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Bayesian analysis of the effects of some identified risk factors of systolic pressure among pregnant women in Ogbomoso, Oyo State, Nigeria

A. P. Onatunji [a,*], O. M. Ajao [b], K. T. Amzat [c], L. A. Oladimeji [a], O. A. Olalude [d]

[a] *Department of Statistics, Faculty of Pure and Applied Sciences, Ladoke Akintola University of Technology, Ogbomoso, Oyo State, Nigeria*
[b] *Department of Mathematical Sciences, Faculty of Natural Sciences, Ajayi Crowther Universisty, Oyo, Oyo State, Nigeria*
[c] *Departement of Mathematical Sciences, College of Natural and Applied Sciences, Crescent University, Abeokuta, Ogun State, Nigeria*
[d] *Department of Statistics, Faculty of Science, University of Ibadan, Nigeria*

Abstract

Unhealthy condition during pregnancy is a function of abnormal Systolic Blood Pressure (SBP). Therefore, this becomes a threat to women and health policy makers on how to reduce the consequence of high SBP. To overcome this challenge, appropriate model must be specified to capture some identified clinical-genetic factors for SBP in pregnant women when the informative prior to these factors is not sufficiently available. The aim of the study is to develop a Bayesian Logit (BLM) to calculate probabilities of different SBP outcomes among pregnant women in LAUTECH Teaching Hospital, Oyo State. The results shows that age, packed cell volume and genotype increase the likelihood of having High Systolic Blood Pressure (HSBP), while blood group and occupation increase the likelihood of having low Systolic Blood Pressure (LSBP) among pregnant women. Also, the probabilities of increase in height and weight cause a systematic change in the SBP among pregnant women. The study concludes that the identified clinical and genetic risk factors contribute to the likelihood of having HSBP and LSBP among pregnant women in Ogbomoso, Oyo State.

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1. Introduction

The effect of BP is highly dynamic among women of reproductive age in Nigeria. This effect cannot be taken for granted; because BP remains a major risk factor for many cardiovascular diseases especially when woman is pregnant. It also leads to Hypertensive Disorders(HDs) of pregnancy causing maternal mortality in Nigeria. Idris *et al.* [1] reported that HDs are high in Sub Sahara African countries. Azubuike & Danjuma [2] claimed hypertension in pregnancy places women at high risk of adverse outcome. Patterns of systolic and diastolic hypertension by age were discussed in the nationally representative National Health and Nutrition Examination Survey (NHANES) III and to determine when treatment and control efforts should be recommended.

*Corresponding author Tel. No.: +234-806-245-8811.
Email address: aponatunji@lautech.edu.ng (A. P. Onatunji)

This study categorized people with isolated systolic hypertension for those less than 50 years of age and above for both untreated and inadequately treated for uncontrolled hypertension. Eighty (80) percent of the older people were untreated and inadequately treated required a greater reduction in systolic blood pressure than those younger group people. Ajayi *et al.* [3] looked at the prevalence of hypertension among adults from a cross sectional study carried out at Mokola area of Ibadan, Oyo State. It was reported that there is a high prevalence of hypertension among adults as well as linear increase with age in this community. This underscores the need for an appropriate approach to control hypertension. Since the creation of the world, procreation remains a blessing to mankind but does not come without a burden of BP among pregnant women. Pregnant women are faced with unhealthy conditions related to SBP in Oyo State. Bamaiyi *et al.* [4] revealed that there is increase in BP as pregnancy develops. The BP is measured in Systolic and diastolic. Assessment of BP enables the diagnosis and management of hypertensive disorders of pregnancy to promote the instigation of life-saving treatments [5]. Disorders in pregnancy from mid-pregnancy (20^{th} week) contribute significantly to maternal and perinatal morbidity and mortality worldwide was reported after a test to know the association between trajectories of SBP during pregnancy and pregnant outcomes that women with different SBP trajectories were at varied risk of adverse maternal and fetal outcomes [6]. Some clinical and genetic factors have been identified to have an impact on SBP in woman with pregnancy.

The following risk factors that have been investigated in literature are age, cholesterol, parity, obesity, tobacco use, excessive use of alcohol, physical inactivity and unhealthy diet [7, 8]. Nigerian women with higher levels of diastolic BP, and the BP had significantly positive correlation with maternal age, height and Quetelex index after 28 weeks of gestation in literature. Dunietz *et al.* [9] found that moderately elevated BP in pregnancy is significantly associated with approximately 2 times the odds of future hypertension. The observed association between moderately elevated BP and future hypertension is larger when SBP is elevated before 20 weeks' gestation. In this same study, it was revealed that increase in BP is related to nutritional and lifestyle factors. Mahmoud *et al.* [10] indicated significant gaps in care and important areas for future studies to improve the quality of care and outcomes for pregnant women with hypertension in Nigeria, a country with the highest burden of maternal mortality globally. This study reported that pregnant women on medications contraindicated in pregnancy had a higher rate of newly diagnosed hypertension in Federal Capital Territory of Nigeria.

The efficacies of both systolic and diastolic BP level are now uncertain because of the failure to adequately demonstrate clinical trials and medication intervention [11]. Okonofua *et al.* [12] suggested that pregnant women with persistent elevation of blood pressures above 130/80 mmHg should be closely monitored. Pregnant women with moderately elevated systolic BP criteria had significantly higher odds of hypertension at follow-up may be at a risk of developing hypertension in the future [13]. Pregnancy offers an opportunity to identify women at risk of hypertension. A majority of pregnant women can have pregnancy induced hypertension relating the possible causes to eating too much salt, stress and over weight [14]. The study used knowledge and attitudes assessment to indicate a high proportion of awareness, hospital's education in the management of this disease.

The aim of the study is to develop a BLSM for pregnant women in LAUTECH Teaching Hospital. The SBP was weakly informative in the light of clinical and genetic risk factors in the study area. Therefore, this model would be used to evaluate the effect of clinical and genetic risk factors associated to SBP among pregnant women.

2. Materials and method

The dataset used in this study is a secondary data collected from Department of Antenatal Clinic, LAUTECH Teaching Hospital, Ogbomoso, Oyo State. Information on total number of 104 pregnant women was collected on response variable, SBP and the explanatory variables Genotype (GEN), Blood Group (BLO), Age, Parked Cell Volume (PCV), Occupation (OCC), Weight (WEI) and Height (HEI).

The SBP originally and metrically measured was recoded (high = 1 and low = 0), GEN (AA = 0, AS = 1, AC = 2), BLO(O = 0, A = 1, B = 2, AB = 3), PCV (low = 1, normal = 2, high = 3), OCC (teacher/researcher = 1, civil servant = 2, artisan = 3, healthworkers = 4, students = 5), Age (15 - 25 = 1, 26 - 35 = 2, 36 - 45 = 3) while both WEI and HEI were quantitatively measured in ratio scale. The BLSM was developed for pregnant women in Ogbomoso town.

Under the assumption that the response variable is binary, SBP is defined as

$$SBP_i = \begin{cases} 1, ...HSBP \\ 0, ...LSBP \end{cases}. \tag{1}$$

The SBP model for pregnant women assumes a dichotomous dependent variable, that is HSBP that takes the value of 1 with a probability of success(ω) or LSBP that takes the value of zero with a probability of having failure ($1-\omega$).

$$SBP_i = \log it\left(\frac{\omega}{1-\omega}\right) = GEN_i\theta_1 + OCC_i\theta_2 + AGE_i\theta_3 + BLO_i\theta_4 + PCV_i\theta_5 + WEI_i\nabla_1 + HEI_i\nabla_2. \tag{2}$$

3. Bayesian method

Parameter estimation in Bayesian approach follows the likelihood function, prior distribution and posterior simulation.

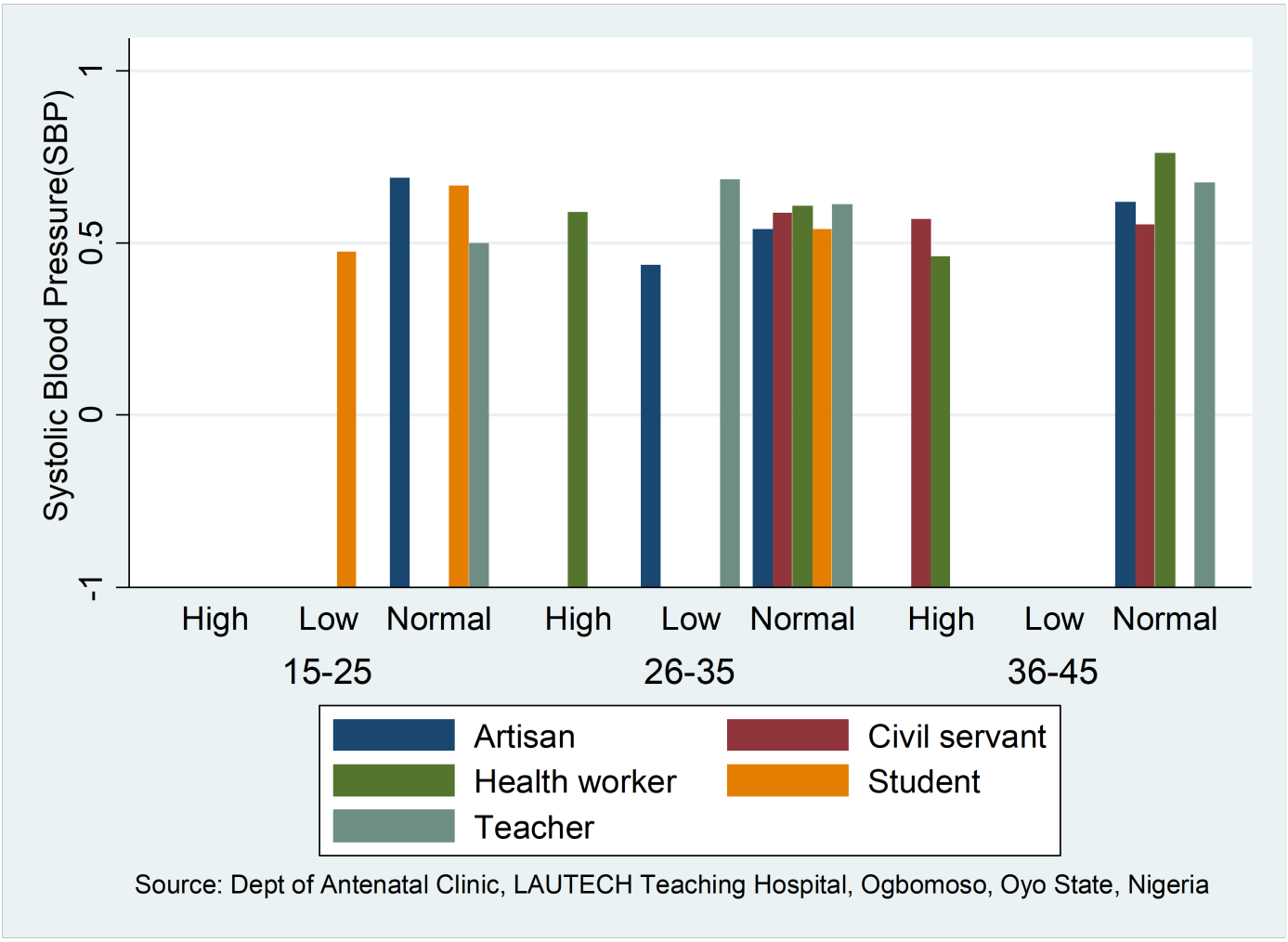

Figure 1: The SBP characterisized by clinical risk factors among pregnant women LAUTECH Teaching Hospital, Ogbomoso, Oyo State, Nigeria.

3.1. Likelihood function of systolic model parameters

The SBP response variable mentioned above follows binomial distribution from which its likelihood function is expressed as

$$L(SBP_i, \omega) = \begin{pmatrix} n \\ SBP_i \end{pmatrix} \omega^n (1-\omega)^{n-SBP_i}, \tag{3}$$

$$P(SBP_i = 1, i = 1, 2, ..., 104) = \omega, \tag{4}$$

where

$$\omega = \frac{1}{1 + \exp(GEN_i\theta_1 + OCC_i\theta_2 + AGE_i\theta_3 + BLO_i\theta_4 + PCV_i\theta_5 + WEI_i\nabla_1 + HEI_i\nabla_2)}. \tag{5}$$

3.2. Prior distributions for systolic model parameters

Different prior distributions were defined for these systolic model parameters when little or no prior knowledge is known about them. When no prior knowledge is known, diffuse priors are chosen for fixed effect parameters, variables distinguishable by nominal and interval scale.

$$p(\theta) \propto const. \tag{6}$$

Also, joint prior distribution is appropriate for the vector of unknown function evaluation of $f_i = (f_1 f_2)$ as the matrix product of a design matrix of metric covariates (Z), weight and height.

$$f_j = Z_j \nabla_j. \tag{7}$$

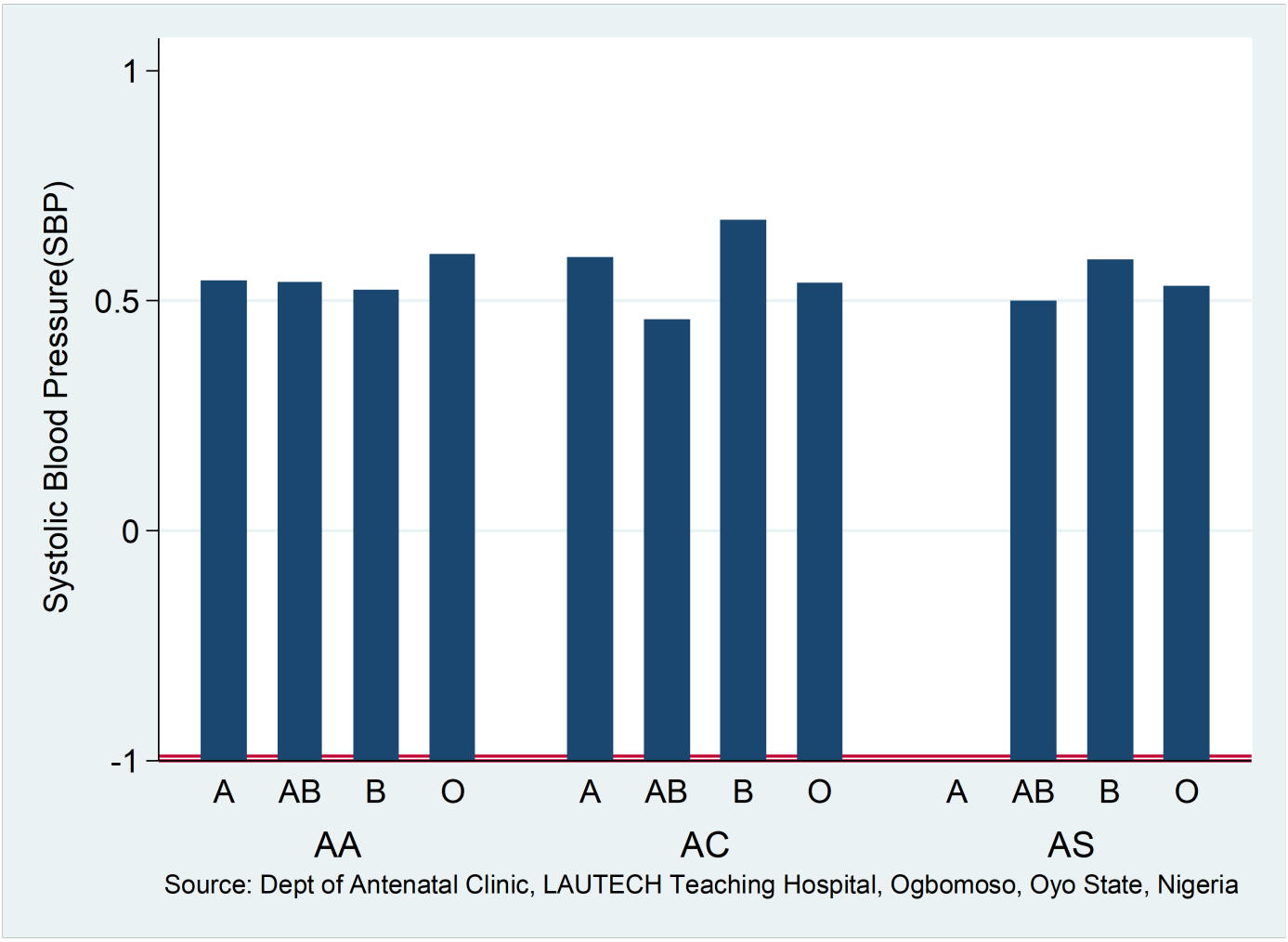

Figure 2: SBP characterised by genetic risk factors among pregnant women , LAUTECH Teaching Hospital, Ogbomoso, Oyo State, Nigeria.

Thus, joint prior for ∇_j is given by:

$$p\left(\nabla_j/\tau_j^2\right) \propto \frac{1}{\left(\tau_j^2\right)^{rank(k_j)/2}} \exp\left(-\frac{1}{2\tau_j^2}\nabla_j' k_j \nabla_j\right), \tag{8}$$

where k_j is a penalty matrix andτ_j^2, variance parameter is equivalent to inverse smoothing parameter in a penalized likelihood approach. In this study, random walk prior is designed for WEI and HEI independently with equally spaced ordered observations in the following equations.

$$z^1 < z^2 < \ldots < z^k. \tag{9}$$

First order random walk

$$\nabla_k = \nabla_{k-1} + u_k. \tag{10}$$

Second order random walk

$$\nabla_k = 2\nabla_{k-1} + \nabla_{k-1} + u_k, \tag{11}$$

such that

$$u_k \sim N\left((0, \tau^2\right), \tau^2 \sim gamma\,(\alpha = \beta = 0.001)\,. \tag{12}$$

3.3. Posterior distribution

Posterior simulation is required for fixed and non linear effect of the Equation (2), which is obtained by multiplying Equations (3), (6) and (8) to give Equation (13)

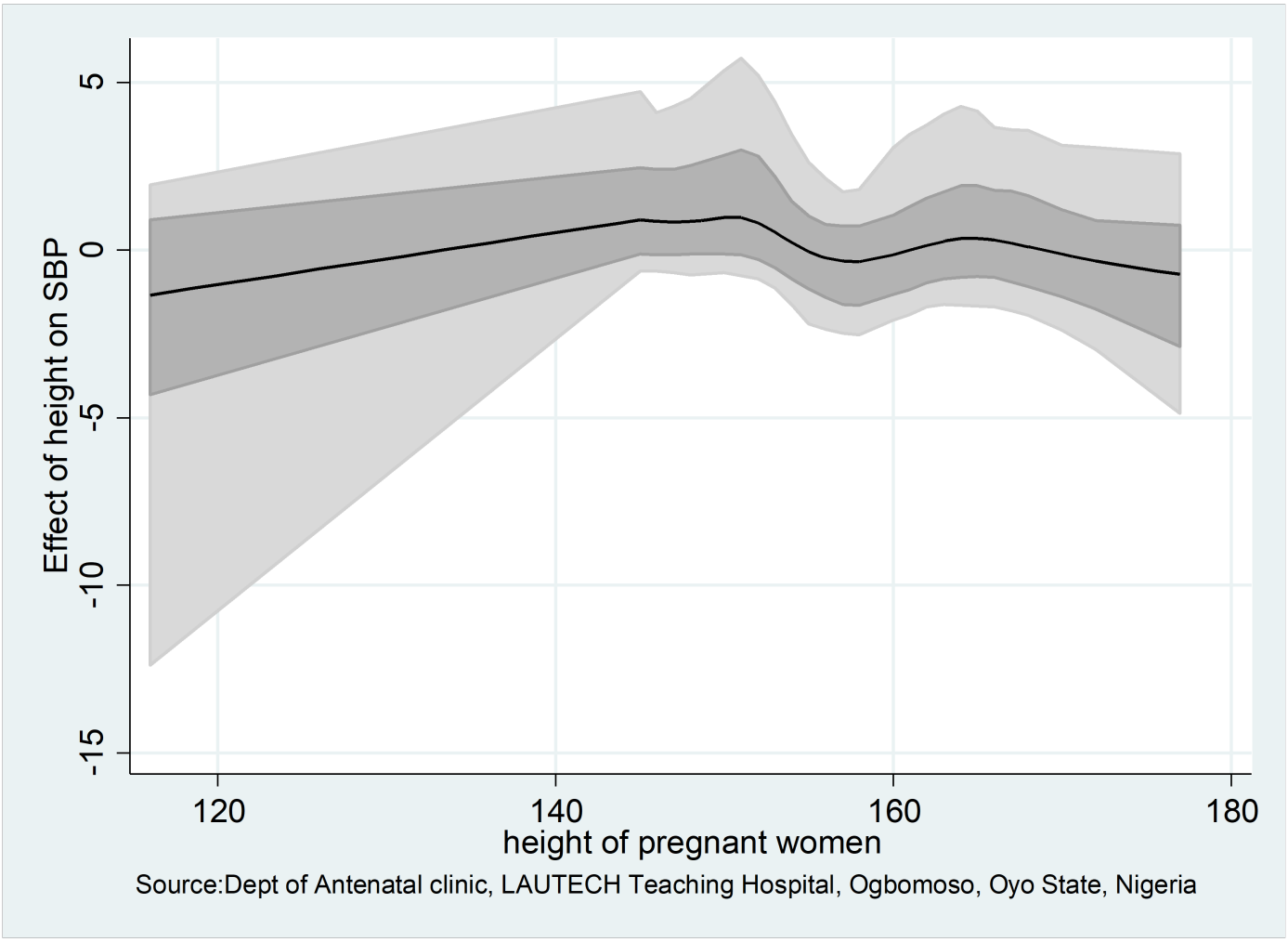

Figure 3: Effect of height of pregnant women on their systolic blood pressure at LAUTECH Teaching Hospital, Ogbomoso, Oyo State.

$$p\left(\varphi/SBP_i\right) = p\left(SBP_i\right) p\left(\nabla_j/\tau_j^2\right) p\left(\theta\right). \tag{13}$$

Equation (13) does not have unknown form of distribution. This equation is now analytically impossible. However, posterior simulation is now used with aids of statistical package, STATA 14. 2 version to carry out the analysis.

4. Results

This study numerically obtains the Posterior Means (PMs) and Posterior Standard Deviations (PSDs) of clinical and genetic risk factors. It also obtains the Odds ratio of SBP by different age groups. The charts for SBPs on clinical, genetic risk factors, nonlinear effects of weight and height on SBP were drawn and shown.

Figure 1 reveals that pregnant women between 15 - 45 years of age have low, normal and high PCV Suffer from SBP. It is evident in this figure that pregnant student between 15 - 25 have a normal PCV. Pregnant health workers between 26 - 45 years of age have a high PCV while those between 36 - 45 years of age have a normal PCV. Pregnant civil servants between 25 - 35 years of age have a high PCV. This shows that pregnant health workers and civil servants are mostly affected by SBP in Ogbomoso.

Figure 2 shows the graph of pregnant women with low-high SBP characterised by genetic risk factors, BLO and GEN. The figure reveals that pregnant women with GEN, AC under category of BLO, AB suffer from high SBP as against those with low SBP under category of GEN(AS) with BLO(O).

Table 1 shows the percentage and odds ratio with P- values of SBP grouped by age of pregnant women at 5% level of significance. The study reveals an increase in the pattern of the estimated odds ratio reflected in the percentage increase of SBP from 8.65 - 75.95 with an increase in age of pregnant woman from 15 - 35 years. Also, test of equal odds and trend for age groups were rejected. This

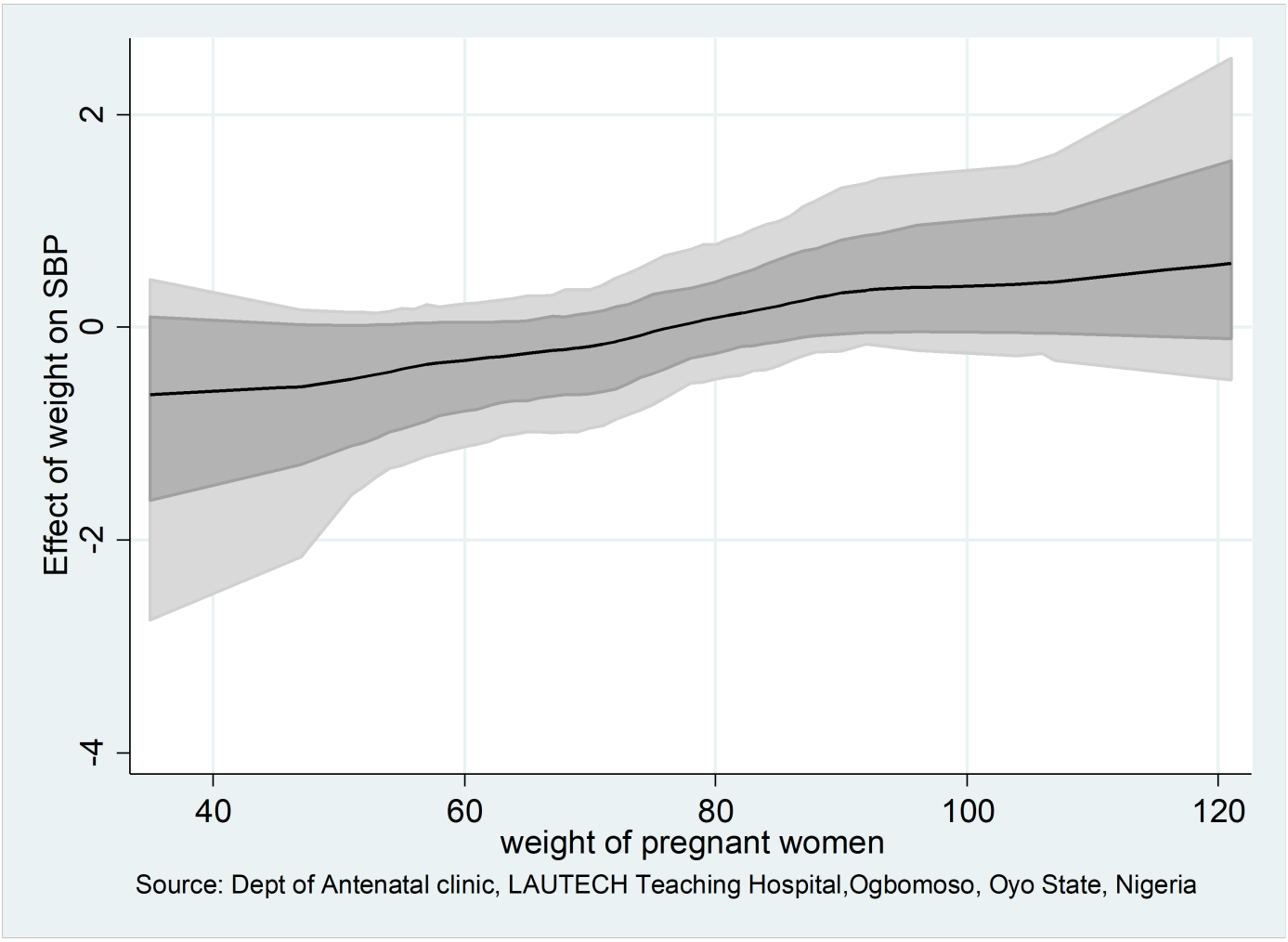

Figure 4: Effect of weight of pregnant women on their systolic blood pressure at LAUTECH Teaching Hospital, Ogbomoso, Oyo State.

Table 1: Odds ratio of SBP by age group of the pregnant women.

Age group of the pregnant woman	Percentage	Odds Ratio	P-value	Test of homogeneity	Trend of odds
15-25	8.65	1.00000			
26-35	75.96	0.95977	0.9615	0.0598	0.0552
36 -45	15.38	3.50000	0.1824		

implies that odds are differed across the age groups and that there no linear trend in the odds of SBP with an increase age groups of the pregnant women.

Figure 3 shows the systematic pattern of the effect of height of pregnant women at LAUTECH Teaching Hospital and its environs. The likelihood of increase in the height(in centimetres) of pregnant women between 120 cm - 140 cm causes steady increase in HSBP. However, there is unsteady change of SBP of pregnant women when their height is above 140 cm.

Figure 4 shows the systematic pattern of the effect of weight of pregnant women at LAUTECH Teaching Hospital and its environs. The likelihood of increase in the weight (in kilogram) of pregnant women between 40 kg - 120 kg causes steady increase in HSBP.

Table 2 shows the results obtained from some identified clinical and genetic risk factors of SBP for women during pregnancy at LAUTECH Teaching Hospital, Ogbomoso, Oyo State. Finding reveals the regression coefficients 0.114755, -0.365823, 2.252289, 0.77883, -0.080559 for GEN, BLO, PCV, Age and OCC respectively. This implies that estimates of GEN, PCV and Age cause the probability of HSBP among pregnant women. However, the obtained estimates of BLO and OCC cause the probability of LSBP for women during pregnancy.

Table 2: Effect of clinical-genetic risk factors on pregnant women at LAUTECH Teaching Hospital, Ogbomoso, Oyo State.

Risk factors	Posterior mean	Post standard deviation
Genotype(GEN)	0.114755	2.5041
Blood group(BLO)	-0.365823	0.356572
PCV	2.52289	1.25371
Age	0.77883	0.434044
Occupation(OCC)	-0.080559	0.232409

5. Discussion of results

The effect of systolic blood risk factors among pregnant women is poorly explained in LAUTECH Teaching Hospital, Ogbomoso and its environs. The results of statistical analysis will be in the form of the objectives as stated: to develop a Bayesian model of SBP during pregnancy. Findings in Figures 1 and 2 reveal that pregnant women who are civil servants, health workers and teachers within age category of 25 - 45 under different GEN and BLO suffered from HSBP. Pregnant women with GEN, A and AB for BLO, AC and AS respectively suffered from LSBP, while those in GEN, A, B and O suffer from HSBP. Also, Figures 3 and 4 show nonlinear effects in height and weight respectively. Increase in the HEI(in centimetres) and WEI(in kilogram) of pregnant women from 120 cm - 140 cm and from 40 kg - 120 kg respectively reflected likelihood of steady increase in HSBP. The Table 1 reveals an increase in estimated odds ratio of SBP from 8.65 - 75.95 with an increase in Age of pregnant woman from 15 - 35 years. While in Table 2, the estimates of risk factors considered clinically and genetically caused HSBP and LSBP. The risk factors GEN, PCV and Age caused the probability of HSBP, BLO, OCC and LSBP for women during pregnancy.

6. Conclusion

The aim of the study is to develop the appropriate model to capture some identified risk factors of SBP for women during pregnancy in LAUTECH Teaching Hospital, Oyo State Nigeria. The BSLM is introduced to deal with health problems associated with BP during pregnancy and to evaluate some identified clinical-genetic risk factors under different effects. Both fixed and non linear effects in the identified risk factors are adequately handled with the aids of BayesX software when little prior information defined on those factors. Findings in this study reveal that Age, PCV, HEI, WEI, GEN(AC and AB) positively contribute to the likelihood of having HSBP. While occupation and GEN(AS) under BLO(O) of the pregnant women negatively contribute to the likelihood of having HSBP.

In future study, we shall develop spatial model for medical impacts of HSBP among pregnant women in Oyo state. This is necessary because little or no geographical information exists about heterogeneity of the effects of the disease among pregnant women. Also, for the purpose of achieving Sustainable Development Goals (SDGs) for health intervention and treatment, attention is going to be geared towards the effect of clinical and genetic risk factors across all local government areas of the state.

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