**Geographic Inequalities and Determinants of Anaemia among Preeclamptic Women: A Cross-Sectional Sample-Based Study in Bangladesh**

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**ABSTRACT**

**Background:** Anaemia among the preeclamptic women is a significant health issue in Bangladesh. It affects pregnant women and women of reproductive age who have haemoglobin levels below 11.0 g/dl. We explored the socio-demographic risk factor of anaemia, and mapped the regional risk of anaemia to understand the geographical inequalities.

**Methods:** Information from 180 respondents was gathered from the Department of Gynaecology 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 logistic regression (LR) to determine the level of association with the risk factors.

**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 LR, several risk factors were identified including age ranged 25-34 (OR: 0.169, *p* <0.05), lower education level (OR: 3.106, *p* <0.05), service holder mothers (OR: 0.604, *p* <0.05), doing exercise (OR: 0.414, *p* <0.05), interval in pregnancy by less than 24 months (OR: 4.646, *p* <0.05), and gestational diabetes mellitus (OR: 2.702, *p* <0.05). Higher incidence rates the total case were observed in the Dhaka district (IR: 1.46), Narayanganj district (IR: 1.11), and Munshiganj district (IR: 0.96).**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 socio-demographic and environmental factors. This will assist in determining the determinants of anaemia and suggest possible measures.

**Keywords:** Preeclampsia, anaemia, Bangladesh.

**Introduction**

Preeclampsia (PE) is a mysterious new onset of hypertension (systolic blood pressure >140 mmHg and diastolic blood pressure > 90 mmHg) with proteinuria after 20 weeks of gestation in previously normotensive women [1, 2]. According to the estimations, this disease affects 8%–10% of the world's population and 20% of those living in underdeveloped nations [3]. To date, PE is responsible for 70000 maternal and 500000 fatal deaths worldwide and is not limited to any geographic zone [4-6]. It is one of the obstetric impediments; the mortality rate is 14 times greater in impoverished nations than in developed ones [7]. According to the World Health Organization (WHO), preeclampsia is directly liable for 10% of maternal deaths in Asia [3, 8]. PE prevalence in Bangladesh is 10% which is comparatively higher than other Asian countries like China 2.07%, Japan 1.19%, Thailand 2.22% and Nepal 0.59% [9, 10]. The aetiology of PE has not been fully elucidated [11] but anaemia is called one of the known hazards for preeclampsia [12].

Anaemia is a clinical condition and there is no certain age. It is widespread more in reproductive stage (15-49), young children and pregnant women [13-15]. WHO defined anaemia as a haemoglobin level ˂ 11.0 g/dl for pregnant women and ˂ 12.0 g/dl for women who are not pregnant [16, 17]. Globally 1.62 billion people are anaemic, among them the most vulnerable group is pregnant women where totally 56 million suffer by this complication [13, 18]. Bangladesh is a densely populated country where anaemia prevalence among pregnant women is 42.2% which is quite high compared to the global prevalence of 40% [19, 20]. As anaemia is influenced by multiple reasons, the contributing factors may change based on geographical situation [21]. Previous study mentioned the variation of anaemia exist more in the rural areas (44.3%) than the urban (40.2%) [22]. On the other hand, about one-third women at reproductive age suffers from this and almost 40% of these women reside in developing regions including sub-saharan Africa [17, 23]. Based on the evidence, the reason behind anaemia are multifactorial including seasonal influence, food habits, geographical clusters etc. [21, 24-26] . Aneamia inhibits oxygen transportation into the blood, resulting in negative effects and results in low birth weight, preterm delivery, stillbirth, loss of productivity, fatigue, breathlessness, dizziness, headaches and even turns into fatal aneamia [27-31]. It is a serious public health issue, with detrimental effects on a woman's health [32]. In 2000 and 2014, due to anaemia significant amount of premature births, fatal impairment, low birth weight as well as infant death were observed and more than half maternal deaths [33-36]. Day by day the prevalence of anaemia has globally increased from an estimated 25% in 2008 to between 29-38%, posing huge concern for the 3rd world countries [31, 37]. However, there is no available information on the load and features linked with anaemia during preeclampsia. Many studies have been conducted to explore the risk factors of anaemia in pregnant women. According to our knowledge and based on the database search, the determinants of anaemia among preeclamptic women are less explored,. Therefore, we conducted a case control study on 180 respondents to explore the determinants of PE in Bangladesh. We further measured the association of the factors related to this and conducted mapping to find out the risk regions by the incidence rate. Our study will help the public health authorities, and government officials to take necessary actions to implement suitable strategies in to reduce the burden of this disease.

**Methods**

**Study settings**

The Department of Gynecology and Obstetrics at the Dhaka Medical College Hospital (DMCH) in Dhaka, Bangladesh, conducted a hospital-based cross-sectional study from September 2021 to August 2022. A total of 180 of the 210 preeclamptic pregnant mothers were recruited for the study and were regularly assessed after taking their consent. The patient's anthropometric measurements including height, weight, socio-demographic information, personal and family histories of diabetes, hypertension, and lifestyle preferences (working or sedentary) were 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. We defined this 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 [38].

**Sampling**

Exclusion and inclusion criteria were strictly followed during data collection. We noted the maternal hemoglobin level in 3rd trimester of pregnancy by the expert medical technologist lab.

**Sample-size**

By using this formula: n = z2q/r2p we estimated the sample size. The following assumption was considered, significant level 0.05 (1.96), margin of error 5%, proportion of anaemia was counted 30% in pregnant women. One study depicted the prevalence of anaemia is 19%-50% [39]. We contemplate 30% and sample size was 175, adding 10% non-response so total 192 was finalized.

**Data collection tools and method**

Face-to-face interviews were performed to assemble data using a previously tested (Ad-din Women Medical College Hospital Dhaka, Bangladesh) semi structured questionnaire. The questionnaire was written in English and was 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.

**Dependent and independent variables**

We defined anaemia in pregnant women by WHO’s definition where Hb <11.0 g/dl count as normal, 10.0-10.9 g/dl mild, 7-7.9 g/dl moderate and <7.0 g/dl severe anaemia. Haemoglobin level <11 g/dl distinct anaemic [17]. Body mass index (BMI) was recommended as <18.5 kg/m2 underweight, 18.5-23.9 kg/m2 normal, 24-27.9 kg/m2 overweight, 28 kg/m2 obesity [40]. Gestational age was assessed by a gap between last menstrual period (LMP) to 1st day of being expected mother. We classified the monthly (mon) household (HH) income (in Bangladeshi taka: BDT) of recruited study people’s family conferring to Bank (WB) Data Help Desk 2016**]** as follow: Low-income group: HH income of ≤ 6,946/ mon, Lower-mid income group: HH income: 6,947–27,336/mon, Upper-mid-income group: HH income: 27,337–84,564/mon, High-income group: HH income of ≥ 84,564 BD/ mon [41].

**Analysis**

All the information was accumulated in a Microsoft Excel spreadsheet, and then we conducted analysis by using SPSS (Version 25.0). Descriptive statistics, chi-square test, logistic regression, and area under curve (AUC) was performed. Descriptive analysis was used to analyse the demographic characteristics of all the variables used in our study. As our variables were categorical, and the dependent variable had two categories (0 = Normal, 1 = Anaemia) we decided to conduct logistic regression and before that, independent variables were short-listed by performing a chi-square test. The independent variables were selected based on prior research. All the finally selected variables: Age, education, mother profession, physical activity of the patient, parity of case, family member, interval in pregnancy, gestational diabetics mellitus; were input within the modelling, enter method was selected. P-value <0.05 was used as denoting significance. To validate our model performance, we conducted AUC, and an ROC curve was generated. We further conducted mapping demonstration to indicate clusters, and incidence rate. ArcGIS Pro (Version 3.1.2) was used to formulate the map, and following formula was used for the incidence rate:

Incidence rate (IR) = {Case (district-wise)} / Female population × 100,000

The incidence rate was calculated for 4 categories: using the total number of anaemia cases, mild anaemia (10.0-10.9 g/dl), moderate anaemia (7.0-9.9 g/dl), and severe anaemia (<7.0 g/dl). **Results**

## Socio-demographic characteristics

A total of 180 respondents participated in this survey. 36.7% (n = 66) of the sample were aged 15 to 24 years, 55.0% (n = 99) were between the ages of 25 and 34 years, and only 8.3% (n = 15) were more than 35 years old. The mean age was 26.85 (SD ± 5.3). 62.2% (n = 112) of the mothers education level was below secondary school certificate (SSC), and 37.8% (n = 68) passed higher secondary school certificate (HSC) or above. 70.6% (n = 126) of the of the participants were housewives, and 29.4% (n = 53) was service holder. According to family income, 70% (n = 126) of respondents had lower mid-income, 19.4% (n = 35) had the upper mid-income, 9.4% (n = 17) had low-income, and 1.1% (n = 2) had higher income. About 52.8% (n = 95) of study participants reported as having sedentary lifestyle and 47.2% (n = 85) do exercise. A total of 27.8% (n = 50) of respondents had more than five family members, in contrast 72.2% (n = 130) of respondents had 1-4 family members. Regarding the use of recreational substances, 63.3% (n = 114) of the respondents reported not using any recreational substances, while 15.6% (n = 28) reported using betel nuts (Table 1).

**Table 1** Socio-demographic features of the respondents, n = 180

|  |  |
| --- | --- |
| **Characteristics** | **Frequency (%)** |
| **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) |
| Betel nut | 26 (14.4) |
| Nut | 28 (15.6) |
| Tobacco leaf | 08 (4.4) |
| Cigarette | 04 (2.2) |

Diastolic blood pressure (DBP) among the respondents 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% (n = 109) were 1-4 parity, 28.3% (n = 51) were prime gravida, and 10.5% (n = 11.1) were parity of >5. 37.2% (n = 67) which is the majority used condom as a contraceptive method, while others used natural barrier (33.2%, n = 60), pill (15%, n = 27), implant (5%, n = 9). 82.2% (n = 148) had a pregnancy break of less than 24 months, while 17.8% (n = 32) had a break of more than 24.1 months. The obstetrical and anaemic characteristics of 180 respondents are illustrated in Table 2.

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

|  |  |
| --- | --- |
| **Characteristics** | **Frequency (%)** |
| **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 (18.5-23.9 kg/m2) | 109 (60.4) |
| Overweight ( 24-27.9 kg/m2) | 44 (25.4) |
| Obese ( ≥28 kg/m2) | 04 (2.2) |
| Underweight (< 18.5 kg/m2) | 23 (12.8) |
| **Gestational diabetics mellitus** |  |
| Yes | 52 (28.9) |
| No | 128 (71.1) |
| **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.

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 haemoglobin, whereas 38.3% had mild anaemia. A total of 5.0% had severe anaemia, and 17.8% had moderate anaemia, as demonstrated in Fig 1.

**Risk factors associated with anaemia**

After performing a chi-square test, we found several indicators including age, education, mother profession, physical activity, parity of case, number of family member, interval in pregnancy, and GDM had significance (*p* < 0.05). Then we conducted logistic regression to explore the level of association. We found that, individuals in the "25-34" age category had a statistically significant lower odds (OR: 0.169; CI: 0.032‐0.886) of the anaemia compared to individuals in the ">35" age category. Individuals with "< SSC" education have a statistically significant higher odds (OR: 3.106; CI: 1.448–6.665) compared to individuals with higher education then SSC level. Mothers in the "Service" profession have a statistically significant lower odds (OR: .604; CI: 0.263–1.388) compared to mothers who are "Housewives." Patients who engage in "Exercise" have a statistically significant lower odds (OR: 0.414; CI: 0.188 - 0.913) compared to patients with "No exercise." None of the categories of "Parity of Case" and “Family Member” show a statistically significant impact on the outcome compared to ">5". Individuals with an "Interval in Pregnancy" of "<24 months" have a statistically significant higher odds (OR: 4.646; CI: 1.694–12.741) of anaemia compared to those with an "Interval in Pregnancy" of ">24.1 months”. Individuals with "Gestational Diabetes Mellitus (GDM)" have a statistically significant higher odds (OR: 2.702; CI: 1.172–6.228) compared to those without GDM ("No"). Table 3 describes the association between predictors and anaemia. We validated our model by checking the Akaike information criteria (AIC), we found the AIC value of 0.794 indicating the strong modelling performance.

**Table 3** Association between predictor determinants and anaemia (Logistic Regression adjusted)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variables** | **Category** | **n** | **RR (95% CI)** | ***p.* value** |
| Age | 15-24 | 66 | .297 (.051-1.726) | > 0.05 |
|  | 25-34 | 99 | .169 (.032-.886) | < 0.05 |
|  | >35 | 15 | 1 |  |
| Education | < SSC | 112 | 3.106 (1.448-6.665) | < 0.05 |
|  | > SSC | 68 | 1 |  |
| Mother professor | Service | 53 | .604 (.263-1.388) | < 0.05 |
|  | Housewife | 127 | 1 |  |
| Physical activity of patient | Exercise | 85 | .414 (.188-.913) | < 0.05 |
|  | No exercise | 95 | 1 |  |
| Parity of case | Primi Gravida | 55 | .536 (.100-2.880) | > 0.05 |
|  | 1-4 | 105 | .259 (.057-1.190) | > 0.05 |
|  | > 5 | 20 | 1 |  |
| Family member | 1-4 | 130 | .503 (.199-1.269) | > 0.05 |
|  | > 5 | 50 | 1 |  |
| Interval of pregnancy | < 24 months | 148 | 4.646 (1.694-12.741) | < 0.05) |
|  | > 24.1 months | 32 | 1 |  |
| GDM | Yes | 52 | 2.702 (1.172-6.228) | < 0.05 |
|  | No | 128 | 1 |  |

**Geographical heterogeneity of the IR**

We divided the anaemia cases based on mild, moderate, and severe anaemia and most importantly, we further mapped the IR of all the anaemia cases. For the total cases, we found highest IR in Dhaka (IR: 1.46), Narayanganj (IR: 1.11), and Munshiganj (IR: 0.96) depicted in Fig 2 (A). For the mild anaemia, highest IR was observed in Dhaka (IR: 0.54), and Narayanganj (IR: 0.42), and Munshiganj (IR: 0.36). For the other types we have illustrated those in the figure 2 where found maximum IR was concentrated in Dhaka district..

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**Figure: IR of the A) Total number of anaemia case B) mild anaemia case, C) moderate anaemia case, D) severe anaemia case.**

**Discussion-**

We focused capacity based cross-sectional study to evaluate the determinants of maternal anaemia among preeclamptic women in Bangladesh. Anaemia is one of the major public health issues in pregnancy affecting children and material’s health. In this study we observed high proportion (61.1) of anaemia (Tab. 2) which was high compared to global prevalence (40.1%) [42]. This finding was comparable to other studies conducted in Bangladesh (59%), Bhutan (59%), and Sri Lanka (60%) [43], China (58.6%) [44], Malaysia (57.4%) [45], Kenya was 57%, and Boditti Health center with 60% [46, 47]. On the other hand, it was incompatible to other studies where anaemia prevalence was 16.6, 21.3, and 19% respectively [48-50]. This discrepancy may be due to the differences in methodology like study period, sampling techniques, antenatal care and iron supplementation during pregnancy. It might be an outcome of gap between these studies and health service improvement. In the current study preeclampsia and single institution base study may be the potential factors behind this result. Moreover, socioeconomic status in densely populous country is a big inhibitor to get proper treatment in time. Present study illustrate that around 70% respondents maintain their live by lower mid-income level (5361-21270) [Ref-income]. Low economic and nutritional status may trigger lower maternal hemoglobin level and preeclampsia in developing countries [51].Our finding that the maternal age is associated with anaemia is found by several other studies[46, 52]. The findings in the study illustrated that maternal education (<SSC) was significantly correlated to the maternal anaemia. The report of Erlindawati *et al.* sustained our findings. Here literacy of mother might plays negative impact on attentiveness of antenatal care and health care services of the population [53]. In the present study mentioned maternal profession usually employed mother was connected to anaemia. This findings was inverse with other studies implemented in Gamo Gofa zone, Ethiopia [54], Nepal [55], India [56], and finally in Walayta Soddo, Otona Hospital [57]. This might be careless of personal health due to shortage of time that led to adequate lack of personal hygiene which disclosure them to different types of parasitic infection. In our study anaemia prevalence viewed to be raised with adjacent interval. Study respondents who experienced with close pregnancy interval less than 2 years were 4.64 times in risk of anaemia paralleled to those who were practical to more than 2 years birth interval. This result carried out the consistent trend with other studies conducted in Arba Minch [54], Bangladesh [43], Mogadishu [56], and Walayta Soddo [57]. This consequences might be connected to low iron storage in women body due to rapid pregnancy succession between following pregnancies. However, Trinidad and Tobago performed another study and mentioned there was relation between pregnancy interval and prevalence of anaemia [58]. In the above study, the cause may be small size as well as methodological variation. The relationship between anaemia and GDM has not been fully documented but in our current study we found a strong association with GDM and anaemia with low prevalence of GDM 52 (28.9%). Similar findings have been reported by Lao et al.[59].

Our study mapped that majority of the cases are concentrated in the Dhaka district, and Narayanganj district. Geographical clusters may provide a better illustration of the high risk zone which may assist in taking necessary actions in the future. Therefore, finding the geographical clusters opens a future research scope. Another important issue is to check whether any climate parameter have association with higher anaemia prevalence within the regions. Bangladesh is prone to vector-borne diseases like dengue, malaria and chikungunya. While malaria and being anaemic is found associated, more study within the vector-borne endemic zones is required [60].Due to climate change, several high altitudes regions, coastal areas, deserts will be affected by dengue in the future. While seasonality is highly related with the mosquito borne diseases, numerous studies suggest that the seasonality of anaemia changes with the malaria transmission [61]. Several authors further mentioned about high level of anaemia to nutritional deficiencies prior to and during the rainy season [62, 63]. This was supported by reports that heavy agricultural work in the rainy season aggravates anaemia and significantly reduces women's weight [64, 65]. In south or central Asia, anaemia is significantly prevalent during monsoonal precipitation and under lower temperature [64]. Therefore, future research in Bangladesh can focus on quantifying the association of the climatic factors with anaemia prevalence. By using robust spatiotemporal models, the high-risk regions may be further differentiated to help with the policy implementation.

Our study has several strengths including the number of parameters we used to understand the socio-demographic characteristics of anaemia in Bangladesh. We further explored the association of the predictor variables to illustrate the major contributing factors associated with anaemia and mapped the disease incidence rate among the 64 districts in Bangladesh. Additionally, we used AIC to check the model performance which is an important factor to validate the model performance. However, our study has some caveats. Along with the lower number of the sample size, we missed many other socio-economic and environmental predictors to check the association. Due to this reason, we were unable to explore the regional clusters which may be addressed in the future studies.

**Conclusions**

According to our findings, several determinants are found which influence anaemia and most importantly anaemia driven preeclampsia. These two complex pathological conditions may increase the maternal mortality rate in Bangladesh in the future. Therefore, our findings will be helpful to policymakers for implementing health related maternal awareness program and further estimate the advancement of maternal condition during pregnancy.

**List of abbreviations**

g/dl: grams per deciliter; PE: preeclampsia; DMCH: Dhaka Medical College Hospital; LR: 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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**Authors’ contributions**

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

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