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Assessment on the Exposure of Air, Water and Noise Pollution, and Mental Stress on Preeclamptic Patients of Rajshahi, Bangladesh

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Abstract

Although preeclampsia claims the lives of 70,000 mothers and 500,000 newborns each year worldwide, its origin is still elusive and a number of risk factors such as environmental pollution are not yet addressed properly. In this study, exposures due to the extents of air, water and noise pollution as well as mental stress on preeclamptic patients have been investigated. Using a cross-sectional longitudinal design, 90 women hospitalized with preeclampsia in 7 hospitals of Rajshahi, Bangladesh were considered, of which Rajshahi Medical College Hospital is a tertiary referral hospital. The data were collected by interviewing the patients, physical examinations and merging the patients' data with British Geological Survey's groundwater data-sets (n=3,540). For statistical analyses, SPSS software was employed. It was found that most of the patients' living rooms were within 15 feet from kitchen. Only 10% patients had good room ventilation, while the remaining 90% patients had either moderate or poor room ventilation. Combination of these facts reveals that the preeclamptic patients were subject to moderate CO_2 exposure. Since 79% of the preeclamptic patients' living rooms were below 50 ft from the nearest roads and 84% for 100 ft distance, they would experience noise pollution. Combination of traffic conditions and potential sources of noise pollution revealed that 60% of the preeclamptic patients experienced moderate to intense noise pollution. Groundwater arsenic, calcium, magnesium, iron and sodium concentrations in the patients' drinking water were higher than WHO guideline values that should favour constipation and mild hypertension. While 70% patients were under high mental stress and 24% under very high mental stress, only 6% patients had moderate mental stress. It is concluded that air, water and noise pollution, and mental stress are potential risk factors of preeclampsia.

Keywords: Preeclampsia, Bangladesh, Air pollution, Water pollution, Noise pollution, Mental stress.

INTRODUCTION

The multi-system obstetrical disorder preeclampsia is estimated to occur in 5-7% of all pregnancies and is responsible for the death of 1,600 lives per day worldwide [1]. More than 90% of these losses occur in low and middle-income countries (LMICs), particularly those on Indian subcontinent and sub-Saharan Africa [2]. For every woman who dies, it is estimated that another 20 suffer a life-altering morbidity [3]. But the origin of preeclampsia remains still elusive. Once preeclampsia is present, there is no definite cure other than to deliver the foetus. The other complications include stroke of brain, placental abruption, cardiovascular disease, HELLP syndrome, premature birth, hemorrhage, etc. [4]. Thus, preeclampsia is life-threatening to both mother and foetus.

The risk factors of preeclampsia are diversified in nature that include maternally and paternally derived fatal genes [5], women who experienced preeclampsia earlier [6], extremes of maternal ages (≤20 and ≥40 years) [7], overweight or obese as adults [8], pre-gestational diabetes (type 1 and 2) [9], women with chronic kidney disease and lupus nephropathy [10], nulliparous women [11], women who had recurrent

spontaneous abortions and infertility treatment [12] and women having a partner aged >45 years [13]. It is surprising that smoking, although having adverse health effects, during pregnancy approximately halves the risk of preeclampsia [14].

In southern Sweden, preeclamptic patients were exposed to an elevated level of the air pollutants $PM_{2.5}$, PM_{10}, black carbon and NO_x with average values of 1.56, 2.92, 0.36 and 14.82 μg/m^3 respectively [15]. In China, higher level of air pollutants $PM_{2.5}$, PM_{10}, NO_2, SO_2, CO and O_3 were identified in preeclamptic patients [16]. World Health Organization (WHO) reported that in 2019, 99% of the world's population was living in places where air quality guideline values were not met [17]. Regarding groundwater pollution, British Geological Survey (UK) reported that in Bangladesh the groundwater is polluted with many toxicants, such as arsenic, whose concentration was found 1,670 μg/L against WHO general guideline value of 10 μg/L [18]. Such impact induces hypertension, cancer and other fatal diseases.

Despite of high parental and foetal mortality rate of preeclampsia and high level of environmental pollution in Bangladesh, the environmental impacts on preeclamptic patients in Bangladesh is not well-studied. Therefore, the objective of this study was to evaluate the exposure of air, water and noise pollution as well as mental stress on preeclamptic patients of Rajshahi region, Bangladesh.

MATERIALS AND METHODS

Study Type and Area

The present investigation was mainly a cross-sectional study with some longitudinal studies, in which purposive sampling techniques were followed. The study was performed in 7 hospitals of Rajshahi, a north-western district of Bangladesh, (Figure 1) during 2016-2018. These include Rajshahi Medical College Hospital (RMCH), Motherland Hospital, Islami Bank Hospital, Janaseba Hospital, Islami Bank Medical College Hospital, Godagari General Hospital and Godagari Model Hospital. Of these, the tertiary referral hospital RMCH was the key for the investigation.

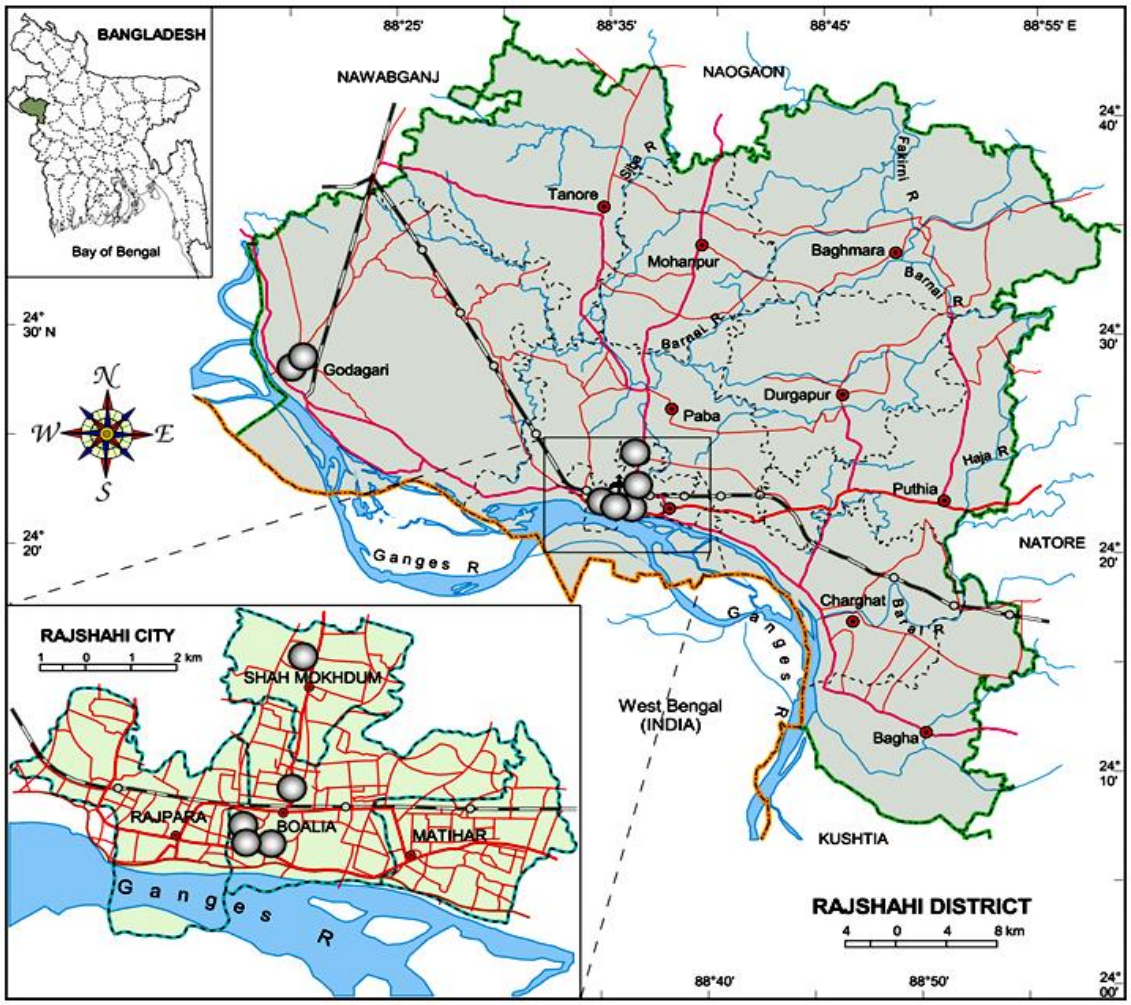

Figure 1: Study area for the investigation [represents study hospital or clinic]

Patient Screening Techniques

In order to screen the pregnant women (especially ≥20 weeks gestation) for preeclampsia, firstly patient's blood pressure (B.P.) was monitored twice (4 hours apart). If B.P. was greater than 140/90 mm of Hg, careful physical observations were made for oedema and other relevant complications (Figure 2). Then the patient's bio-clinical investigation reports were analyzed for elevated levels of proteinuria, serum creatinine and R.B.C. count along with lower level of platelet count. The above criteria which were in accordance with those of American College of Obstetricians and Gynecologists confirmed preeclampsia [19-20].

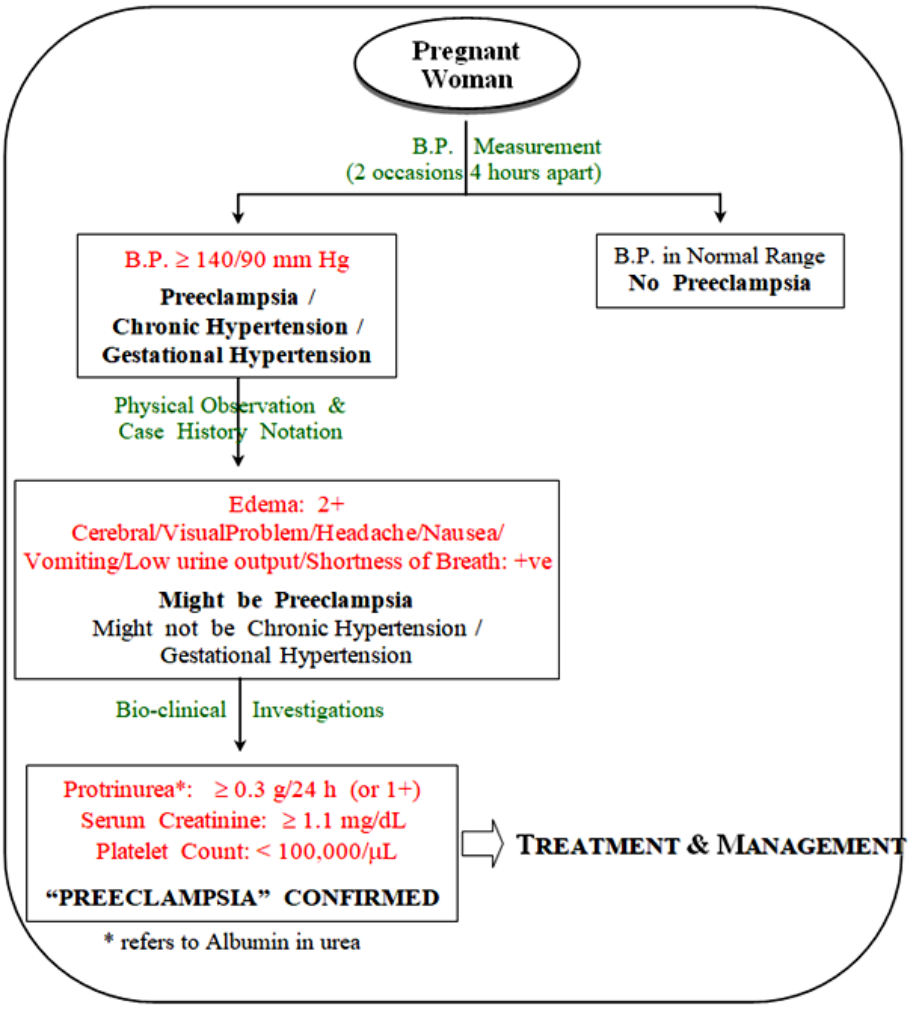

Figure 2: Flow-chart representing the screening of preeclampsia

Respondent Selection and Data Collection Procedure

The sample size (n) was determined based on the model $n = Z^2pq/d^2$, which was 87. A total of 90 preeclamptic patients visiting OPD or admitted into the hospitals and clinics of age 16-40 were the respondents of this study, of which two-thirds were from RMCH. The respondents were not only from Rajshahi districts, but also from other neighbouring districts, as RMCH is a tertiary referral hospital.

The data were gathered by interviewing the patients based on developed multi-level questionnaire, by physical examinations and by analyzing patient's pathological profile. The physical and chemical properties of groundwater of the patients' intake as drinking water were adapted from British Geological Survey's (BGS) datasets (n=3,540) in Bangladesh [18]. For this, we merged the patients' data and geographical locations with BGS's groundwater data-sets. The mental stress index was estimated online based on the criteria set by Canadian Mental Health Association [21] with the help of gathered primary data (from answers of 25 questions).

Ethical Consideration

The Ministry of Health and Family Welfare, the Government of the People's Republic of Bangladesh allowed the study to conduct. Moreover, permissions from the authority of concerned Upazilla Health Complex of Rajshahi district and Rajshahi Medical College Hospital, Rajshahi were taken for the study. The aim and objectives of the study along with its procedure, risks and benefits of the study were explained properly to the respondents in easily understandable language.

When the participants agreed to cooperate on voluntary basis, their written consents were taken.

Quality Control

For recoding patient's B.P., average value of both mercury and aneroid sphygmomanometers' readings were considered. Sometimes, it was cross-checked with the reading taken by a highly skilled surgeon. During the interview, sometimes the right answer was collected by side question or discussion. The bio-clinical investigation reports were only accepted when those were performed by highly-skilled pathologists and the instruments were calibrated with *r* values of 0.998 or better.

Statistical Analyses

The datasets obtained were treated separately for analyzing basic statistical parameters and for making cross-tabulations and cross-plots. The SPSS (release 20.0) and Microsoft Excel (release 12.0) were employed for the purpose. The Box-and-Whisker plots were constructed using SPSS.

RESULTS

Characteristics of the Preeclamtic Patients and Their Outcomes

The average age of the concerned 90 participating preeclamptic patients (of 16-40 years) was 25.90 ± 0.65 years. The youngest mothers (≤20 years; 24.45%) were vulnerable for preeclampsia (Table 1). The obese and overweight patients (68.89%) were at high risk of preeclampsia who were associated with some additional complications such as severe oedema, headache, vomiting, lower abdominal pain and hyperacidity. About three-fourths of the concerned patients were of lower social class, of which the majority were under education level 10 and were not very conscious about preventing preeclampsia. Most of the preeclamptic patients were Muslims (88.89%) of joint families (57.78%), serving as housewives (88.89%), having white skin complexion (61.11%). Most of the preeclamptic patients (53.33%) were primiparous.

About three-fourths of the patients' deliveries were made by C/S, while the rest by NVD (Table 1). Generally, patients' B.P. fell down after delivery. One patient out of 88 had died after giving birth, but her female infant (weighing 2.0 kg) was in good condition. Only one case of twin-pregnancy was recorded. After giving births, 28% of mother had no complications, while the rest had mild to severe complications. Male children dominated (60%) over female children (40%). A total of 9 (10%) neonatal deaths were recorded. About 28% of the newborn infants had no complications, while 16% had mild complications and 56% had severe complications including Asphyxia, IUGR, etc.

Table 1: Personal characteristics of the preeclamptic patients (n=90)

Characteristic	Value
Age at delivery (year)	
≤ 20	22 (24.45%)
21 – 39	67 (74.44%)
≥ 40	01 (01.11%)
Average	25.90 ± 0.65
Pregnancy BMI (kg m^{-2})	
< 18.5 (Underweight)	02 (02.22%)
18.5–24.9 (Normal)	26 (28.89%)
25–29.9 (Overweight)	26 (28.89%)
≥ 30 (Obese)	36 (40.00%)
Education level	
Illiterate	04 (04.44%)
Junior high school	35 (38.89%)
Upto college	33 (36.67%)
Graduate and above	18 (20.00%)
Socio-economic Index	
10–30 (lower class)	69 (76.67%)
> 30 (higher class)	21 (23.33%)
Parity	
Primiparous	48 (53.33%)
Multiparous	42 (46.67%)
Gestational age (week)	
Range	32 – 40
Average	37
Family demography	
Nuclear	38 (42.22%)
Joint	52 (57.78%)
Skin complexion	
White	55 (61.11%)
Brown	12 (13.33%)
Black	23 (25.56%)
Delivery status (n = 88)*	
Normal vaginal delivery	21 (23.86%)
Caesarean section	65 (73.87%)
Abortion	02 (2.27%)
Maternal life status	
Alive	87 (98.86%)
Dead	01 (1.14%)
Neonatal life status	
Alive	79 (89.77%)
Dead	09 (10.23%)

* two patients were discharged for admission into other hospitals.

Impact of Environmental Pollution on Preeclamptic Patients

Since environmental pollution causes adverse physiological and mental health effects that might induce severe hypertension leading to preeclampsia, we made an attempt to estimate the exposure of environmental pollution, namely, air pollution, noise pollution and groundwater pollution, that exerted on the concerned preeclamptic patients.

A. Air Pollution: Both the distance of living room from kitchen and room ventilation status were treated as a qualitative measure of CO_2 exposure. The peak of the normal distribution curve (Figure 3A) reflects that most of the patients' living rooms were within 16.22 feet from kitchen. Figure 3B refers to that 10% of the patients had good room ventilation, whereas the remaining 90% patients had either moderate or poor bed room ventilation. Combination of the factors reveals that the preeclamptic patients were subject to moderate CO_2 exposure. Thus, it might be a risk factor of preeclampsia.

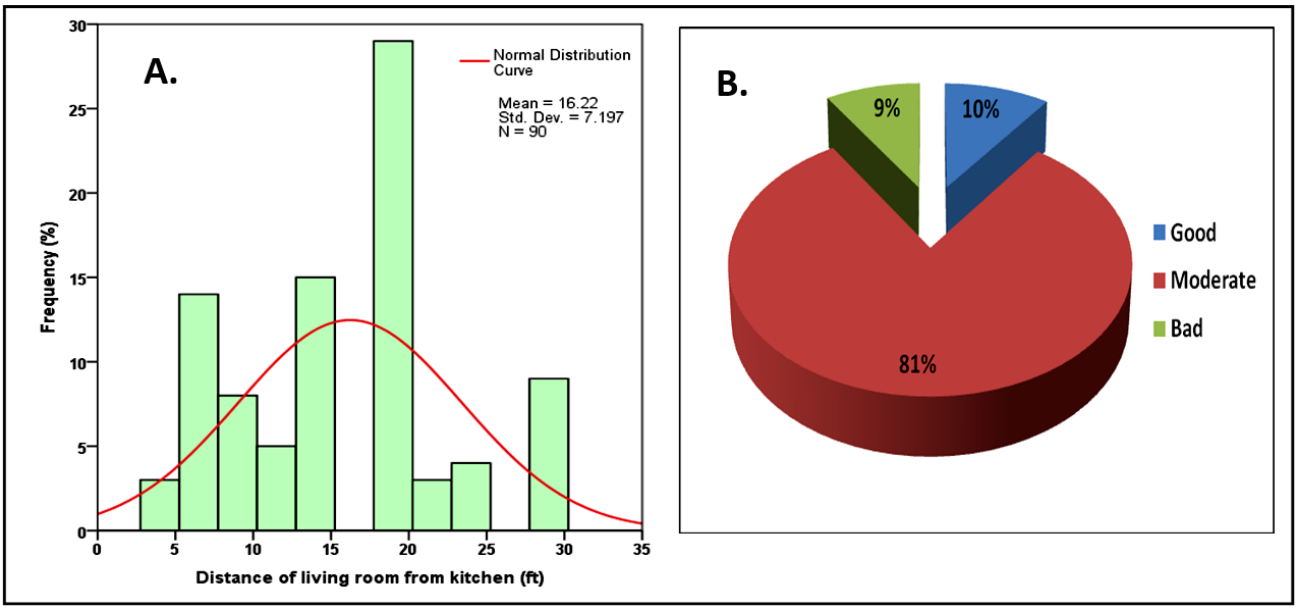

Figure 3: Exposed air pollution [**A.** Frequency of distance of living room from kitchen; **B.** Room ventilation status]

B. Noise Pollution: Both the road distance from the living room and traffic condition of the road were considered as a qualitative measure of noise exposure. It was found that 78.89% of the preeclamptic patients' living rooms were below 50 ft from the nearest roads, whereas it was 84.44% for 100 ft distance (Figure 4A). Moreover, 60% (54) patients experienced moderate to intense noise pollution, while 40% (36) experienced low noise exposure (Figure 4B). The sources of intense noise pollution included intense noise of Govt. owned sugar mill, private sugarcane crusher mill, diesel driven power generator, hydraulic horn of some trucks and buses, movement of rail car with whistle, etc. Combination of the two mentioned effects indicates that 90% of the preeclamptic patients would experience noise pollution, > 40 dB(A) according to the Department of Environment (DoE) of Bangladesh [22].

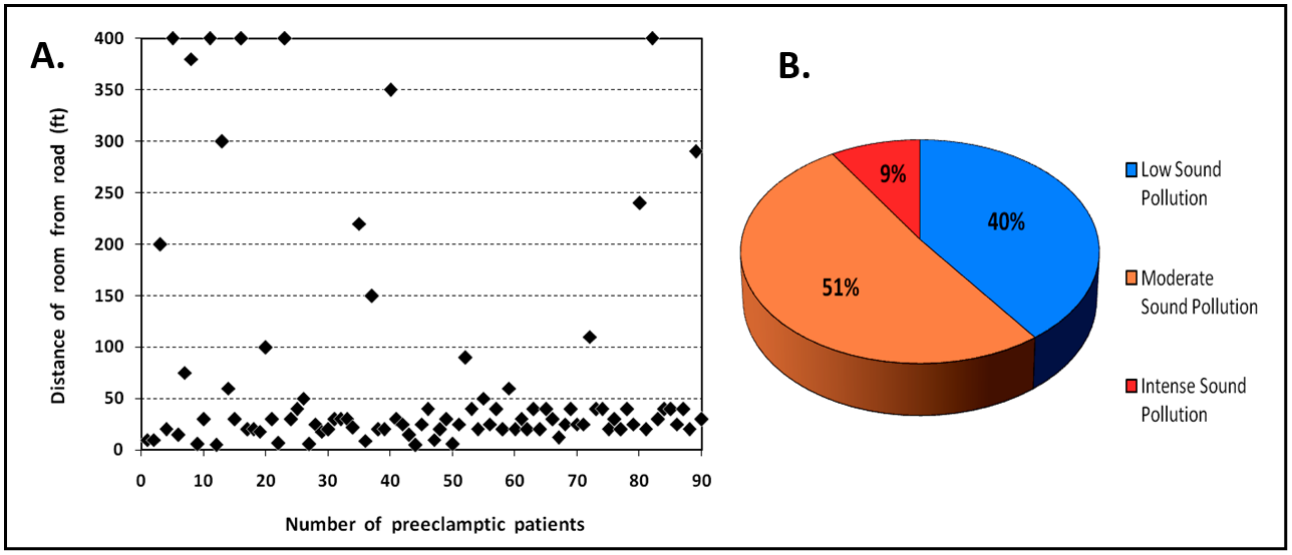

Figure 4: Exposed noise pollution [**A.** Distance of living room from nearest road; **B.** Intensity of noise pollution experienced]

C. Water Pollution: British Geological Survey (BGS, UK) in collaboration with Department of Public Health Engineering (DPHE, Bangladesh) made an extensive groundwater survey in Bangladesh (n=3,540) in 2000 [18]. Merger of their data-sets with the preeclamptic patients' geographical locations allowed to estimate 15 metal concentrations of their drinking water (n=40), whose distribution is presented in the Box-and-Whisker Plots (Figure 5). Comparison of the data with WHO guideline values (Table 2) reveals that arsenic (As), calcium (Ca), magnesium (Mg), iron (Fe) and sodium (Na) concentrations in the patients' drinking water were comparatively higher [23]. The higher values of calcium, magnesium and iron indicate that the waters were hard that might favour constipation. Sodium might assist in developing mild hypertension. The metalloid arsenic (As) has been classified as a human carcinogen of Group 1 by International Agency for Research on Cancer (IARC) [24]. The observed high level of carcinogenic arsenic in drinking water (the maximum concentration was 164 μg L^{-1}) might facilitate several adverse health effects including preeclampsia.

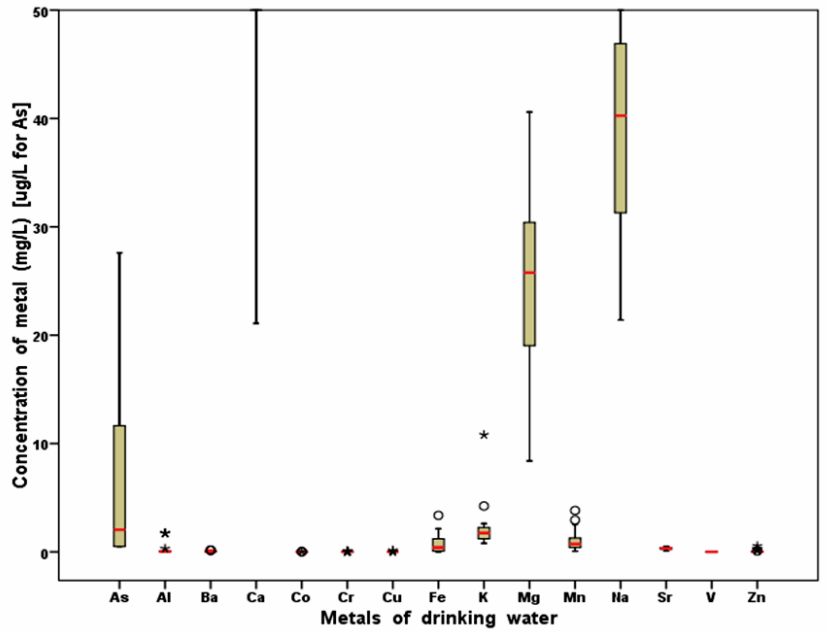

Figure 5: Box-and-Whisker plots for fifteen metals in the drinking water

[(-) indicates median; lower and upper box boundaries 25^{th} and 75^{th} percentiles of each distribution; Whiskers as vertical lines ending in horizontal lines at the largest and smallest observed values; (*) indicates outside value and (^{O}) far outside value**.** Calcium concentration is out of the scale**.**]

Table 2: Statistical analysis and comparison of the metals in drinking water

	As (ug/L)	Al (mg/L)	Ba (mg/L)	Ca (mg/L)	Co (mg/L)	Cr (mg/L)	Cu (mg/L)	Fe (mg/L)	K (mg/L)	Mg (mg/L)	Mn (mg/L)	Na (mg/L)	Sr (mg/L)	V (mg/L)	Zn (mg/L)
WHO Std	10	0.2	0.7	-	0.1	0.05	2	0.3 - 1.0	-		0.1	50	-	-	3
Bd Std	50	0.2	0.01	75	-	0.05	1	0.3	12	30 - 35	0.1	200	-	-	5
No. of Obs.	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Max	164	1.72	0.165	148	0.056	0.064	0.118	3.37	10.8	40.6	3.82	60.7	0.524	0.008	0.54
Min	0.5	0.01	0.013	21.1	0.001	0.002	0.001	0.014	0.8	8.39	0.057	21.4	0.09	0.002	0.008
Mean	14.78	0.18	0.07	93.76	0.01	0.01	0.01	0.68	1.96	24.63	0.94	38.92	0.32	0.00	0.06
Std. Error of Mean	5.74	0.07	0.00	5.33	0.00	0.00	0.00	0.12	0.25	1.35	0.12	1.61	0.02	0.00	0.02
Median	2.05	0.05	0.07	95.45	0.00	0.00	0.01	0.40	1.75	25.77	0.73	40.25	0.33	0.00	0.02
Std. Deviation	36.33	0.45	0.03	33.69	0.01	0.02	0.02	0.73	1.59	8.53	0.79	10.20	0.10	0.00	0.10
Variance	1320.12	0.20	0.00	1135.24	0.00	0.00	0.00	0.53	2.53	72.84	0.62	103.98	0.01	0.00	0.01
Skewness	3.75	3.30	1.39	-0.29	4.62	2.61	4.27	1.57	4.62	-0.39	1.82	0.13	-0.41	0.80	3.55
Kurtosis	13.85	9.47	2.55	-0.57	24.36	6.15	17.17	3.30	25.42	-0.73	4.24	-0.75	0.14	-0.92	14.13

Mental Stress of the Preeclamptic Patients

Mental stress of the concerned preeclamptic mothers was estimated based upon the 25 questions as suggested by Canadian National Health Association [21]. Out of the 90 preeclamptic patients, 63 (70%) patients were under high mental stress and 22 (24%) under very high mental stress (Figure 6). On the contrary, only 5 (6%) patients had moderate mental stress. No preeclamptic patients were found to have less or without mental stress. Since high mental pressure induces hypertension, it is obviously a potential risk factor for preeclampsia.

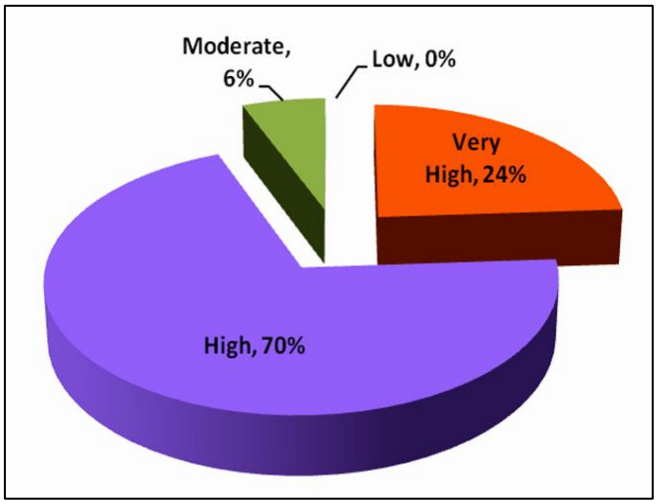

Figure 6: Mental stress of the concerned preeclamptic patients

DISCUSSION

Among the previously pregnant preeclamptic mothers (58%), about 20% had their children. The gestational age ranged 40-32 weeks, averaging 37 weeks. After delivery (C/S was 75%), mothers' health became good, but the infants' health deteriorated. Hence, patients' B.P. fell down in an irregular pattern after delivery and 1% maternal death and 10% neonatal deaths were recorded. Male children dominated (60%) over female children (40%). The main severe complications of the newborn were Asphyxia, IUGR, etc. Our findings on post-delivery maternal and neonatal health are in accordance with the incidence of many countries such as Thailand, Ghana, etc. [25-26].

In Scania of Sweden, the mean exposed levels of total $PM_{2.5}$, total PM_{10} and NO_x in preeclamptic women were found as 11.09, 15.81 and 14.82 $\mu g/m^3$ respectively [15]. The results suggested that maternal exposure to ambient air pollutants during gestation is an important factor that may contribute to the development of preeclampsia. It was found in China that the exposure to $PM_{2.5}$, PM_{10}, NO_2, O_3 were risk factors for preeclampsia in the first and second trimester of pregnancy, while only at high level, SO_2 and CO were risk factors for preeclampsia in the second trimester of Pregnancy [16]. In the present study, it was found that 90% of the preeclamptic patients were subject to moderate CO_2 exposure that might be considered as a risk factor of preeclampsia.

In Canada, it was found that the prevalence of preeclampsia was higher for women exposed to elevated environmental noise pollution levels, which were 3.79% for ≥ 65 dB(A) and 2.80% for <50 dB(A) [27]. The Department of Environment (DoE) of Bangladesh has set the maximum permissible limit of 50 and 40 dB(A) in cases of indoor noise exposure for day and night respectively [22]. We assigned the level of >40 dB(A) as noise pollution. This study identified the sources of intense noise pollution as intense noise of Govt. owned sugar mill, private sugarcane crusher mill, diesel driven power generator, hydraulic horn of some trucks and buses, movement of rail car with whistle, etc. Since 90% of the concerned preeclamptic patients experienced moderate to intense noise pollution, it is definitely a potential risk factor of preeclampsia.

British Geological Survey (BGS, UK) conducted countrywide groundwater survey (n=3,540) in Bangladesh in 2000 and revealed that the overall groundwater condition was not very safe to drink. Because the highest concentrations (in $\mu g\ L^{-1}$) of some toxic and hypertension inducing metals (against WHO guideline values) were 2,500 (10) for arsenic, 28.60 (10) for lead, 47 (2) for uranium, 1360 (700) for barium, 600 (20) for sodium and so on [18]. In the present study, the higher values of calcium, magnesium and iron indicate that the waters were hard that might favour constipation. Sodium and other toxic metals such as arsenic might assist in developing mild hypertension. This is in accordance with International Agency for Research on Cancer (IARC) [24]. Therefore, intake of unsafe drinking water is certainly another potential risk factor of preeclampsia.

Zhang *et al.*, (2013) found that mental stress was associated with an increased risk of gestational

hypertension (OR, 1.26; 95% CI, 1.00-1.59; P = 0.047) and preeclampsia (OR, 1.49; 95% CI, 1.27-1.74; P < 0.001) [28]. They also found that the work stress (OR, 1.50; 95% CI, 1.15-1.97; P = 0.003) and anxiety or depression (OR, 1.88; 95% CI, 1.08-3.25; P = 0.02) were positively associated with risk of preeclampsia. The present findings are in accordance with the above results [28].

CONCLUSION

Most of the patients' living rooms were within 16.22 feet from kitchen and 90% of the preeclamptic patients had either moderate or poor room ventilation. Combination of these facts reveals that the preeclamptic patients were subject to moderate CO_2 exposure. Since 78.89% of the preeclamptic patients' living rooms were below 50 ft from the nearest roads and 84.44% for 100 ft distance, they would experience noise pollution. Combination of traffic conditions and potential sources of noise pollution indicate that 60% of the preeclamptic patients experienced moderate to intense noise pollution (>40 dB(A)). Groundwater arsenic, calcium, magnesium, iron and sodium concentrations in the patients' drinking water were higher than WHO guideline values that should favour constipation and mild hypertension. While 70% patients were under high mental stress and 24% under very high mental stress, only 6% patients had moderate mental stress. In conclusion, air, water and noise pollution, and mental stress are potential risk factors of preeclampsia.

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