 98 (6.5) | 1717 (27.0) |  | 257 (7.8) | 770 (13.3) |  | 52 (4.9) | 913 (26.1) |  |
| **Body mass index (mother)** | | | | | | | | | |
| Underweight | 50 (3.3) | 320 (5.0) | <0.001 | 151 (4.6) | 309 (5.3) | <0.001 | 153 (14.5) | 1005 (28.9) | <0.001 |
| Normal | 1034 (68.4) | 4934 (77.2) |  | 2221 (67.5) | 4283 (74.0) |  | 568 (53.7) | 2051 (58.9) |  |
| Overweight | 427 (28.3) | 1138 (17.8) |  | 917 (27.9) | 1197 (20.7) |  | 336 (31.8) | 426 (12.2) |  |
| **Breastfeeding status** | | | | | | | | | |
| Yes | 1483 (98.2) | 6208 (97.1) | 0.020 | 3273 (99.5) | 5769 (99.6) | 0.374 | 891 (83.9) | 3011 (86.1) | 0.018 |
| No | 27 (1.8) | 183 (2.9) |  | 16 (0.5) | 21 (0.4) |  | 171 (16.1) | 484 (13.9) |  |
| **Sex of the children** | | | | | | | | | |
| Male | 784 (51.9) | 3226 (50.5) | 0.331 | 1758 (53.5) | 2914 (50.3) | 0.004 | 575 (54.1) | 1768 (50.6) | 0.205 |
| Female | 727 (48.1) | 3166 (49.5) |  | 1531 (46.5) | 2876 (49.7) |  | 487 (45.9) | 1727 (49.4) |  |
| **Child’s age group in months** | | | | | | | | | |
| 0-11 | 766 (50.7) | 3138 (49.1) | 0.264 | 1677 (51.0) | 2688 (46.4) | <0.001 | 372 (35.0) | 1090 (31.2) | 0.168 |
| 12-23 | 744 (49.3) | 3254 (50.9) |  | 1450 (44.1) | 2702 (46.7) |  | 375 (35.3) | 1182 (33.8) |  |
| 24-35 | - | - |  | 161 (4.9) | 400 (6.9) |  | 315 (29.7) | 1223 (35.0) |  |
| **Size at birth** | | | | | | | | | |
| Very large | 5 (0.3) | 6 (0.1) | <0.001 | 60 (1.8) | 53 (0.9) | <0.001 | 23 (2.2) | 78 (2.2) | 0.009 |
| Larger than average | 326 (22.0) | 718 (12.2) |  | 435 (13.3) | 479 (8.4) |  | 154 (14.5) | 327 (9.4) |  |
| Average | 881 (59.4) | 3794 (64.6) |  | 2188 (66.8) | 4089 (71.4) |  | 710 (66.8) | 2379 (68.1) |  |
| Smaller than average | 228 (15.4) | 1134 (19.3) |  | 933 (16.3) | 933 (16.3) |  | 118 (11.1) | 480 (13.7) |  |
| Very small | 44 (3.0) | 222 (3.8) |  | 173 (3.0) | 173 (3.0) |  | 57 (5.4) | 230 (6.6) |  |
| **Weight at birth** | | | | | | | | | |
| Low | 306 (22.8) | 560 (37.0) | <0.001 | 2292 (73.2) | 1080 (66.6) | <0.001 | - | - | - |
| Normal | 1037 (77.2) | 952 (63.0) |  | 838 (26.8) | 541 (33.4) |  | - | - |  |

\*Hinduism, Buddhism, Christianity

**Table 2: Model selection criteria for PS and NB model**

|  |  |  |  |
| --- | --- | --- | --- |
| **Data** | **Model** | **AIC** | **BIC** |
| **MICS (2012)** | Poisson | 24684.24 | 24698.17 |
| **NB** | **24610.48** | **24621.38** |
| **MICS (2019)** | Poisson | 27400.02 | 27421.40 |
| **NB** | **27165.02** | **27179.27** |
| **BDHS (2014)** | Poisson | 13348.55 | 13361.40 |
| **NB** | **12565.08** | **12584.35** |

\*NB: Negative Binomial, AIC: Akaike information criterion, BIC: Bayesian information criterion

**Table 3: Association between C-section (vs normal delivery) and common childhood diseases from the crude and adjusted NB Regression model**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **MICS 2012** | | **MICS 2019** | | **BDHS 2014** | |
| **Model** | **Exposure** | **RR (95% CI)** | **p-value** | **RR (95% CI)** | **p-value** | **RR (95% CI)** | **p-value** |
| **Crude Model** | C-section vs.  normal delivery | 1.05  (1.02-1.08) | <0.001 | 1.16  (1.14-1.18) | <0.001 | 1.08  (0.97-1.19) | 0.159 |
| **Adjusted Model** | C-section vs.  normal delivery | 1.01  (0.97-1.04) | 0.071 | 1.14  (1.11 - 1.17) | <0.001 | 1.15  (1.05 - 1.27) | 0.004 |

RR: Risk Ratio

**Table 4: Association between C-section (vs normal delivery) and common childhood diseases from crude and adjusted PS models**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **MICS 2012** | | **MICS 2019** | | **BDHS 2014** | |
| **Model** | **Exposure** | **ARR (95% CI)** | **p-value** | **ARR (95% CI)** | **p-value** | **ARR (95% CI)** | **p-value** |
| **Crude Model** | C-section vs.  Normal delivery | 1.12  (0.94-1.31) | 0.201 | 1.02  (0.87-1.20) | 0.080 | 1.11  (1.01-1.23) | 0.042 |
| **Adjusted Model** | C-section vs.  Normal delivery | 1.02  (0.90-1.14) | 0.082 | 1.01  (0.98-1.03) | 0.075 | 1.17  (1.05-1.29) | 0.030 |

**SUPPLEMENTARY MATERIAL**

**Table S1: Unadjusted LR statistics for type 3 analysis**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **MICS 2012** | | **MICS 2019** | | **BDHS 2014** | |
| **Source** | **Chi-Square** | **P-value** | **Chi-Square** | **P-value** | **Chi-Square** | **P-value** |
| **Type of Delivery** | 11.58 | <0.001 | 226.75 | <0.001 | 1.88 | 0.170 |

**Table S2: Adjusted LR Statistics for Type 3 Analysis**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **MICS 2012** | | **MICS 2019** | | **BDHS 2014** | |
| **Covariates** | **Chi-Square** | **P-value** | **Chi-Square** | **P-value** | **Chi-Square** | **P-value** |
| **Type of Delivery** | 0.08 | 0.071 | 106 | <0.001 | 8.24 | 0.004 |
| **Mother Age** | 10.87 | 0.004 | 0.51 | 0.775 | 2.06 | 0.357 |
| **Religion** | 2.50 | 0.114 | 0.75 | 0.387 | 0.62 | 0.429 |
| **Place of residence** | 0.00 | 0.989 | 0.01 | 0.905 | 0 | 0.969 |
| **Division** | 60.13 | <0.001 | 91.56 | <0.001 | 9.48 | 0.148 |
| **Mother's education** | 8.95 | 0.062 | 0.05 | 0.973 | 3.76 | 0.288 |
| **Wealth Index** | 3.21 | 0.524 | 4.26 | 0.372 | 5.71 | 0.222 |
| **Body Mass Index** | 8.93 | 0.012 | 6.64 | 0.036 | 6.41 | 0.041 |
| **Breastfeed** | 0.99 | 0.321 | 2.54 | 0.111 | 2.63 | 0.105 |
| **Sex of the children** | 1.65 | 0.199 | 0.06 | 0.808 | 4.26 | 0.039 |
| **Child age** | 0.55 | 0.459 | 3.23 | 0.199 | 9.71 | 0.008 |
| **Size at birth** | 5.54 | 0.045 | 4.39 | 0.356 | 7.63 | 0.106 |
| **Weight at birth** | 4.02 | 0.045 | 0.10 | 0.750 | - | - |

**Table S3: Influence of factors associated with childhood diseases (lower diseases and normal delivery vs. higher diseases due to C-section delivery)**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Sources** |  |  | **Adjusted Estimates** | | | | | | | |
| **MICS 2012** | | | **MICS 2019** | | |  |  | **BDHS 2014** | |
| **ARR\*** | **95% CI** | **p-value** | **ARR\*** | **95% CI** | **p-value** | **ARR\*** | | **95% CI** | **p-value** |
|  |  |  |  |  |  |  |  | |  |  |
| **Type of Delivery** | | | | | | | | | | |
| C-section | 1.02 | 0.97-1.04 | 0.071 | 1.14 | 1.11-1.17 | <0.001 | 1.15 | | 1.05 - 1.27 | 0.004 |
| Normal | 1 | - | - | 1 | - | - | 1 | | - | - |
| **Mother’s age group in years at birth** | | | | | | | | | | |
| 15-19 | 1.04 | 0.97-1.12 | 0.276 | 1.01 | 0.96-1.06 | 0.720 | 1.05 | | 0.95-1.15 | 0.182 |
| 20-34 | 0.93 | 0.88-0.97 | 0.002 | 0.98 | 0.94-1.02 | 0.510 | 0.96 | | 0.87-1.06 | 0.376 |
| 35+ | 1 | - | - | 1 | - | - | 1 | | - | - |
| **Religion** | | | | | | | | | | |
| Islam | 0.95 | 0.90-1.01 | 0.107 | 0.99 | 0.95-1.02 | 0.381 | 1.06 | | 0.92-1.21 | 0.431 |
| Other religion (Hinduism, Buddhism, Christianity) | 1 | - | - | 1 | - | - | 1 | | - | - |
| **Place of residence** | | | | | | | | | | |
| Urban | 1.01 | 0.95-1.05 | 0.989 | 1.01 | 0.97-1.03 | 0.905 | 1.00 | | 0.91-1.10 | 0.969 |
| Rural | 1 | - | - | 1 | - | - | 1 | | - | - |
| **Division** | | | | | | | | | | |
| Barishal | 0.94 | 0.82-1.08 | 0.486 | 0.94 | 0.90-0.99 | <0.001 | 1.00 | | 0.85-1.17 | 0.981 |
| Chattogram | 0.90 | 0.81-0.99 | 0.037 | 0.88 | 0.84-0.92 | 0.017 | 1.07 | | 0.94-1.22 | 0.319 |
| Dhaka | 0.90 | 0.82-0.99 | 0.029 | 0.95 | 0.90-1.01 | 0.420 | 0.94 | | 0.82-1.07 | 0.339 |
| Khulna | 1.10 | 0.99-1.21 | 0.164 | 1.02 | 0.95-1.09 | 0.596 | 1.04 | | 0.89-1.21 | 0.636 |
| Mymenshing | - | - | - | 0.99 | 0.94-1.04 | 0.719 | - | | - | - |
| Rajshahi | 1.03 | 0.94-1.14 | 0.389 | 0.89 | 0.84-0.94 | 0.016 | 0.96 | | 0.83-1.11 | 0.554 |
| Rangpur | 1.07 | 0.97-1.18 | 0.075 | 1.02 | 1.02-1.07 | <0.001 | 0.90 | | 0.77-1.01 | 0.160 |
| Sylhet | 1 | - | - | 1 | - | - | 1 | | - | - |
| **Educational level (mother)** | | | | | | | | | | |
| None | 0.89 | 0.82-0.96 | 0.042 | 0.99 | 0.94-1.05 | 0.911 | 0.89 | | 0.75-1.05 | 0.166 |
| Primary incomplete | 0.93 | 0.86-1.01 | 0.091 | 0.91 | | 0.81-1.03 | 0.154 |
| Primary | 0.97 | 0.91-1.04 | 0.395 | 0.99 | 0.97-1.03 | 0.827 | 0.98 | | 0.87-1.11 | 0.780 |
| Secondary incomplete | 0.98 | 0.92-1.03 | 0.336 | - | - | - | - | | - | - |
| Secondary complete/higher | 1 | - | - | 1 | - | - | 1 | | - | - |
| **Wealth Index** | | | | | | | | | | |
| Richest | 1.04 | 0.99-1.10 | 0.259 | 1.03 | 0.98-1.07 | 0.574 | 1.17 | | 1.03-1.34 | 0.191 |
| Richer | 1.03 | 0.98-1.09 | 0.150 | 1.02 | 0.97-1.05 | 0.555 | 1.10 | | 0.95-1.28 | 0.119 |
| Middle | 1.02 | 0.96-1.09 | 0.494 | 1.01 | 0.96-1.02 | 0.249 | 1.11 | | 0.96-1.28 | 0.148 |
| Poorer | 1.00 | 0.95-1.07 | 0.876 | 1.00 | 0.95-1.03 | 0.678 | 1.11 | | 0.98-1.25 | 0.110 |
| Poorest | 1 | - | - | 1 | - | - | 1 | | - | - |
| **Body Mass Index (mother)** | | | | | | | | | | |
| Underweight | 1.11 | 1.04-1.19 | 0.002 | 1.05 | 1.01-1.09 | 0.027 | 1.13 | | 1.01-1.26 | 0.025 |
| Overweight | 1.12 | 1.03-1.21 | 0.005 | 1.01 | 0.97-1.02 | 0.621 | 1.17 | | 1.03-1.32 | 0.015 |
| Normal | 1 | - | - | 1 | - | - | 1 | | - | - |
| **Breastfeeding status** | | | | | | | | | | |
| Yes | 0.91 | 0.76-1.10 | 0.634 | 0.81 | 0.64-1.03 | 0.081 | 0.91 | | 0.81-1.02 | 0.066 |
| No | 1 | - | - | 1 | - | - | 1 | | - | - |
| **Sex** |  |  |  |  |  |  |  | |  |  |
| Male | 1.03 | 0.99-1.06 | 0.822 | 1.01 | 0.98-1.02 | 0.808 | 1.08 | | 1.00-1.16 | 0.039 |
| Female | 1 | - | - | 1 | - | - | 1 | | - | - |
| **Child’s age group in months** | | | | | | | | | | |
| 0-11 | 1.02 | 0.98-1.06 | 0.459 | 1.03 | 0.98-1.08 | 0.199 | 1.15 | | 1.04-1.27 | 0.006 |
| 12-23 | 1 | - | - | 1.02 | 0.97-1.07 | 0.521 | 1.14 | | 1.04-1.26 | 0.005 |
| 24-35 | - | - | - | 1 | - | - | 1 | | - | - |
| **Size at birth** | | | | | | | | | | |
| Very large | 0.81 | 0.60-1.09 | 0.166 | 0.95 | 0.88-1.03 | 0.411 | 0.93 | | 0.80-1.07 | 0.314 |
| Larger than average | 0.82 | 0.61-1.10 | 0.223 | 0.95 | 0.88-1.03 | 0.993 | 0.95 | | 0.79-1.14 | 0.585 |
| Average | 0.83 | 0.62-1.12 | 0.223 | 0.93 | 0.86-1.00 | 0.951 | 0.96 | | 0.73-1.27 | 0.795 |
| Smaller than average | 0.89 | 0.65-1.21 | 0.461 | 0.95 | 0.86-1.07 | 0.589 | 1.07 | | 0.90-1.27 | 0.418 |
| Very small | 1 | - | - | 1 | - | - | 1 | | - | - |
| **Weight at birth** | | | | | | | | | | |
| Low | 0.96 | 0.92-1.00 | 0.042 | 0.99 | 0.97-1.02 | 0.750 | - | | - | - |
| Normal | 1 | - | - | 1 | - | - | - | | - | - |

*RR: Risk Ratio; CI: Confidence Interval; ARR: Adjusted risk ratio*

*\*Model adjusted with Propensity scores \*\*Model adjusted with confounding and/or covariates*