Determinants of preeclampsia and eclampsia among women delivering in county hospitals in Nairobi, Kenya [version 1; peer review: 1 not approved]

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Abstract

Background: Preeclampsia is defined as the onset of a new episode of high blood pressure in a woman usually after 20 weeks gestation plus proteinuria, whereas eclampsia is defined as generalized seizures in a pregnant woman who generally has preeclampsia criteria. Preeclampsia and eclampsia are hypertensive disorders of pregnancy and thus, among the top causes of maternal death worldwide. The objective of this study was to investigate risk factors for preeclampsia/eclampsia.

Methods: This was a hospital-based unmatched case-control study carried out among women of reproductive age (15-49 years) who have given birth at Nairobi County Hospitals and admitted to the postnatal ward July-September 2019 with a sample size of 352 participants (88 cases and 264 controls). All cases were selected, while controls were simple random sampled, as per eligibility criteria. Information or data were gathered using a structured interviewer-administered questionnaire and data abstraction tool. Descriptive analysis was carried out, where, categorical variables were presented in percentages or proportions, whereas; continuous variables were presented in means, standard deviations, and range. This was followed by a bivariable mixed-effect logistic regression analysis and a multivariable mixed-effect logistic regression analysis using the significant variables from bivariable analysis.

Results: Of all the 88 cases enrolled in the study 5 (5.68%) had eclampsia and 83 (94.32%) had preeclampsia. There was a significant association between personal history of hypertension (AOR=7.1; 95% CI: 2.6-19.3, p=0.001), Occupation as a housewife (AOR=3.1; 95% CI: 1.1-8.8, p=0.034), nulliparity (AOR=7.5; 95% CI: 1.5-37.5, p=0.015),
primiparity (AOR=2.1; 95% CI: 1.1-4.2, p=0.031), advanced maternal age 35-49 years (AOR=5.9; 95% CI: 1.1-33.3, p=0.042), and the occurrence of preeclampsia/eclampsia.

**Conclusions:** The following conclusions were made regarding the study findings: Personal history of hypertension, older/advanced maternal age (35-49 years), occupation, and parity were factors significantly associated with preeclampsia/eclampsia.

**Keywords**
Preeclampsia, Eclampsia, Determinants

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Introduction

Preeclampsia affects 2–10% of pregnant women globally and eclampsia 0.03–0.05%\(^1\). However, the overall prevalence of preeclampsia according to studies varies from 4.5% to 23%\(^2\). Preeclampsia affects about 4% of pregnancies in the United States of America\(^3\). In Kenya, the incidence of preeclampsia is about 0.3%\(^4\) while the prevalence is 6.1%\(^5\). Similarly in Ethiopia, the prevalence of preeclampsia is about 5%\(^6\). In Nigeria, the prevalence of preeclampsia ranges between 2 and 16.7%\(^7\).

The maternal mortality ratio in Sub-Saharan Africa is estimated to be 510 maternal deaths per 100,000 live births\(^8\). Maternal and fetal complications in addition to maternal and fetal mortality are much greater in mothers with pre-eclampsia and eclampsia than those without\(^9\). Preeclampsia is the second top cause of maternal death globally, which may lead to grave maternal complications (stroke, eclampsia, and organ failure), and poor perinatal outcome for the fetus and infant especially intrauterine development restriction, low birth weight, and stillbirth\(^10\). Preeclampsia develops in 20% of first pregnancies and entails more than 40% of premature birth resulting from treatment\(^1\). About 98% of maternal, fetal, and neonatal death related to preeclampsia and eclampsia occur in low-income countries, with much of this mortality in South Asia and Sub-Saharan Africa\(^11\). Preeclampsia also accounts for increasing maternal & perinatal/infant mortality, and it is a major cause of maternal mortality 15–20% in developed countries\(^11\).

Preeclampsia and eclampsia are among the hypertensive disorders of pregnancy. About 13% of maternal mortality globally is due to hypertensive disorders of pregnancy and the number is even higher in developing countries with an estimate between 20–80% in Africa and Latin America\(^1\).

Many risk factors have been associated with preeclampsia/eclampsia\(^12\). Nevertheless, a full account of the risk factors of preeclampsia/eclampsia has not been well established in the Kenyan population\(^1\). Therefore, this study was conducted to investigate some risk factors of preeclampsia/eclampsia namely; socio-demographic, reproductive and obstetric, clinical, behavioral and family history-related factors, with a view of informing policy, creating awareness, and formulating strategies to improve antenatal care and delivery services among women of reproductive age in Kenya.

Methods

Study design and setting

This was a hospital-based unmatched case-control study carried out at Nairobi County Hospitals’ postnatal ward. This study design was chosen because it is appropriate for identifying risk factors associated with pre-eclampsia/eclampsia, which are latent conditions among gravid women.

This study was carried out at Mbagathi District Hospital (Kibra), Mama Lucy Kibaki Hospital (Embakasi Central), and Pumwani Maternity Hospital (Kamukunji) in Nairobi County, Kenya; with a catchment population of 4.6 million people, 58% of which are slum dwellers. These are public county hospitals offering primary, secondary, and tertiary health care services to Nairobi residents and neighboring counties such as Kajiado, Kiambu and Machakos counties.

Study population and eligibility of participants

The study population was women of reproductive age (15–49 years) who have given birth at Nairobi County Hospitals and admitted to the postnatal ward from July–September, 2019. The controls and cases were selected from the study population-based outlined criteria for eligibility. A postnatal ward mother that met/satisfied the definition of a case or control and consented to participation was included. Those aged less than 18 years old were included in the study, but both the parent/guardian and patient were required to sign consent and assent forms, respectively. A postnatal ward mother that did not meet the definition of a case or control was excluded from the study.

Case definition and recruitment

A case was defined as a woman of reproductive age (15–49 years) admitted in postnatal ward after being diagnosed of preeclampsia (high blood pressure during pregnancy, ≥140/90 mmHg, plus proteinuria ≥300 mg/24 hours or ≥ 1+ dipstick) or eclampsia (high blood pressure during pregnancy, proteinuria plus generalized seizures) at Nairobi County Hospitals July-September, 2019. All cases that met the case definition were selected during the study period, July-September 2019, to obtain the required sample of 88 cases and the response rate was 100%. Thus, each case was selected after the physician (medical officer or consultant obstetrician/gynecologist) had made a diagnosis (preeclampsia/eclampsia) and client admitted to the postnatal ward.

Control definition and recruitment

Control was defined as a woman of reproductive age (15–49 years) admitted to the postnatal ward without preeclampsia/eclampsia at Nairobi County Hospitals from July-September 2019. Controls were simple randomly sampled from a list of women admitted to each of the three hospitals’ post-natal ward without preeclampsia/eclampsia which was recruited at the time of selection of the cases. A total of three controls for each case were selected by the time of selection to cases. The sampling frame was updated as per deliveries taking place in study hospitals from July–September 2019.

Sample size determination

The sample size of 352 participants (264 controls & 88 cases) was determined as specified by Kelsey, Jennifer, and others\(^11\) for case-control studies as follows:

\[
n_1 = \frac{(Z_\alpha + Z_\beta)^2 \bar{p} \bar{q}(\bar{r} + 1)}{r(p_1 - p_2)^2}, \quad p_1 = \frac{p_2 \text{OR}}{1 + p_2 \text{OR} - 1}
\]

\[
\bar{p} = \frac{p_1 + r p_2}{r + 1}, \quad \bar{q} = 1 - \bar{p}
\]

\[
n_2 = r n_1
\]
Since the outcome is rare in the Kenyan population, the ratio of 3 controls to 1 case was used in calculating the sample size but still maintains the statistical power of the study; $N_1$ is the number of cases and $N_2$ is the number of controls. Furthermore, $P_1$ is the proportion of cases exposed thus, was the proportion of women with pre-eclampsia/eclampsia that attend less than four antenatal clinic (ANC) visits; $P_2$ is the proportion of controls exposed and this was the proportion of women without pre-eclampsia/eclampsia that attends less than four ANC visit, that was set at 42%; $Z_{a_1}$ (1.96) and $Z_{a_2}$ (-0.84) were the required values specifying the two-tailed confidence interval (95%) and statistical power (80%) desired respectively. The odds for attending less than four ANC visits-preeclampsia/eclampsia association was been set at 2 (universally acceptable) and $r=3$, is the ratio of controls to cases. Given these figures, the desired sample size of 352 participants (88 cases and 264 controls) was computed.

### Study variables

The dependent variable was pre-eclampsia/eclampsia status measured as a binary categorical variable. The independent variables of interest were maternal age, education, residence, marital status, occupation, ethnicity, religion, maternal age, age at first marriage, age at first pregnancy, number of antenatal care visit, time/trimester of first ANC visit, gravidity, parity, child sex, anaemia in pregnancy, urinary tract infection (UTI) in pregnancy, alcohol use, tobacco use, family history of hypertension, family history of diabetes, personal history of diabetes, personal history of hypertension, and use of traditional treatment or medicine. All of these explanatory variables were more or less potential confounders and a determination of which one is a confounder was made during analysis. A pre-tested structured interview questionnaire was used to collect primary data from postnatal mothers and a data abstraction tool was also used to collect some secondary data, both available as Extended data.

### Ethical considerations

The research was granted ethical clearance by Kenyatta National Hospital (KNH)-University of Nairobi (UON) Ethics and Research Committee (P426/05/2019) and the Nairobi City County Government - Public health division (Ref. No. NCC/HRD/HRM/11/904/JWN/2019). Furthermore, written consent was obtained from the participants after they were informed about the nature of the study.

### Minimization of biases

Before starting data collection, six research assistants (two for each of the three health facilities) were trained on the sampling technique for cases and controls and standard interview skills to reduce systemic error and interview bias. Research assistants were also trained to get information such as the number of antenatal care (ANC) visits, time/trimester of first ANC visit from the patient medical record using data abstraction tool in an attempt to reduce recall bias. Misclassification bias which could affect both cases and controls was minimized by including cases and controls determined by the obstetrician.

### Statistical analysis

The filled questionnaires were first checked for completeness then followed by the entry of data collected from the field into Microsoft Excel spreadsheets, cleaned, formatted, coded and audited for quality and consistency using Epi-info software before exporting the dataset to Stata -version 14.0 computer programming software. Descriptive analysis was carried out, where, categorical variables were presented in percentages or proportions, whereas, continuous variables were presented in means and standard deviations. This was followed by bivari able mixed-effect logistic regression analysis and a multivariable mixed-effect logistic regression analysis using the significant variables ($p \leq 0.20$) from the bivariable analysis. A modified Hosmer-Lemeshow goodness-of-fit test was carried out; after which, variables with $p \leq 0.05$ were considered as factors associated with preeclampsia/eclampsia.

### Results and discussion

**Results**

**Socio-demographic characteristics of the study participants.** The study participants were 352, of whom 88 were cases and 264 were controls. Among the cases, preeclampsia accounted for 83 (94.3%) and eclampsia 5 (5.7%). This was a multicenter study conducted in Pumwani Maternity Hospital which had 196 participants (55.7%), Mama Lucy Kibaki Hospital with 99 participants (28.1%) and Mbagathi District Hospital with 57 participants (16.2%). The distribution of study participants by study hospital is presented in Table 1; individual-level responses to questionnaire items are available as Underlying data.

The mean maternal age of the study participants was 26.1 years (SD=5.5); the mean maternal age of controls being 26.1 years with a standard deviation 5.3 years (range: 18–41 years) and the mean maternal age of cases being 27.6 years with 5.9 standard deviation (range: 17–42). About 81% of cases and 83% of controls were mothers aged between 20 and 34 years old. Among the controls and cases, 71 (26.9%) and 23 (26.1%) had primary-level education, respectively, whereas 140 (53.0%) of the controls and 40 (45.5%) of cases had a secondary level of education. In terms of marital status, 80.7% of cases and 80.7% of controls were married. The majority of cases 49 (55.7%) and controls 114 (43.2%) had an occupation as housewife.

Concerning the county of residence, 247 (93.6%) of controls and 86 (97.7%) of cases were residents of Nairobi County. Mothers of Kenyan ethnicity accounted for 258 (97.7%) of controls and 86 (97.7%) of cases whereas, those of non-Kenyan ethnicity were 2 (2.3%) of cases and 6 (2.3%) of controls. Among the cases and controls, 97.7% and 97.0% were Christians respectively; whereas Muslim mothers represented 8 (3.0%) controls and 2 (2.3%) of cases. The socio-demographic factors of the study population are presented in Table 2.
### Table 1. Distribution of study participants by study hospital.

| Study hospital       | Controls (n=264), n (%) | Cases (n=88), n (%) | Total, n (%) |
|----------------------|-------------------------|---------------------|--------------|
| Mama Lucy Kibaki     | 74 (28.0)               | 25 (28.4)           | 99 (28.1)    |
| Mbagathi District    | 43 (16.3)               | 14 (15.9)           | 57 (16.2)    |
| Pumwanity maternity  | 147 (55.7)              | 49 (55.7)           | 196 (55.7)   |

### Table 2. Socio-demographic characteristics of the respondents.

| Variable                  | Cases, n (%) | Controls, n (%) | Total, n (%) |
|---------------------------|--------------|-----------------|--------------|
| **Education Level**       |              |                 |              |
| No education              | 1 (1.1)      | 1 (0.4)         | 2 (0.6)      |
| Primary education         | 23 (26.1)    | 71 (26.9)       | 94 (26.7)    |
| Secondary education       | 40 (45.5)    | 140 (53.0)      | 180 (51.1)   |
| Tertiary education        | 24 (27.3)    | 52 (19.7)       | 76 (21.6)    |
| **Maternal Age**          |              |                 |              |
| <20                       | 4 (4.55)     | 19 (7.2)        | 23 (6.5)     |
| 20–34                     | 71 (80.7)    | 220 (83.3)      | 291 (82.7)   |
| 35–49                     | 13 (14.8)    | 25 (9.5)        | 38 (10.8)    |
| **Marital status**        |              |                 |              |
| Married                   | 71 (80.7)    | 213 (80.7)      | 284 (80.7)   |
| Separated                 | 0 (0.0)      | 4 (1.5)         | 4 (1.1)      |
| Single                    | 16 (18.2)    | 45 (17.1)       | 61 (17.3)    |
| widowed                   | 1 (1.1)      | 2 (0.8)         | 3 (0.9)      |
| **Occupation**            |              |                 |              |
| Salaried employee         | 10 (11.4)    | 26 (10.0)       | 36 (10.2)    |
| Housewife                 | 49 (55.7)    | 114 (43.2)      | 163 (46.3)   |
| Merchant/business         | 22 (25.0)    | 91 (34.5)       | 113 (32.1)   |
| Other occupation          | 7 (8.0)      | 33 (12.1)       | 40 (11.4)    |
| **County of residence**   |              |                 |              |
| Nairobi                   | 86 (97.7)    | 247 (93.6)      | 333 (94.6)   |
| Other counties            | 2 (2.3)      | 17 (6.4)        | 19 (5.4)     |
| **Specific place of residence** | | | |
| Urban/estate              | 42 (47.7)    | 143 (54.2)      | 185 (52.6)   |
| Rural                     | 0 (0.0)      | 8 (3.0)         | 8 (2.3)      |
| Informal settlement       | 46 (52.3)    | 113 (42.8)      | 159 (45.2)   |
| **Ethnicity**             |              |                 |              |
| Kenyan                    | 86 (97.7)    | 258 (97.7)      | 344 (97.7)   |
| Non-Kenyan                | 2 (2.3)      | 6 (2.3)         | 8 (2.3)      |
| **Religion**              |              |                 |              |
| Christian                 | 86 (97.7)    | 256 (97.0)      | 342 (97.2)   |
| Muslim                    | 2 (2.3)      | 8 (3.0)         | 10 (2.8)     |
The socio-demographic factors associated with preeclampsia/eclampsia. The socio-demographic factors hypothesized to significantly associate with preeclampsia/eclampsia include maternal age, maternal level of education, marital status, maternal occupation, maternal county of residence, and religion.

Compared to mothers aged less than 20 years, mothers 20–34 years of age were 1.5 times more likely to suffer preeclampsia/eclampsia (OR=1.5, 95% CI=0.5-4.7, p=0.451) whereas mothers aged 35–49 years were 2.5 times more likely to experience preeclampsia/eclampsia than mothers aged less than 20 years (OR=2.5, 95% CI=0.7-8.8, p=0.163).

Postnatal mothers from government/private occupation were 1.8 times more likely to suffer from preeclampsia/eclampsia than those from other occupations (OR=1.8, 95% CI=0.6-5.4, p=0.286) whereas those that have an occupation as housewives were 2.0 times more likely to develop preeclampsia/eclampsia than other occupations. Similarly, mothers that have merchant/business occupation were more likely to develop preeclampsia/eclampsia than other occupations (OR=1.1, 95% CI=0.5-2.9, p=0.789).

Postnatal mothers from Nairobi County were at increased risk of preeclampsia/eclampsia compared to those from other counties (OR=3.0, 95% CI=0.7-13.1, p=0.152). The associations between socio-demographic factors and preeclampsia/eclampsia are summarized in Table 3.

The reproductive and obstetric factors associated with preeclampsia/eclampsia

We hypothesized that reproductive and obstetrics factors likely associated with preeclampsia/eclampsia were maternal age, age at first marriage, age at first pregnancy, number of ANC visits, time/trimester of first ANC visit, gravidity, parity, and child-Sex.

Table 3. Association between socio-demographic factors and preeclampsia/eclampsia.

| Variable                  | Cases, n (%) | Controls, n (%) | $\chi^2$ | Crude OR (95% CI)       | p-value |
|---------------------------|--------------|-----------------|----------|-------------------------|---------|
| **Age group**             |              |                 |          |                         |         |
| <20                       | 4 (4.6)      | 19 (7.2)        | 2.44     | Ref                     |         |
| 20–34                     | 71 (80.7)    | 220 (83.3)      |          | 1.5 (0.5-4.7)           | 0.451   |
| 35–49                     | 13 (14.8)    | 25 (9.5)        |          | 2.5 (0.7-8.8)           | 0.163   |
| **Education Level**       |              |                 |          |                         |         |
| Up to Primary             | 24 (27.3)    | 72 (27.3)       | 2.47     | Ref                     |         |
| Secondary                 | 40 (45.5)    | 140 (53.0)      |          | 0.9 (0.5-1.5)           | 0.603   |
| Tertiary                  | 24 (27.3)    | 52 (19.7)       |          | 1.4 (0.7-2.7)           | 0.34    |
| **Marital Status**        |              |                 |          |                         |         |
| Married                   | 71 (80.7)    | 213 (80.7)      | 0.46     | 2 (0.2-16.9)            | 0.524   |
| Separated/Widowed         | 1 (1.1)      | 6 (2.3)         |          | Ref                     |         |
| Single                    | 16 (18.2)    | 45 (17.1)       |          | 2.1 (0.2-19.1)          | 0.498   |
| **Occupation**            |              |                 |          |                         |         |
| Salaried employee         | 10 (11.4)    | 26 (9.9)        | 5.34     | 1.8 (0.6-5.4)           | 0.286   |
| House Wife                | 49 (55.7)    | 114 (43.2)      |          | 2.0 (0.8-4.9)           | 0.116   |
| Merchant/Business         | 22 (25.0)    | 91 (34.5)       |          | 1.1 (0.5-2.9)           | 0.789   |
| Others                    | 7 (8.0)      | 33 (12.5)       |          | Ref                     |         |
| **County of Residence**   |              |                 |          |                         |         |
| Nairobi                   | 86 (97.7)    | 247 (93.6)      | 2.05     | 3.0 (0.7-13.1)          | 0.152   |
| Other County              | 2 (2.3)      | 17 (6.4)        |          | Ref                     |         |
| **Specific Place of Residence** |          |                 |          |                         |         |
| Informal/Rural Settlement | 46 (52.3)    | 121 (45.8)      | 1.09     | Ref                     |         |
| Urban/Estate              | 42 (47.7)    | 143 (54.2)      |          | 1.3 (0.8-2.1)           | 0.295   |
| **Religion**              |              |                 |          |                         |         |
| Christians                | 86 (97.7)    | 256 (97.0)      | 0.14     | 0.7 (0.2-3.6)           | 0.712   |
| Muslims                   | 2 (2.3)      | 8 (3.0)         |          | Ref                     |         |
Nulliparous mothers were 4.8 times more likely to suffer from preeclampsia/eclampsia than multiparous mothers (OR=4.8, 95% CI=1.0-22.4, p=0.045) whereas primiparous mothers were 1.4 times more likely to develop preeclampsia/eclampsia than those that were multiparous (OR=1.4, 95% CI=0.9-2.3, p=0.187). Nulliparous mothers, though, were at increased risk of suffering preeclampsia/eclampsia; however, the association was not statistically significant in that the 95% confidence included 1 despite a p-value of 0.045 (OR=4.8, 95% CI=1.0-22.4, p=0.045). Therefore, there was no significant association between parity and development of preeclampsia and/or eclampsia. Compared to mothers aged 20 years and above, teenage mothers were 30% less likely to develop preeclampsia/eclampsia (OR=0.7, 95% CI=0.4-1.3, p=0.199).

Compared to mothers whose first antenatal care visit was in the first trimester of pregnancy, mothers whose first antenatal care visit was in the second and third trimesters were at reduced risk of preeclampsia/eclampsia (OR=0.8, 95% CI=0.5-1.4, p=0.473 and OR=0.5, 95% CI=0.2-1.4, p=0.191). Mothers whose age at first marriage was <20 years old were 10% less likely to develop preeclampsia/eclampsia than those that were ≥20 years old (OR=0.9, 95% CI=0.5-1.6, p=0.659) whereas mothers whose age at first pregnancy was <20 years old were 0.7 times more likely to develop preeclampsia/eclampsia than those that were ≥20 years old (OR=0.7, 95% CI=0.4-1.3, p=0.199). The associations between reproductive and obstetric factors and preeclampsia/eclampsia are summarized in Table 4.

### The clinical factors associated with preeclampsia/eclampsia

Anemia and urinary tract infections in pregnancy were hypothesized to relate significantly with the occurrence of preeclampsia and eclampsia. Compared to mothers with a normal number of pus cells (0–5 hpf) on admission for delivery, mothers with mild-moderate and severe UTI (6–10 hpf and >10 hpf) in pregnancy on admission were 1.7 times more likely to develop preeclampsia/eclampsia (OR=1.7, 95% CI=0.4-7.0, p=0.454). Mothers with mild-moderate and severe levels (7-10.9 g/dl and <7 g/dl) of anemia on admission for delivery were 0.9 times as likely to suffer from preeclampsia/eclampsia than those with normal hemoglobin level (≥11 g/dl); (OR=0.9, 95% CI=0.5-1.6, p=0.625). Associations

### Table 4. Association between reproductive and obstetric factors and preeclampsia/eclampsia.

| Variable                     | Cases, n (%) | Controls, n (%) | χ²  | Crude OR (95% CI) | p-value |
|------------------------------|--------------|-----------------|-----|------------------|---------|
| **Age at First Marriage**    |              |                 |     |                  |         |
| <20                          | 19 (26.4)    | 64 (29.1)       | 0.19| 0.9 (0.5-1.6)    | 0.659   |
| ≥20                          | 53 (73.6)    | 156 (70.9)      |     | Ref              |         |
| **Age at First Pregnancy**   |              |                 |     |                  |         |
| <20                          | 24 (27.3)    | 89 (33.7)       | 1.25| 0.7 (0.4-1.3)    | 0.199   |
| ≥20                          | 64 (72.7)    | 175 (66.3)      |     | Ref              |         |
| **Number of ANC Visits**     |              |                 |     |                  |         |
| <4                           | 39 (44.3)    | 106 (40.2)      | 0.47| 1.2 (0.7-1.9)    | 0.492   |
| ≥4                           | 49 (55.7)    | 158 (59.9)      |     | Ref              |         |
| **Time/Trimester First ANC Visit** |         |                 |     |                  |         |
| Up to First trimester        | 29 (33.0)    | 73 (27.7)       | 1.78| Ref              |         |
| Second trimester             | 53 (60.2)    | 162 (61.4)      |     | 0.8 (0.5-1.4)    | 0.473   |
| Third Trimester              | 6 (6.8)      | 29 (11.0)       |     | 0.5 (0.2-1.4)    | 0.191   |
| **Gravidity**                |              |                 |     |                  |         |
| Primigravida                 | 37 (42.1)    | 99 (37.5)       | 0.57| Ref              |         |
| Multigravida                 | 51 (58.0)    | 165 (62.5)      |     | 0.8 (0.5-1.4)    | 0.449   |
| **Parity**                   |              |                 |     |                  |         |
| Nulliparous                  | 4 (4.6)      | 3 (1.1)         | 5.08| 4.8 (1.0-22.4)   | 0.045   |
| Primiparous                  | 42 (47.7)    | 109 (41.3)      |     | 1.4 (0.9-2.3)    | 0.187   |
| Multiparous                  | 42 (47.7)    | 152 (57.6)      |     | Ref              |         |
| **Child Sex**                |              |                 |     |                  |         |
| Male                         | 41 (46.6)    | 138 (52.3)      | 1.31| 0.5 (0.1-2.2)    | 0.35    |
| Female                       | 44 (50.0)    | 121 (45.8)      |     | 0.6 (0.1-2.6)    | 0.505   |
| Multi-sex                    | 3 (3.4)      | 5 (1.9)         |     | Ref              |         |
between clinical factors and preeclampsia/eclampsia are presented in Table 5.

**The behavioural and family history-related factors associated with preeclampsia/eclampsia**

Further, the relationships between alcohol use, tobacco use, traditional treatment use, diabetes, and hypertension with preeclampsia/eclampsia were assessed. History of diabetes and hypertension were personal and family history.

Postnatal mothers who used tobacco were 3.9 times more likely to develop preeclampsia/eclampsia than those who did not use tobacco (OR=3.9, 95% CI=1.0-14.9, \( p=0.046 \)). Postnatal mothers who used tobacco were at increased risk of suffering preeclampsia/eclampsia; however, the association was not statistically significant in that the 95% confidence interval included 1 despite a \( p \)-value of 0.046 (OR=3.9, 95% CI=1.0-14.9, \( p=0.046 \)). On the other hand, mothers with a personal history of hypertension were 6.3 times more likely to suffer from preeclampsia/eclampsia than those without a personal history of hypertension (OR=6.3, 95% CI=2.7-14.8, \( p=0.001 \)). In addition, there was a significant association between personal history of hypertension and development of preeclampsia/eclampsia (\( p<0.001 \)). The associations between behavioural and family history-related factors and preeclampsia/eclampsia are presented in Table 6.

**Multivariable mixed-effect logistic regression on risk factors for preeclampsia/eclampsia.** A multivariable mixed-effect logistic regression model was used to determine the effect of various socio-demographic, reproductive and obstetric, clinical, behavioral and family history-related factors. Only variables

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**Table 5. Association between clinical factors and preeclampsia/eclampsia status.**

| Variable                                      | Cases, n (%) | Controls, n (%) | \( \chi^2 \) | Crude OR (95% CI) | \( p \)-value |
|------------------------------------------------|--------------|-----------------|---------------|-------------------|--------------|
| Pus cells count on admission for delivery     |              |                 |               |                   |              |
| Normal                                        | 3 (23.1)     | 18 (34.0)       | 0.56          | Ref               |              |
| Mild-moderate and severe UTI in pregnancy     | 10 (76.9)    | 35 (66.0)       |               | 1.7 (0.4-7.0)     | 0.454        |
| Haemoglobin level on admission for delivery   |              |                 |               |                   |              |
| Normal                                        | 67 (77.9)    | 189 (75.3)      | 0.24          | Ref               |              |
| Mild-Moderate and severe level of anaemia     | 19 (22.1)    | 62 (24.7)       |               | 0.9 (0.5-1.6)     | 0.625        |

**Table 6. Association between behavioral and family history-related factors and preeclampsia/eclampsia.**

| Variable                  | Cases, n (%) | Controls, n (%) | \( \chi^2 \) | Crude OR (95% CI) | \( p \)-value |
|---------------------------|--------------|-----------------|---------------|-------------------|--------------|
| Alcohol Use               |              |                 |               |                   |              |
| YES                       | 8 (9.1)      | 17 (6.4)        | 0.7           | 1.5 (0.6-3.5)     | 0.404        |
| NO                        | 80 (90.9)    | 247 (93.6)      |               | Ref               |              |
| Tobacco use               |              |                 |               |                   |              |
| YES                       | 5 (5.7)      | 4 (1.5)         | 4             | 3.9 (1.0-14.9)    | 0.046        |
| NO                        | 83 (94.3)    | 260 (98.5)      |               | Ref               |              |
| Personal history of hypertension |          |                 |               |                   |              |
| YES                       | 16 (18.2)    | 9 (3.4)         | 17.69         | 6.3 (2.7-14.8)    | <0.001       |
| NO                        | 72 (81.8)    | 255 (96.6)      |               | Ref               |              |
| Family history of hypertension |          |                 |               |                   |              |
| YES                       | 19 (21.6)    | 36 (13.6)       | 3.12          | 1.7 (0.9-3.2)     | 0.078        |
| NO                        | 69 (78.4)    | 228 (86.4)      |               | Ref               |              |
| Family history of diabetes |            |                 |               |                   |              |
| YES                       | 4 (4.6)      | 21 (8.0)        | 1.13          | 0.6 (0.2-1.7)     | 0.287        |
| NO                        | 84 (95.5)    | 243 (92.1)      |               | Ref               |              |
| Traditional Treatment use |              |                 |               |                   |              |
| YES                       | 4 (4.5)      | 16 (6.1)        | 0.28          | 0.7 (0.2-2.3)     | 0.596        |
| NO                        | 84 (95.5)    | 248 (93.9)      |               | Ref               |              |
nulliparity to a maternal immune maladaptation. This is for the reason that nulliparity is due to early trophoblastic invasion and how the mother reacts to it. The breakdown or malfunction of the normal invasion of trophoblastic cells leads to maladaptation of the coiled arterioles, which are linked to the causation of preeclampsia.

Mothers that attended less than four ANC visits were at increased risk of developing preeclampsia/eclampsia when compared with those that attended four or more ANC visits. This is comparable to a study conducted in Nigeria. Long-distance to access health facility, limited knowledge about antenatal care (ANC) services coupled with low socio-economic status could possibly be responsible for postnatal mothers not meeting the WHO recommended four or more ANC visits; a situation which could predispose mothers to obstetric complications such as preeclampsia and eclampsia. In this study however, the association between a number of ANC visits and the outcome (preeclampsia/eclampsia) was not statistically significant in that the 95% confidence interval included 1 despite a p-value of 0.041 (AOR = 1.8; 95% CI: 1.0-3.3, p=0.041).

The study results found out that anemia and UTI in pregnancy were not significantly associated with preeclampsia/eclampsia; however, this finding contradicts studies conducted in Egypt, Sudan, and by WHO.

Women with personal history of hypertension were more likely to suffer from preeclampsia/eclampsia compared with those that attended four or more ANC visits. A similar finding was found in a study conducted in Nigeria. It is probable that lifestyle modifications/behavioral factors are the reason for influencing women to an increased threat of preeclampsia/eclampsia. For instance, mothers taking-in an unhealthy diet; eating food high in fats and carbohydrates could increase their triglyceride levels, narrowing blood flow, which may predispose them to develop hypertensive disorders in pregnancy.

**Limitations of the study.** This study had some limitations. First, not all admission for delivery had their hemoglobin level (337 out of 352 study participants) and urinary pus cells count (337 out of 352) recorded in the study hospitals, therefore; if this study was repeated in other facilities with better recording of lab results of maternal admission, then the findings could be different. Secondly, there might have been recall bias regarding some factors such as the specific traditional treatment use and purpose of using the said treatment. Lastly, the hospital-based approach included only women attending the study hospitals.

**Conclusions**

This study indicated that a personal history of hypertension, older/advanced maternal age (35–49 years), occupation, and parity (nulliparous/primiparous) were factors significantly associated with preeclampsia/eclampsia. In this study, only 66 out of 352 participants (18.8%) had their urinary pus cells recorded on admission for delivery and whether UTI in pregnancy is actually not associated with preeclampsia/eclampsia.
Table 7. Risk factors of preeclampsia/eclampsia.

| Variable                        | Cases, n (%) | Controls, n (%) | Adjusted OR (95% CI) | p-value |
|--------------------------------|--------------|-----------------|-----------------------|---------|
| **Age group**                   |              |                 |                       |         |
| <20                             | 4 (4.6)      | 19 (7.2)        | Ref                   |         |
| 20–34                           | 71 (80.7)    | 220 (83.3)      | 2.2 (0.5-8.8)         | 0.28    |
| 35–49                           | 13 (14.8)    | 25 (9.5)        | 5.9 (1.1-33.3)        | 0.042   |
| **Occupation**                  |              |                 |                       |         |
| Salaried employee               | 10 (11.4)    | 26 (9.9)        | 2.1 (0.6-7.5)         | 0.241   |
| Housewife                       | 49 (55.7)    | 114 (43.2)      | 3.1 (1.1-8.8)         | 0.034   |
| Merchant/Business               | 22 (25.0)    | 91 (34.5)       | 1.5 (0.5-4.6)         | 0.469   |
| Others                          | 7 (8.0)      | 33 (12.5)       | Ref                   |         |
| **County of residence**         |              |                 |                       |         |
| Nairobi                         | 86 (97.7)    | 247 (93.6)      | 2.6 (0.6-12.4)        | 0.224   |
| Other Counties                  | 2 (2.3)      | 17 (6.4)        | Ref                   |         |
| **Age at first pregnancy**      |              |                 |                       |         |
| <20                             | 24 (27.3)    | 89 (33.7)       | 1.05 (0.5-2.1)        | 0.902   |
| ≥20                             | 64 (72.7)    | 175 (66.3)      | Ref                   |         |
| **Number of ANC visits**        |              |                 |                       |         |
| <4                              | 39 (44.3)    | 106 (40.2)      | 1.8 (1.0-3.3)         | 0.041   |
| ≥4                              | 49 (55.7)    | 158 (59.9)      | Ref                   |         |
| **Time/trimester first ANC visit** |          |                 |                       |         |
| Up to First trimester           | 29 (33.0)    | 73 (27.7)       | Ref                   |         |
| Second trimester                | 53 (60.2)    | 162 (61.4)      | 0.9 (0.5-1.7)         | 0.74    |
| Third Trimester                 | 6 (6.8)      | 29 (11.0)       | 0.5 (0.1-1.6)         | 0.214   |
| **Parity**                      |              |                 |                       |         |
| Nulliparous                     | 4 (4.6)      | 3 (1.1)         | 7.5 (1.5-37.5)        | 0.015   |
| Primiparous                     | 42 (47.7)    | 109 (41.3)      | 2.1 (1.1-4.2)         | 0.031   |
| Multiparous                     | 42 (47.7)    | 152 (57.6)      | Ref                   |         |
| **Haemoglobin level on admission for delivery** | | | | |
| Normal                          | 67 (77.9)    | 189 (75.3)      | Ref                   |         |
| Mid-Moderate level anaemia and severe | 19 (22.1) | 62 (24.7) | 0.9 (0.5-1.9)         | 0.968   |
| **Tobacco use**                 |              |                 |                       |         |
| YES                             | 8 (9.1)      | 17 (6.4)        | 1.7 (0.4-7.8)         | 0.518   |
| NO                              | 80 (90.9)    | 247 (93.6)      | Ref                   |         |
| **Personal history of hypertension** |          |                 |                       |         |
| YES                             | 16 (18.2)    | 9 (3.4)         | 7.1 (2.6-19.3)        | <0.001  |
| NO                              | 72 (81.8)    | 255 (96.6)      | Ref                   |         |
| **Family history of hypertension** |         |                 |                       |         |
| YES                             | 4 (4.6)      | 21 (8.0)        | 1.2 (0.6-2.5)         | 0.633   |
| NO                              | 84 (95.4)    | 243 (92.0)      | Ref                   |         |
needs further investigation. Anemia in pregnancy was 10% less likely to develop preeclampsia/eclampsia.

Based on the study findings, this study makes the following recommendations to policymakers, county government, hospital management teams, and other relevant institutions:

1. Health Workers in Maternal and Child Health units of health facilities should emphasize the risk factors for preeclampsia and/or eclampsia to pregnant and postnatal mothers during their health talks in the health facilities. These messages should be extended to other pregnant and postnatal mothers in the catchment areas of the health facilities through Community Health Workers.

2. Maternity In-charges should ensure that urinary pus cell count and hemoglobin level for pregnant women are ordered and results recorded in the admission notes for delivery.

3. That future studies should investigate the association between UTI in pregnancy and preeclampsia/eclampsia in a multi-county study.

Data availability

Underlying data

Harvard Dataverse: Replication data for: Determinants of preeclampsia and eclampsia among women delivering in county hospitals in Nairobi, Kenya: https://doi.org/10.7910/DVN/BYFL3J14.

This project contains the following underlying data:

- Logan preeclampsia dataset Final. (Study dataset)
- Logan preeclampsia dofile Final2 (do file code for Determinants-Preeclampsia/eclampsia identification).

Extended data

Harvard Dataverse: Replication data for: Determinants of preeclampsia and eclampsia among women delivering in county hospitals in Nairobi, Kenya: https://doi.org/10.7910/DVN/BYFL3J14.

This project contains the following extended data:

- Logan Interview Questionnaire & Data Abstraction Tool. (Questionnaire and data abstraction tool used in this study.)

Data are available under the terms of the Creative Commons Zero “No rights reserved” data waiver (CC0 1.0 Public domain dedication).

Acknowledgments

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Ishag Adam
Faculty of Medicine, University of Khartoum, Khartoum, Sudan

The authors investigated an important topic “preeclampsia”. I have some points that need to be addressed.

Abstract:
○ No need to have details of statistic methods in the abstract.

Methods:
○ It is not clear if these cases were mild or severe cases or if these were early or late preeclampsia.
○ More elaborations are needed because the risk factors are different in the different types of preeclampsia.
○ There many factors that were not investigated e.g. anemia, malaria, body mass index, blood groups.
○ I think all this information could be added to your work and you might have different results.

Sample size:
○ It is advisable to consider the difference between the two groups using the least prevalent one e.g. smoking or alcohol such as 3.0 vs 2.%. and not using the high one as you used antenatal care.

Statistics:
○ I do not think you used mix model I think you used logistic regression models.
○ In the methods, you mentioned that variables with p ≤ 0.2 were entered in the model. Then later on you contradict yourself and you mentioned that variables that were shown to be
associated with preeclampsia were entered in the model regardless of their P value.

**Results:**
- All your tables can be summarized in two tables only:
  - Table 1 all comparing all variables between preeclampsia and controls
  - Table 2 logistic regression with non-adjusted and adjusted values

**Is the work clearly and accurately presented and does it cite the current literature?**
Yes

**Is the study design appropriate and is the work technically sound?**
Yes

**Are sufficient details of methods and analysis provided to allow replication by others?**
Partly

**If applicable, is the statistical analysis and its interpretation appropriate?**
Partly

**Are all the source data underlying the results available to ensure full reproducibility?**
Yes

**Are the conclusions drawn adequately supported by the results?**
Partly

**Competing Interests:** No competing interests were disclosed.

**Reviewer Expertise:** Maternal and perinatal epidemiology

I confirm that I have read this submission and believe that I have an appropriate level of expertise to state that I do not consider it to be of an acceptable scientific standard, for reasons outlined above.
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