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LOGISTIC REGRESSION: PREDISPOSING FACTORS AND ASSOCIATED PREECLAMPSIA AMONG PREGNANT WOMEN IN NIGERIA

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Abstract: Preeclampsia is a hypertensive disorder that usually occurs after 20 weeks of gestation and is one of the leading causes of maternal and perinatal morbidity and mortality worldwide. It causes severe morbidity, long-term disability, and death in both mothers and their children. Therefore, this study Statistical Analysis of the predisposing factors and associated of Preeclampsia among Pregnant Women was conducted to decompose changes in pre-eclampsia between 2019 and 2021. The data for the study were extracted from the patient's health records (casenotes) for the year 2019 and 2021. The outcome variable was the occurrence of pre-eclampsia, while the explanatory variables include age, residence, education status, wealth index, and number of children. Pre-eclampsia and its determinants in 2019 and 2021 were summarized using frequency and percentages. Percentage change in both outcome and explanatory variables between 2019 and 2021 was estimated. Logistic regression was used to explore factors associated with pre-eclampsia. A multivariate decomposition technique was used to partition changes in pre-eclampsia prevalence into two components contribution of changes in determinants and changes in the effect of determinants. A total of 520 patient's health records (casenotes) for the year 2019 and 2021 respectively were used for the analysis. Pregnant women living in the rural areas were 37% (OR = 1.37, $p < 0.001$) more likely to have pre-eclampsia than pregnant women in the urban areas. Pregnant women in the poor wealth quintile were 7% at higher risk of having pre-eclampsia than those in the middle wealth quintile (OR = 1.07, $p = 0.493$), while pregnant women in the rich wealth quintile were 93% (OR = 0.93, $p < 0.001$) at lower risk of having pre-eclampsia compared with pregnant women in the middle wealth quintile. The overall decomposition model showed that occurrence of pre-eclampsia was 0.3188 ($p < 0.001$) in 2019 and 0.1309 ($p < 0.001$) in 2021 with a difference of 0.1879 ($p < 0.001$). There was a decline in the occurrence of pre-eclampsia among the pregnant women in the year 2022. Government intervention programmers and NGO efforts were the most contributing factors to the decline in the occurrence of pre-eclampsia.

Keywords: pre-eclampsia, logistic regression, Nigeria, morbidity and mortality

1. INTRODUCTION

Preeclampsia is a hypertensive illness condition that usually appears 20 weeks after conception and is one of the primary worldwide causes contributing to maternal and neonatal death and morbidity. According to [1], rising high blood pressure and protein in the urine are signs of a rapidly worsening scenario. These lead to ultimate chronic disability, severe morbidity, and death in both mothers and their offspring. About 910 women perished from pregnancy-related causes every day in 2014 [2]. The majority of these deaths were avoidable and occurred in communities with little resources or wealth. [3] state that one of the primary illnesses and fatalities that impact pregnant women is pregnancy-induced hypertension, which includes preeclampsia. Compared to five in industrialized nations, there were 550 maternal fatalities per day in Sub-Saharan Africa. The five direct obstetrical factors—high blood pressure, infection, delayed labor, sepsis, and issues related to abortion—account for more than 85% of all maternal fatalities [4]. Globally, pregnancy-related illnesses and deaths are significant public health concerns, especially in underdeveloped nations. Nigeria has one of the highest and most notable rates of maternity fatalities worldwide, accounting for 19% (64, 000) of all maternal deaths worldwide, with 741/100,000 live births and a maternal death rate [5].

Placental abruption, early delivery, acute renal failure, bleeding, and maternal mortality are among the risks associated with pre-eclampsia. Additionally linked to an increased risk of birth defects and low birth weight during pregnancy. The illness also affects the social and financial lives of expectant mothers. Additionally, the risk of developing metabolic syndrome, a stroke, cardiovascular disease, and other conditions later in life is higher for kids delivered during a complex pregnancy with preeclampsia [6,7]. These days, pre-eclampsia is mostly detected by healthcare professionals; hence, the illness is mostly avoidable. Low pre-eclampsia awareness and ignorance of pre-

eclampsia signs and symptoms are associated with a delay in seeking care, putting both the mother and the unborn child in danger as they are unaware of the significance of using medical facilities [8]. In Nigeria, preeclampsia is still a major problem that causes a great deal of maternal and newborn mortality. The aim of this study is to determine the incidence of preeclampsia and risk factors in pregnant patients getting antenatal care at University College Hospital Ibadan in Oyo State, Nigeria.

The specific goals are to analyze changes in preeclampsia among expectant mothers at University College Hospital Ibadan between 2019 and 2021, investigate variations in pre-eclampsia common occurrence and some of its associated factors in Nigeria between 2019 and 2021, and investigate the statistical relationship between pre-eclampsia and certain factors among pregnant women who visit ANC at University College Hospital Ibadan.

2. MATERIALS AND METHODS

■ Logistics Regression

Logistic regression is a subset of the generalized linear model, which is associated with linear regression and is widely used in health research. It is a type of regression model in which the dependent variable is categorical. It is used in combination with a logistic function to estimate the likelihood of a binary response, which is a variable with only two values, such as the occurrence or non-occurrence of an event, based on one or more independent variables.

— Logistic Regression Model

The simple multiple regression model in the form:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots \dots \beta_p X_p \quad (1)$$

where, Y is the response variable which is binary in nature

β 's are the coefficient of the explanatory variables

X's are the explanatory variables

Y can be expressed as $\text{logit}(p)$, where p is the probability of an event occurring. The occurrence of pre-eclampsia is the event of interest in this study.

The logit transformation is expressed as the log of odds:

$$\text{odds} = \frac{\text{probability of occurrence of pre-eclampsia}}{\text{probability of non-occurrence of pre-eclampsia}} = \frac{p}{1-p} \quad (2)$$

The log of the odds fluctuates between -1 and 1, as the odds range from 0 to 1. This implies that an additive unit change in the value of an explanatory variable is responsible for a change in the probability by a constant multiplicative amount.

$$\text{logit}(p) = \log(\text{odds}) = \log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \dots + \beta_p X_p \quad (3)$$

By using the model's exponential, this now becomes:

$$e^{\text{logit}(p)} = \text{odds} = \left(\frac{p}{1-p}\right) = e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \dots + \beta_p X_p} \quad (4)$$

$\text{Logit}(p) = z$ allows for the rewriting of equation 4 as:

$$e^z = \left(\frac{p}{1-p}\right) = e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \cdots \dots + \beta_p X_p} \quad (5)$$

The inverse of the logit function is called the logistic function.

$$p = \frac{e^z}{1+e^z} \quad (6)$$

■ Oaxaca Blinder Decomposition

The Oaxaca Blinder decomposition statistical technique can be used to split outcome variables between two groups into parts that can be explained by differences in the observed features and parts that can be explained by differences in the predicted regression model coefficients. The Blinder-Oaxaca decomposition approach is very necessary and beneficial for identifying and explaining the individual contributions of group variances in quantifiable characteristics like age, education, geography, and education to the occurrence of preeclampsia in its outcomes variable. For the intended outcome, the approach just requires the sample means of the independent

variables utilized in the regressions model and coefficient estimates from the linear regressions model. This makes it easy to implement. To discern the extent to which variations in the size of regression coefficients and group similarity in explanatory variable levels account for the variance in mean findings between two groups [9].

The difference in mean response across groups or over time is divided into components using a statistical technique known as multivariate Oaxaca Blinder decomposition, which represents the fluctuations in the mean levels of model predictors and their impacts on groups or over time. Multivariate decomposition offers further depth by examining the relative contributions of various factors to these components.

■ Decomposition in two steps

The Oaxaca blinder decomposition approach splits the regression model into two halves. The model consists of the years 2019 and 2021.

Regression model includes:

$$Y_{2019} = \alpha + \beta X_{2019} + \epsilon \quad (7)$$

$$Y_{2021} = \alpha + \beta X_{2021} + \epsilon \quad (8)$$

Y_{2019} and Y_{2021} represent occurrence of pre-eclampsia for year 2019 and 2021 respectively.

α represent the intercept term or constant

β represent the coefficient of the explanatory variables

X_{2019} & X_{2021} represent the explanatory variables for the year 2019 and 2021.

E represent the residual term.

By applying the Oaxaca blinder decomposition approach, the regression model is split into two halves. The model is composed of two groups: 2019 and 2021.

$$\bar{Y}_{2021} - \bar{Y}_{2019} = X_{2021}\beta_{2021} - X_{2019}\beta_{2019} \quad (9)$$

Subtract and then add $X_{2019}\beta_{2021}$ in equation 9

$$\bar{Y}_{2021} - \bar{Y}_{2019} = X_{2021}\beta_{2021} - X_{2019}\beta_{2021} + X_{2019}\beta_{2021} - X_{2019}\beta_{2019} \quad (10)$$

$$\bar{Y}_{2021} - \bar{Y}_{2019} = (X_{2021} - X_{2019})\beta_{2021} + X_{2019}(\beta_{2021} - \beta_{2019}) \quad (11)$$

The mean difference between equations (10) and (11) can therefore be used to rewrite Y:

$$\bar{Y}_{2021} - \bar{Y}_{2019} = \bar{X}_{2021}\hat{\beta}_{2021} - \bar{X}_{2019}\hat{\beta}_{2019} \quad (12)$$

$$\Delta\bar{Y} = (\bar{X}_{2021} - \bar{X}_{2019})\hat{\beta}_{2019} + \bar{X}_{2021}(\hat{\beta}_{2021} - \hat{\beta}_{2019}) + (\bar{X}_{2021} - \bar{X}_{2019})(\hat{\beta}_{2021} - \hat{\beta}_{2019}) \quad (13)$$

3. RESULTS AND DISCUSSION

■ Background and Characteristics of Pre-Eclampsia in Pregnant Women

Table 1 displays percentage change in the prevalence of pre-eclampsia based on a few background factors.

Table 1: Percentage change of pre-eclampsia occurrence according to some selected background characteristics

Factors	Pre-clampsia in 2019(%)	Pre-clampsia in 2021(%)	Percentage Change
Mothers' age			
< 20	112(21.5)	121(23.3)	8.4
20 – 35	309 (59.4)	320 (61.5)	3.5
> 35	99 (19.0)	79(15.2)	-20
Mother's Education			
None	152(29.2)	171 (32.9)	12.7
Primary	173 (33.3)	163 (31.3)	7.5
Secondary/Higher	195 (37.5)	186 (35.8)	-16.5
Place of Residence			
Rural	353 (67.9)	291 (56.0)	-17.5
Urban	167 (32.1)	229 (44.0)	37.1
Wealth Index			
Poor	205 (39.4)	210 (40.4)	2.5
Middle	196 (37.7)	204 (39.2)	4.0
Richer	119 (22.9)	106 (20.4)	-11
Number of children			
1	104 (20)	192 (37)	85
2	258 (49.6)	112 (21.5)	-56.7
3	224 (43.1)	136 (26.2)	-39.2
> 4	66 (12.7)	80 (15.4)	21.3

Pre-eclampsia prevalence increased by 8.4% over the course of two years, with the highest rates among women aged 20 to 35 (59.4% in 2019 and 61.5% in 2021), followed by those under 20 (21.5% in 2019 and 23.3% in 2021), and those 35 and older (19% in 2019 and 15.2% in 2021).

Pre-eclampsia was prevalent among women with higher education or secondary education (37.5% in 2019 and 35.8% in 2021) with 16.5 decrease within the two years. While the number of women with no formal education increased by 12.7% (from 29.2% in 2019 to 17.1% in 2021).

Pre-eclampsia was prevalent in rural areas among pregnant women (67.9% in 2019 and 56.0% in 2021) with little change over the two-year period. Pre-eclampsia affected nearly one-quarter (39.4% in 2019 and 40.4% in 2021) of pregnant women in the richest wealth quintile (22.9% in 2019 and 20.4% in 2021). This is an 11% drop in pre-eclampsia.

■ Logistic Regression Analysis of Factors Implicit in Pre-Eclampsia in Pregnant Women in 2019

Pre-eclampsia in pregnant women was investigated using a multivariate logistic regression to examine the factors impacting the condition. Pregnant women in the 20–35 year age group are at 39% higher danger of pre-eclampsia than under 20 years old (OR = 1.39, $p=0.001$), while those over 35 years old had a 7.0% higher risk (OR = 1.07, $p=0.445$).

Pre-eclampsia risk was increased by 40% (OR = 1.40, $p=0.001$) for pregnant women with no formal education compared to those with secondary or higher education, and by 14% (OR = 1.14) for pregnant women with secondary or higher education.

Pregnant women who resided in rural areas were 37% (OR = 1.37, $p=0.001$) more likely to develop pre-eclampsia than those who did in urban areas. Pregnant women in the wealthy wealth quintile had a 93% lower risk of getting pre-eclampsia (OR = 0.93, $p=0.001$) than those in the middle wealth quintile, who had a 7% greater risk (OR = 1.07, $p=0.001$) than those in the poor wealth quintile.

Table 2: Logistic Regression Analysis of Factors Implicit in Pre-Eclampsia in Pregnant Women in 2019

Factors	OR	95% Conf. Int Lower Upper		P-Value
Mothers' age				
< 20 ^c	1.00			
20 – 35	1.39	1.1703	1.6523	<0.001*
BBB> 35	1.07	0.8970	1.2807	
Mother's Education				
None	1.40			<0.001*
Primary	1.14	1.2099	1.6164	
Secondary/Higher ^c	1.00	0.9576	1.3447	
Place of Residence				
Urban ^c	1.00			<0.001*
Rural	1.37	1.2105	1.5556	
Wealth Index				
Poor	1.07	0.8872	1.2821	0.493
Middle ^c	1.00			<0.001*
Richer	0.93	0.7666	1.1183	
Number of children				
1 ^c	1.00			<0.001*
2	1.49	1.1704	1.6533	
3	1.08	0.8980	1.2808	
> 4	0.74	0.4788	0.7162	

c = Reference category, * $p<0.05$

■ Logistic Regression Analysis of Factors Implicit in Pre-Eclampsia in Pregnant Women in 2021

Pregnant women in the 20–35 year age range are 53% at higher chance of developing pre-eclampsia compare to those under 20 (OR = 1.53, $p=0.001$), while those in the 35 year and older range had a 7% reduced risk (OR = 1.07, $p=0.013$). Pregnant women without a formal education had a 7.0% higher risk of developing pre-clamsia than those with a secondary or higher education (OR = 1.70, $p=0.089$), while those without a formal education in primary school had an 11% higher risk of developing pre-eclampsia (OR = 1.11, $p=0.043$). Pregnant women in rural areas had a 12% (OR = 1.12, $p=0.003$) higher pre-eclampsia prevalence than those in urban areas. While pregnant women in the poor wealth quintile had a 1.0% higher risk of pre-eclampsia (OR = 1.01, $p=0.938$),

pregnant women in the middle wealth quintile had an 81% (OR = 0.81, p 0.001) lower risk of pre-eclampsia compared to pregnant women in the middle wealth quintile.

Table 3: Logistic Regression Analysis of Factors Implicit in Pre-Eclampsia in Pregnant Women in 2021

Factors	OR	95% Conf. Int Lower Upper		P-Value
Mothers' age				
< 20 ^c	1.00			
20 – 35	1.53	1.3807	1.6878	<0.001*
> 35	1.70	0.6195	0.7867	0.013*
Mother's Education				
None	1.07			
Primary	1.11	0.9895	1.1592	0.089
Secondary/Higher ^c	1.00	1.0031	1.2169	0.043*
Place of Residence				
Urban ^c	1.00			
Rural	1.12	1.0375	1.2033	<0.003*
Wealth Index				
Poor	1.01	0.9064	1.1121	0.938
Middle ^c	1.00			
Richer	0.81	0.7246	0.9060	<0.001*
Number of children				
1 ^c	1.00			
2	1.49	1.1704	1.6533	<0.001*
3	1.08	0.8980	1.2808	0.446
➤ 4	0.74	0.4788	0.7162	0.001*

c = Reference category, *p<0.05

Model of General Decomposition of Pre-Eclampsia in Pregnant Women

Oaxaca Blinder decomposition analysis was performed to examine the role that several factors had in explaining the variation in pre-eclampsia incidence between the years 2019 and 2021. Pre-eclampsia incidence was divided into three components; the composition effect, or the first part, is the result of variations in the distribution of the determinants between the years 2019 and 2021. The composition effect and coefficient effect combine to create the third component, which is the coefficient effect, which is the part of the effect that results from changes in these determinants' effects between the groups.

Pre-eclampsia incidence varied by 0.1879 (p0.001) between 2019 and 2021, from 0.3181 (p0.001) to 0.1309 (p0.001). Using the general decomposition model, this was made clear. According to Figure 2, the variation in each pre-eclampsia determinant's (coefficient) impact between 2019 and 2021 accounted for roughly 96.4% of the decrease in pre-eclampsia over the course of two years and 5.7% of the observed reduction in pre-eclampsia (p0.001). However, the interaction's influence was minimal and insignificant.

Table 4: Pre-Eclampsia Occurrences among pregnant women between 2019 and 2021: General decomposition model results

	Coefficient	Stand.Error	95% Conf. Int Lower Upper		P-value
2019	0.3188	0.006605	0.3058	0.3317	<0.001*
2021	0.1309	0.002022	0.1269	0.1348	<0.001*
Difference	0.1878	0.006908	0.1743	0.2014	<0.001*
Determinants	0.0098	0.002318	-0.0143	-0.0052	<0.001*
Coefficients	0.1991	0.013055	0.1735	0.2247	<0.001*
Interaction	-0.0014	0.011311	-0.0236	0.0206	0.896

*p<0.05

Each Factor's Contribution to Pre-Eclampsia Prevalence in Pregnant Women

Table 5 illustrates how each factor has affected how pre-eclampsia has changed over time. While the negative percentages show that a negative factor lessened the difference in pre-eclampsia between the years 2019 and 2021, the positive percentages show that a positive factor contributed to the difference.

Age contributed 9.7% (p0.001) of the observed decrease in pre-eclampsia to the change in pre-eclampsia incidence. Between the two years, there was a 4% documented decrease in pre-eclampsia cases due to residence (p = 0.013). Primary education contributed 5.9% (p=0.004) to the

observed difference in pre-eclampsia between the two years, whereas secondary/higher education contributed 14.0% (p0.002) to the observed difference.

To the reported decrease in pre-eclampsia between the two years, the poor wealth quintile contributed 1.3%, the middle wealth quintile contributed 0.7%, and the wealthier wealth quintile contributed –5.3%. The difference in pre-eclampsia was explained by the wealth index at –20.7%.

Table 5: Contribution of Each Determinant to Pre–Eclampsia Occurrence Among Pregnant Women Between 2019 And 2021

Factors	Coefficient	Stand.Error	95% Conf. Int Lower Upper		P–Value	% Contribution
Mothers' age	0.00114	0.00029	0.0005	0.0017	<0.001*	9.7
Mother's Education						
None ^c						
Primary	0.0008	0.00025	0.0003	0.0014	0.005*	6.9
Secondary/Higher	–0.0026	0.00050	–0.0034	–0.0009	<0.001	–15.0
Place of Residence						
Urban ^c						
Rural	0.0005	0.00019	0.0001	0.0008	0.013*	4.0
Wealth Index						
Poor ^c						
Middle	0.00008	0.00011	–0.0001	0.0003	0.457	0.7
Richer	–0.0005	0.00031	–0.0011	0.0001	0.099	–4.3
Number of children						
1 ^c						
2	–0.0001	0.00048	–0.0019	–0.0001	0.043*	–8.3
3	0.0107	0.00242	–0.0155	–0.0059	<0.001*	91.7
➤ 4	0.0016	0.000775	0.00003	0.0031	0.045*	13.3

c = Reference category, *p<0.05.

■ Differences in Pre–Eclampsia Determinants Contribution Among Pregnant Women

Table 6 displays the portion of the decomposition that results from variations in each determinant's effect over time (coefficient effect). 95.9% of the variation in pre-eclampsia between the two years was accounted for by the change in coefficient effects. 15.7% change, the residence had the biggest impact on preeclampsia prevalence. (p = 0.002). The age related variation in pre-eclampsia incidence was 5.8%.

Pregnant women with primary education provided 5.4% (p = 0.001), while those with secondary or higher education supplied roughly 10% (p 0.001). Education contributed 15.5% of the total. The richer category provided about half (5.2%) of this contribution (p = 0.009) to the change that occurred in occurrence of preeclampsia within two years, with wealth index accounting for about 9% of the difference in pre-eclampsia.

Table 6: Contribution: Differences in Pre–Eclampsia Determinants' Effect on Pregnant Women

Factors	Coefficient	Stand.Error	95% Conf. Int Lower Upper		P–Value	% Contribution
Mothers' age	–0.0115	0.0081	–0.0273	0.0044	0.158	–5.8
Mother's Education						
None ^c						
Primary	–0.0107	0.0032	–0.0169	–0.0045	0.001*	– 5.4
Secondary/Higher	–0.0202	0.0058	–0.0315	–0.0089	<0.001	–10.1
Place of Residence						
Urban ^c						
Rural	0.03118	0.0099	0.0116	0.0507	0.002*	15.7
Wealth Index						
Poor ^c						
Middle	0.00184	0.0038	–0.0056	0.0092	0.626	0.9
Richer	0.01029	0.0039	0.0025	0.0180	0.099*	5.2
Number of children						
1 ^c						
2	–0.00271	0.0140	–0.0302	0.0248	0.847	–1.4
3	–0.0035	0.0063	–0.0158	0.0089	0.582	–1.7
>4	0.19449	0.0222	0.1510	0.2379	<0.001*	97.7

4. CONCLUSION

According to the research, over past two years, pre-eclampsia incidence has reduced. Given substantial resources, programs, public education efforts, and intervention put forth by the management of University College Hospital (UCH), the Ministry of Health, and non-governmental

organizations, this reduction is not unexpected. Pre-eclampsia decreased by 45% in research conducted in Senegal between 1997 and 2011 [10]. According to [11], the percentage of pre-eclampsia patients fell by 55% in Ethiopia between 2001 and 2005.

Oyo State in the southwest still maintains a high pre-eclampsia rate even though this study revealed a decrease in pre-eclampsia incidence. According to study from Nigeria, where pre-eclampsia prevalence was shown to be comparable [8], this is consistent.

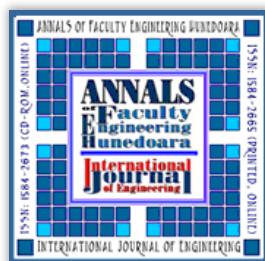
Pre-eclampsia is more common in rural than in urban areas, according to the results, which also indicated a relationship between the illness and place of residency. Pregnant women in urban areas were more aware of pre-eclampsia preventive strategies than those in rural areas were, according to a study conducted in south-south Nigeria that indicated pre-eclampsia is more prevalent in rural areas than in urban ones [12]. Women in this study with no formal education experienced pre-eclampsia more frequently, which may be related to the fact that these women were more likely to have received prompt and effective treatment if they had at least a secondary education. Furthermore, studies have shown a connection between maternal education and a successful pregnancy [13]. Higher educated pregnant women often have a better grasp on health problems and how to handle them. In this study, pre-eclampsia incidence was linked to household wealth: pre-eclampsia rates were greater among expectant women from homes in the lowest wealth quintile.

This study employed Oaxaca blinder decomposition analysis to explain the variations in pre-eclampsia incidence from 2019 to 2021. With the help of this methodology, it is possible to identify the percentage of changes that may be attributed to determinant changes as well as the percentage of changes in determinant effects between groups. The findings demonstrated that variations arise in the prevalence of pre-eclampsia are mostly caused in variations by the determinants' effects. According to the decomposition analysis, there will be fewer pregnant women developing pre-eclampsia in 2021 than there were in 2019. Pregnant women in Nigeria have little knowledge of PE. Higher education is a significant factor that facilitates adequate knowledge of pre-eclampsia. This emphasizes how critical it is to raise pre-eclampsia awareness among women in order to improve pregnancy outcomes. National education programs, social media, or contextual health education from ANC might all be used to spread knowledge. Awareness should be made for pregnant women to register at Antenatal Clinic at early stage of pregnancy for early detection and treatment of preeclampsia. Also, there is need for pregnant women to attend ANC follow up for early diagnosis and management of preeclampsia and strict adherence to advice from health care providers in order to prevent future complications. Similarly, educative programmes on factors associated with Preeclampsia and their consequences for mothers and their unborn children should also be emphasized during ANC followup. Finally, government should equip hospitals at secondary levels with standard resources both human and material so that Caesarean Sections be performed in cases of Emergencies.

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