Geographic Inequalities and Determinants of Aneamia among Preeclamptic Women in Bangladesh

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Abstract

Background

Anaemia is among preeclamptic women's main health problems in Bangladesh. Aneamia affects pregnant women and women of reproductive age who have hemoglobin levels below 11.0 g/dl. In Bangladesh, the prevalence of aneamia among pregnant women is 42.2%, compared to a global incidence of 38.2%, which raises a major public health concern.

Methods

Information from 180 respondents was gathered from the Department of Gynecology and Obstetrics, Preeclampsia (PE) ward at Dhaka Medical College Hospital (DMCH), Dhaka, Bangladesh, between September 2021 and August 2022 [Ethical approval Ref: Memo No. ERC-DMC/ECC/2022/31]. Factors associated with aneamia were explored using the chi-square test, and then we performed multinomial logistic regression (MLR) to determine the level of association with the risk factors. We further conducted cluster analysis, Global *Moran's I*, and Anselin local *Moran's I* to check the geographical distribution of anaemia cases from our sample.

Results

Early and late PE onset were recorded and classified into two categories; 28.9% of respondents reported an early onset of PE, while 71.1% reported a late onset of PE. A total of 38.9% of subjects had normal hemoglobin counts, whereas 38.3% had mild aneamia. A total of 17.8% had moderate aneamia, and 5.0% had severe aneamia. By performing MLR, anaemia had a statistically significant association with several underlying factors, e.g., recreational substance use (RR = 83.093, 95% CI- 3.351 to 2060.315), gestational age (RR = 10.235, 95% CI- 1.478 to 70.879), gestational diabetes mellitus (RR = 4.906, 95% CI- 1.920 to 12.532), pregnancy interval (RR = 4.374, 95% CI- 1.338 to 4.303), education (RR = 3.448, 95% CI- 1.542 to 7.709), profession (RR = 0.263, 95% CI- 0.109 to 0.635), parity (RR = 0.117, 95% CI- 0.026 to 0.529), and respondent age (RR = 0.160, 95% CI- 0.032 to 0.802). Higher incidence rates for all kinds of aneamia were observed in the Dhaka, Narayanganj, and Munshiganj districts. The global *Moran's I* value ranged from 0.14 to 0.44, and high-high cluster regions were detected in the central region.

Conclusions

The risk factors indicated in this study and geographical inequalities will help policymakers take necessary steps. The geographical distribution of the incidence rate raises concern for further research, including sociodemographic and environmental factors. This will assist in determining the determinants of aneamia and suggest possible measures.

Background

Aneamia is an important public health burden worldwide, especially for women of reproductive age and pregnant women. Aneamia prevalence in pregnant women is 42.2% in Bangladesh, compared to a global prevalence of 40% (1, 2). The World Health Organization (WHO) defined aneamia as a hemoglobin level 11.0 g/dl for pregnant women and 12.0 g/dl for women who are not pregnant (3). Aneamia inhibits oxygen transportation into the blood, resulting in negative effects and outcomes (low birth weight, preterm delivery, stillbirth, and fetal aneamia) for the mother and fetus (4–6). Anaemia is a serious public health issue, with detrimental effects on a woman's health (7), with particular impacts on mothers and children under the age of five (8). These impacts include significant maternal morbidity and mortality (9), anxiety (10, 11), high blood pressure levels (12, 13), and detrimental consequences on the baby, such as birth defects and premature delivery, which can all be caused by aneamia. Aneamia caused adverse effects in 38% of pregnant women and 29% of nonpregnant women worldwide in 2011 (8) and affects pregnant women at high rates in low- and middle-income (LMIC) nations.

Aneamia, eclampsia, and preeclampsia are prevalent conditions in underdeveloped nations. According to the WHO, a 5–19% prevalence indicates mild public health concern, whereas Sub-Saharan Africa, India, Bangladesh, and Iran report that more than 40% of pregnant women suffer from this (14). Women in impoverished countries frequently suffer preeclampsia and eclampsia, although the number of cases is beyond the range of 15–20% in high-income nations similar to the USA (15). Given preexisting obstacles such as gender disparities, a paucity of healthcare and family planning, and deprivations, other women in low-income countries are at the greatest risk of aneamia. Due to inadequate acclimation to seasonal shifts, vulnerability will consequently amplify the influence of seasonal fluctuations on maternal outcomes (16). Preeclampsia is primarily influenced by the weight, age, personal and family ancestry of high blood pressure, and diabetes in the mother (17, 18). Increased occurrence in Latin American countries has been linked to variables including social economic position, national development, and advancements in diagnosis (19, 20). Crucial risk factors for elevated morbidity and death in preeclamptic mothers include late care-seeking behavior, delayed diagnosis, and delayed management (21). According to a recent study, the risk of eclampsia is 50% higher for nulliparous women who live more than one hour away from obstetric facilities (21). Previous studies have also suggested that preeclampsia is influenced by high altitude during pregnancy (22–24). Therefore, the principal goal of this study is to determine the risk factors associated with preeclampsia and demonstrate the regional variation in Bangladesh.

Methods

Study setting and design

The Department of Gynecology and Obstetrics at the Dhaka Medical College Hospital (DMCH) in Dhaka, Bangladesh, launched a hospital-based cross-sectional study from September 2021 to August 2022. A total of 180 of the 210 preeclamptic pregnant mothers who were recruited for the study and regularly assessed at these clinics gave their permission. The patient's anthropometric measurements (height,

weight), sociodemographic, personal, and family histories of diabetes and hypertension, and lifestyle preferences (working or sedentary) were all recorded on a questionnaire form. Information about preexisting hypertension and the need for antihypertensive medications was acquired based on individual reports or medical records. Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured at DMCH using mercury sphygmomanometer equipment after the patient had rested for at least 10 minutes. The participant's blood pressure was checked from the right side, and they were weighed using a weighing scale (Beurer BF 700, Germany), both without shoes and without bulky clothing. The nearest 0.1 kilogram (kg) was used to measure weight.

Inclusion criteria

Pregnant women with preeclampsia in the second trimester were recruited for this study. Defined as women with previously normal blood pressure (BP), after the 20th week of gestation with two different measures of BP that were at least four hours apart, diastolic ≥ 90 mmHg and systolic ≥ 140 mmHg with a dipstick value of 1 + proteinuria of 300 mg or more per 24-hour urine sample (25).

Exclusion criteria

Participants who already had renal disease, had a family history of diabetes mellitus, thyroid problems, or liver disease, or had a history of PE were excluded from the study. We took into consideration the subjects' self-reported information and/or medical history of their prior conditions when we removed the participants.

Data collection tools and procedure

Face-to-face interviews were performed to assemble data using a previously tested (Ad-din Women Medica College Hospital Dhaka, Bangladesh) semi structured questionnaire. The questionnaire was written in English and translated to Bengali. Two BSc nurses were engaged to accumulate data and trained before data collection. The principal investigator coordinated data collection and checked the inclusiveness of the collected questionnaire. The medical record was reviewed for clinical investigation and another laboratory report.

Statistical analysis

After compiling the data from our study sample, all information was imported into Excel 2016 by Microsoft, USA. The baseline data variables were presented using descriptive statistics. *P values* for comparing quantitative variables were determined using the chi-square test. Using multinomial logistic regression (MLR), the association level with the risk factors was investigated. The independent variables that were important in the univariate analysis as well as some relevant variables were counted in the MLR models with a p value < 0.05 as significant. We determined the normal aneamia. We collected the female population district wise to determine the incidence rate for normal (> 10.91 g/dl), mild (10.0-10.9 g/dl), moderate (7.0-9.9 g/dl), and severe (< 7.0 g/dl) aneamia.

$$Incidencerate\,(IR) = \frac{\text{Case(district} - \text{wise)}}{\text{Femalepopulation}} \times 100{,}000$$

The spatial variation was determined using cluster analysis using the global *Moran's I* and Anselin Local *Moran's I* test. Spatial heterogeneity was conducted by the district wise IR, and then we performed Pearson correlation to check regional relationships for mild, moderate, and severe types of aneamia. All analyses were performed using the IBM SPSS 25.0 statistical software program and ArcGIS pro (version 3.1.2).

Results

Sociodemographic characteristics

A total of 180 respondents participated in this survey. Approximately 36.7% (66) were aged 15 to 24 years, more than half (55.0%) were between the ages of 25 and 34 years (99), and only 8.3% (15) were more than 35 years old. The mean age was 26.85 ± 5.3. The education level of the mother was 62.2% below secondary school certificate (SSC), and 37.8% was higher secondary school certificate (HSC) or above school certificate. The majority of the participants were housewives, with only 29.4% as the service holder. According to family income, 70% of respondents belonged to the lower mid-income category, 9.4% belonged to the low-income category, and only 1.1% belonged to the high-income category. Based on physical activity, more than 50% of study participants reported a sedentary lifestyle. A total of 27.8% of respondents had more than five family members, compared to 72.2% of respondents who had 1–4 family members. Regarding the use of recreational substances, 63.3% of the respondents reported not using any recreational substances, while 14.4% reported using betel nuts. Of the respondents, 15.6% reported using nuts, and 4.4% reported using tobacco leaves. Only 2.2% of the respondents reported using cigarettes. The dependent and independent variables' sociodemographic characteristics are shown in Table 1 along with their frequency and proportion.

Table 1
Sociodemographic features of the respondents, n = 180

Characteristics	Frequency	Percentage (%)
Age		
15–24	66	36.7
25–34	99	55.0
> 35	15	8.3
Mean ± SD	26.85 ± 5.3	
Living area		
Urban	67	37.2
Rural	113	62.8
Mother education		
<SSC	112	62.2
HSC or above	68	37.8
Mother profession		
Service	53	29.4
Housewife	127	70.6
Family income		
low income (< 5360)	17	9.4
lower mid-income (5361–21270)	126	70.0
upper mid-income (21271–65761)	35	19.4
High income (> 65762)	02	1.1
Physical activity of the patient		
Exercise	85	47.2
No exercise	95	52.8
Family member		
1–4	130	72.2
> 5	50	27.8
Use of the recreational substance		
No	114	63.3

Characteristics	Frequency	Percentage (%)
Age		
Betel nut	26	14.4
Nut	28	15.6
Tobacco leaf	08	4.4
Cigarette	04	2.2

Diastolic blood pressure (DBP) was 75.89 ± 5.7 mmHg, and the average systolic blood pressure (SBP) was 150.5 ± 12.4 mmHg. In the parity of cases, 60.6% were 1–4 parity, 28.3% were prime gravida, and 10.5% were parity of > 5. The most common contraceptive method used was the natural barrier, with 33.3% of the respondents using this method. A total of 37.2% of the respondents used condoms, while 15% used oral contraceptive pills and 5% used contraceptive implants. Eighty-two percent of respondents (82.2%) had a pregnancy break of less than 24 months, while 17.8 percent had a break of more than 24.1 months. The obstetrical and anemic characteristics of 180 respondents are illustrated in Table 2.

Table 2
Obstetrical and anemic personality traits of the respondents, n = 180

Characteristics	Frequency	Percentage (%)
Blood pressure		
SBP (mmHg)	150.47 ± 12.4	
DBP (mmHg)	75.89 ± 5.7	
Parity of case		
primi gravida	51	28.3
1–4	109	60.6
> 5	20	11.1
Contraceptive method		
Condom	67	37.2
Natural barrier	60	33.3
OCP	04	2.2
Injection	08	4.4
Pill	27	15.0
Implant	09	5.0
Copper-T	05	2.8
Interval in pregnancy		
< 24 month	148	82.2
> 24.1 months	32	17.8
BMI in pregnancy		
Normal BMI	109	60.4
Overweight	44	25.4
Obese	04	2.2
Underweight	23	12.8
Gestational diabetics mellitus		
Yes	52	28.9
No	128	71.1

Note: SBP-systolic blood pressure, DBP-diastolic blood pressure, OCP- oral contraceptive pill.

Characteristics	Frequency	Percentage (%)
Blood pressure		
Gestational age		
< 34 weeks	42	23.3
34–37 weeks	76	42.2
> 37 weeks	62	34.4
Onset of PE		
Early onset of PE	52	28.9
Late onset of PE	128	71.1
Aneamia level in PE patient		
Normal	70	38.9
Mild aneamia	69	38.3
Moderate aneamia	32	17.8
Severe aneamia	09	5.0
Note: SBP-systolic blood pressure, DBP-diastolic blood pressure, OCP- oral contraceptive pill.		

Based on recorded weight and height, 60.4% of the respondents had a normal body mass index (BMI) in pregnancy, while 25.4% were classified as overweight. A total of 12.8% were underweight, and 2.2% were obese. Gestational diabetes mellitus status was recorded, with 71.1% of the respondents reporting no gestational diabetes, while 28.9% reported having gestational diabetes. Regarding the gestational age of the respondents, 42.2% of the respondents were at a gestational age of 34–37 weeks, while 23.3% were less than 34 weeks and 34.4% were more than 37 weeks.

By performing MLR, we exposed the association of aneamia with several determinants. Before that, we conducted a chi-square test to obtain the significant indicators. The results showed a positive association of aneamia less than 10.90 with secondary (SSC) level education (RR = 3.448, 95% CI- 1.542 to 7.709), mother professionals who are involved in the service sector (RR = 0.263, 95% CI- 0.109 to 0.635), recorded parity of case from 1–4 (RR = 0.117, 95% CI- 0.026 to 0.529), pregnancy interval of fewer than 24 months (RR = 4.374, 95% CI- 1.338 to 4.303), recreational substance (tobacco leaf) user (RR = 83.093, 95% CI- 3.351 to 2060.315), those who had gestational diabetes mellitus (RR = 4.906, 95% CI- 1.920 to 12.532), and gestational age under 34 weeks (RR = 10.235, 95% CI- 1.478 to 70.879). Table 3 illustrates the MLR findings.

Table 3
Association between predictor determinants and aneamia (Hb-<10.9 g/dl)

Characteristics	Risk Ratio	95% CI	*P value*
Recorded age			
15–24	0.433	0.080–2.341	
25–34	0.160	0.032–0.802	< 0.05
> 35	1	1	
Mother education			
<SSC	3.448	1.542–7.709	< 0.01
HSC or above	1	1	
Family Income			
Low income	2.265	0.110–46.490	> 0.05
Lower mid Income	0.471	0.030–7.468	
Upper mid-income	0.347	0.021–5.642	
High income	1	1	
Mother profession			
Service	0.263	0.109–0.635	< 0.01
Housewife	1	1	
Parity of case			
Primi gravida	0.253	0.046-1.400	
1–4	0.117	0.026–0.529	< 0.05
> 5	1	1	
Family member			
1–4	0.614	0.238–1.583	> 0.05
> 5	1	1	
Contraceptive method			
Condom	0.184	0.014–2.446	> 0.05
Natural barrier	0.136	0.011–1.693	
OCP	0.221	0.007–7.326	

Characteristics	Risk Ratio	95% CI	*P value*
Recorded age			
Injection	2.556	0.106–61.726	
Pill	0.171	0.011–2.666	
Implant	1.118	0.046–27.561	
Copper-T	1	1	
Interval in pregnancy			
< 24 months	4.374	1.338–4.303	< 0.05
> 24.1 months	1	1	
BMI in pregnancy			
Normal BMI	1.040	0.332–3.256	> 0.05
Overweight	0.571	0.140–2.323	
Obese	0.346	0.055–2.172	
Underweight	1	1	

Table 3
(Continued)

Characteristics	Risk Ratio	95% CI	*P value*
Recreational substance			
No	6.266	0.547–71.794	> 0.05
Betel nut	8.888	0.673-117.382	
Nut	4.507	0.353–57.501	
Tobacco leaf	83.093	3.351-2060.315	< 0.01
Cigarette	1	1	
Gestational diabetics mellitus			
Yes	4.906	1.920-12.532	< 0.01
No	1	1	
Gestational age			
< 34 wks.	10.235	1.478–70.879	< 0.05
34–37 wks.	1.414	0.620–3.225	> 0.05
> 37 wks.	1	1	
Onset PE			
Early < 34 wks.	0.414	0.084–2.030	> 0.05
Late > 34 wks.	1	1	

The onset of PE was recorded and divided into two categories: early onset of PE and late onset of PE. A total of 28.9% of respondents reported an early onset of PE, while 71.1% reported a late onset of PE. Overall, 38.9% of participants had normal levels of hemoglobin, whereas 38.3% had mild aneamia. A total of 5.0% had severe aneamia, and 17.8% had moderate aneamia, as demonstrated in Fig. 1.

Geographical heterogeneity of the IR and cluster analysis

After calculating the incidence rate, we found higher incidence rates in the Dhaka (IR: 0.09–0.54), Narayanganj (IR: 0.05–0.48), Munshiganj (IR: 0.12–0.36) and Narsinghdi (IR: 0.00-0.15) districts for normal aneamia, as depicted in Fig. 2 (A). We further detected the geographical distribution of mild aneamia, moderate aneamia and severe aneamia, as illustrated in Fig. 2, Map (B), Map (C), and Map (D), respectively. The correlation among the districts for the incidence rate of normal, mild, moderate, and severe aneamia was stronger ($r > 0.68$, *p value* < 0.01), which indicates that there was homogeneity among the locations. The global *Moran's I* was used to measure the clusters for mild, moderate, and severe aneamia. We illustrated the *Moran's I* result in Fig. 3, and we found that the *Moran's I* value ranged from 0.14–0.44. Therefore, using Anselin Local *Moran's I*, we found several clusters of mild, moderate,

and severe types of aneamia among our respondents. Most of the cluster districts are in the central region. Although our sample size was limited, we identified significant clusters for the moderate and mild types of aneamia.

Discussion

Aneamia is one of the major public health issues affecting preeclamptic women in Bangladesh. It can be influenced by the absence of healthcare facilities and dietary supplements (maternal care, adequate nutrition education). Our findings are higher than the global average of approximately 40% of pregnant women with aneamia. However, this number may be attributed to one institutional base study or this population. Generally, aneamia is affected by many circumstances, such as a lack of medical services and dietary supplements. The WHO states that if aneamia prevalence is ≥ 40% in any population, a serious population health issue exists (26, 27). In this study, approximately 20.5% of PE mothers experienced preterm birth whose hemoglobin levels (Hb) were less than 10.9 g/dl. Another study with similar results found that PE was related to low (Hb) levels throughout the early part of pregnancy (28). In addition, preeclampsia and low maternal Hb levels were discussed as indicators of poor socioeconomic and nutritional conditions in developing countries (29). The opposite view is that a high hemoglobin concentration is related to PE; in primiparas, 7% of hypertension is documented with Hb < 10.5 g/dl and 42% with Hb > 14.5 g/dl (30). A geographic study conducted in Nepal showed a non-random spatial distribution, with statistically significant hotspots and cold spots indicating the spatial and temporal significance of aneamia (31). Our findings revealed additional factors that were associated with aneamia, including the age of the mothers, educational qualifications, career, parity number, use of recreational drugs, gestational age, and gestational diabetes mellitus.

To our knowledge, this is the first study to investigate the factors that contribute to aneamia in preeclamptic pregnancy in Bangladesh. We highlight the case distribution of aneamia where effective public health measures should be taken to reduce the risk. Furthermore, by conducting spatial analysis, the cluster areas were detected. Our research opens several prospective opportunities. The sociodemographic and economic data districtwise have yet to be explored. The districtwise aggregated number of cases, individual patient information, healthcare data, etc., should be used in future research. We found that aneamia leading to preeclampsia is related to several environmental factors, e.g., household environment (32), household size, passive smoking (33), ambient air pollution (34, 35), walkability (36, 37), etc. Therefore, future studies can address those factors in determining the overall risk. The weakness of this study should also be mentioned. First, we used a limited number of samples; therefore, the causal relationship withdrawn from this study questions the reliability. Furthermore, we have assumed that the patients of the total sample represent the total geographical distribution of the country without addressing more data from state wise or division wise. Although we did not gather data from each district or division, our results demonstrate some validity in considering the determinants of aneamia. It is obvious that with more epidemiological data, robust analysis is possible, which is possibly our future direction.

Conclusion

By exploring the related risk factors and adjusting the indicators in the model, we found that various biomarkers contributed to aneamia prevalence in the Bangladesh population. These findings can support the implementation of aneamia-related programs and inform public health policies to address aneamia problems. Our study demonstrated preliminary factors associated with aneamia and geographical inequalities. We further showed evidence about the aneamia clusters in Bangladesh within our sample that can assist in formulating more research questions to be explored in the future.

Abbreviations

g/dl: grams per deciliter; PE: preeclampsia; DMCH: Dhaka Medical College Hospital; MLR: multinomial logistic regression; WHO: World Health Organization; SBP: systolic blood pressure; DBP: diastolic blood pressure; BP: blood pressure; BSc: Bachelor of Science; IRB: Institutional Review Board (BRB); SSC: secondary school certificate; HSC: higher secondary school certificate; BMI: body mass index; Hb: hemoglobin; IRB: Institutional Review Board; LMIC: low and middle income.

Declarations

Ethics approval and consent to participate

The research was authorized by the Institutional Review Board (IRB) of Dhaka Medical College (DMC), Dhaka, Bangladesh [Ref: Memo No. ERC-DMC/ECC/2022/31]. Before being enrolled in the study, all participants were acknowledged of its objectives and allowed to provide written inform consent and sign inform consent collected from legal guardian. The decision to participate was entirely optional. Throughout the study duration, confidentiality was rigorously maintained. The current study's methodologies were all performed under the necessary standards and laws. We had 3 respondents aged below 18, we have attached their consent form from their legal guardian in the Supplementary Material.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare that they have no competing interests.

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We did not receive funding for this study.

Authors' contributions

MAA, JI: Conception and coordination; RP, SP, MAA, RI, SS, AR, STT, SH: Investigation and data collection; JI: Data, GIS analysis & image processing, MAA, JI, RP, ATMMC: Writing the manuscript; All authors read and approved the final manuscript.

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Figures

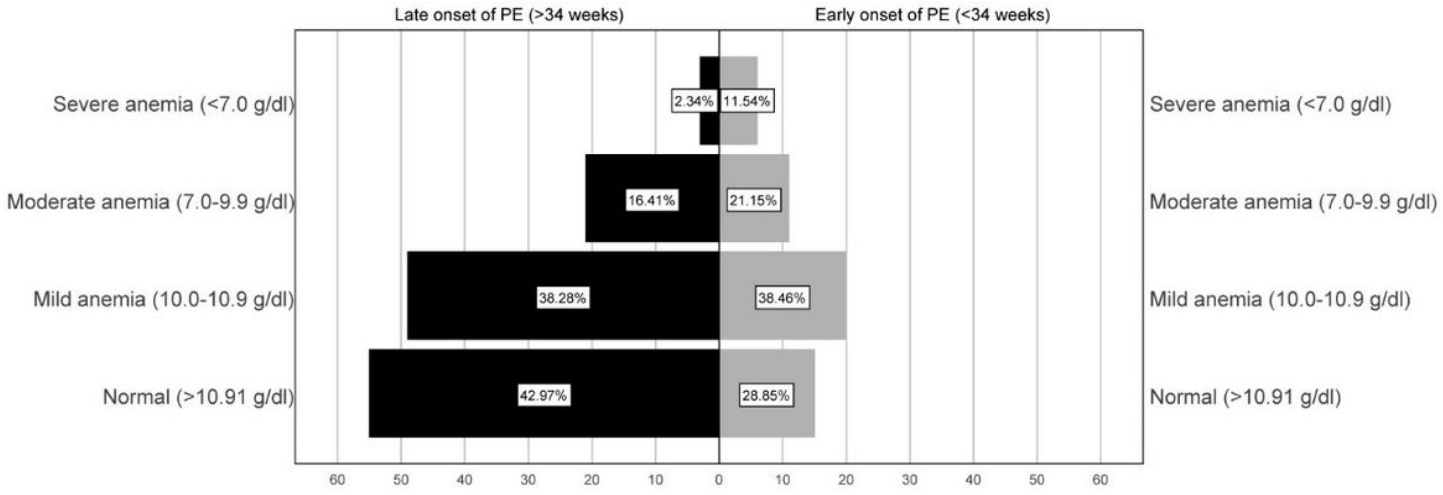

Figure 1

Prevalence of aneamia and outcome of PE among the respondents

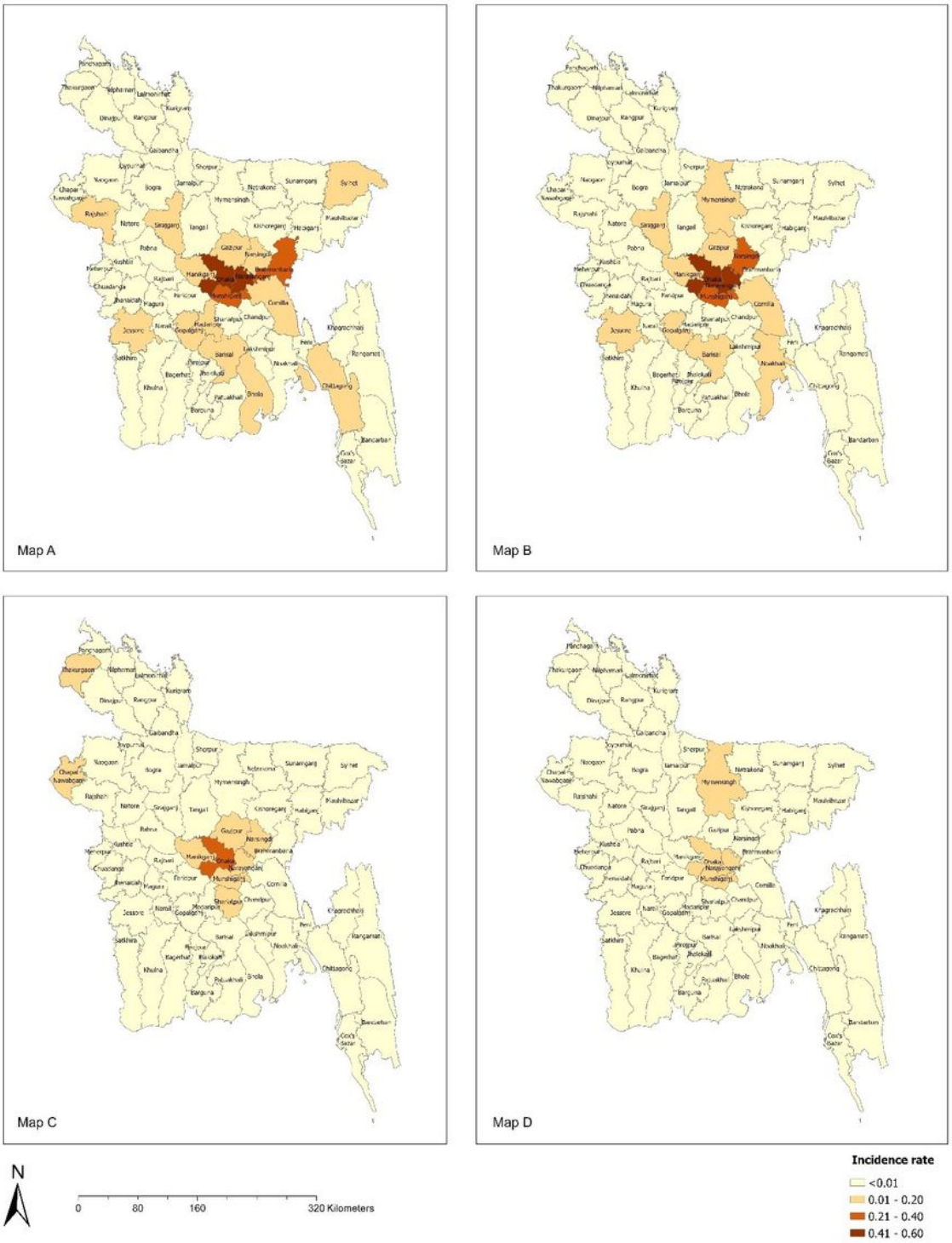

Figure 2

Geographical distribution of the anaemiaincidence rate (IR) in Bangladesh using the sample data. Map (A) IR for normal aneamia (> 10.91 g/dl), Map (B) IR for mild aneamia (10.0 – 10.9 g/dl), (C) IR for moderate aneamia (7.0 – 9.9 g/dl), (D) IR for severe aneamia (< 7.0 g/dl).

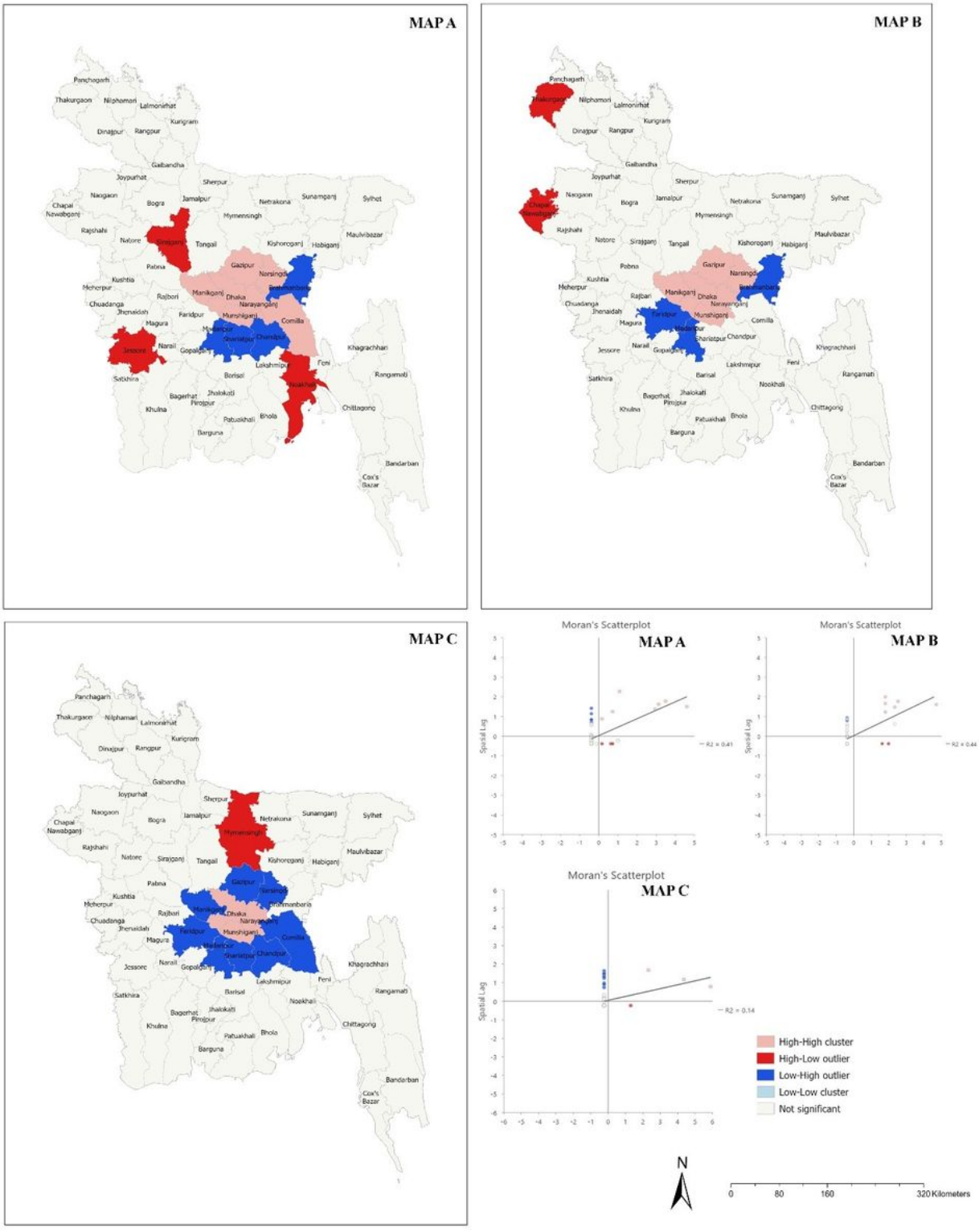

Figure 3

Geographical cluster of aneamia incidence rate (IR). Map (A) cluster map for normal aneamia (> 10.91 g/dl), Map (B) cluster map for mild aneamia (10.0 – 10.9 g/dl), (C) cluster map for moderate aneamia (7.0 – 9.9 g/dl), (D) cluster map for severe aneamia (< 7.0 g/dl).