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Modeling the Socio-Economic Factors of Type 2 Diabetes Among Outpatients of Some Selected Hospitals in Tamale, Ghana

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Abstract

Type 2 diabetes is among the most significant and quickly spreading public health challenges in today's society. Type 2 diabetes is becoming an epidemic and poses an increasing threat to world health due to cultural and societal changes, as well as the aging population in developing countries. The study seeks to model the socioeconomic factors of Type 2 diabetes among outpatients in Tamale, Ghana using proportional odds model. A total of 1,203 type 2 diabetes cases were obtained for this study; comprising 300 cases from SDA Hospital, 271 from Kabsad Hospital and 632 cases from Tamale Teaching Hospital. Findings show that age, occupation, residence and gender of patients are the socio-economic factors associated with Type 2 diabetes. The study further revealed that the proportional odds model has good diagnostic accuracy as the classification accuracy was above 60%. The study recommends that healthcare professionals work with dieticians, fitness experts, and mental health specialists to create individualized programs that take the patients' socioeconomic situation into account.

Keywords: Outpatient, Proportional Odds Model, Type 2 diabetes

Introduction

The World Health Organization (2021) describes Type 2 diabetes mellitus as a metabolic condition with a long history and high blood glucose or blood sugar levels as its hallmark. Over time, this illness has the potential to cause significant injury to the heart, blood vessels, eyes, kidneys, and nerves. Type 2 diabetes mellitus happens when the body either doesn't create enough insulin or can't use it well. Type 2 diabetes mellitus is a problem that is escalating, placing an increasing burden on individuals and having an effect on public health (Centers for Disease Control and Prevention, 2017). According to the WHO (2021), Type 2 diabetes mellitus is the main factor in renal disease, lower limb amputations, heart attacks, and strokes. Between 2000 and 2016, type 2 diabetes is thought to have directly contributed to 1.5 million fatalities, making it the tenth leading cause of death in 2019 (WHO, 2021). Obesity and Type 2 diabetes afflict some populations more severely than others, typically along social, racial, or economic lines, and the prevalence of type 2 diabetes mellitus is associated with rising obesity rates. In other words, type 2 diabetes mellitus

is the most prevalent disease caused by metabolic abnormalities (Azizi *et a*l., 2000). According to Tol *et al*. (2013), type 2 diabetes is currently the fourth leading cause of medical visits and the fifth leading cause of death in western countries. The World Health Organization (WHO), which has urged all governments to join the fight against type 2 diabetes mellitus since 1993 (Spinaci *et al*., 2006), notes that the condition is becoming an increasingly serious threat to global health. Type 2 diabetes mellitus has been identified in a vast body of literature as one of the chronic diseases with the quickest rate of growth in both Europe and Africa. Interventions have therefore been implemented globally to lessen its rising trend. According to studies from Spain (Lara-Rojas *et al.*, 2010; Tomlin *et al*., 2006), type 2 diabetes patients had hospitalization rates that were 2.6 times greater than those of non-patients with the condition globally. Over 45 million Africans between the ages of 20 and 79, according to the WHO, have impaired glucose tolerance, which puts them at a high risk of acquiring type 2 diabetes soon. By 2045, this number is expected to rise to 110 million if the necessary steps are not immediately implemented. Because of this, some African member nations have recently devoted a sizeable percentage of their health budgets to battling the illness inside their borders (Gudjinu and Sarfo, 2017; Atun *et al.*, 2017). It has been known that the number of adults aged 20 to 79 who have diabetes has increased by more than three times, from an estimated 151 million to 537 million (10.5%), and that the number will rise to 643 million by 2030 if the issue is not urgently addressed (IDF, 2021). Currently, type 2 diabetes mellitus makes up more than 90% of all cases of diabetes worldwide (IDF, 2019; Zimmet, 2017; Mbaye, 2014). It frequently goes hand in hand with aging, inactivity, unhealthy diet, and obesity (Arnett *et al.*, 2019). In Ghana, very little was known about Type 2 diabetes until the latter part of the twentieth century, despite its long history in the country (Amoah *et al.*, 1998; Amoah *et al*., 2002). Amoah *et al.* (1998) found a commonly held misconception that diabetes is a health issue of the wealthy in their extensive research of the condition across the country. Studies conducted at teaching hospital revealed a sharp rise in the admission of patients with endocrine disorders or type 2 diabetes mellitus of 633% over 31 years (Sarfo-Kantanka *et al*., 2016) and 9.7% over 9 years in Ghana (Sarfo-Kantanka *et al*., 2022).

Several studies have focused on lifestyle, psychological and nutritional factors that lead to Type 2 diabetes using different methodology other than proportional odds model to examine the said factors associated with Type 2 diabetes. While few studies have been done on socio-economic causes of Type 2 diabetes in Ghana, there is gap in the subject area in the context of Ghana, in that, no study has used proportional odds model to ascertain the socio-economic factors linked to Type 2 diabetes within Tamale using secondary source of data.

Related research work

According to country-specific studies by Werfalli *et al.* (2016) and Mensah (2013), diabetes has been connected to such socioeconomic characteristics as education, work status, income, and social status. According to a study by Parker *et al.* (2003), only men were shown to have an increased risk of acquiring diabetes. This connection may be explained by the cumulative effects of early exposure to the biological, social, and behavioral risk factors for diabetes. According to a study by the National Institute for Health and Care Excellence (2011), type 2 diabetes is more common in people over the age of 40, or over 25 for several black and minority ethnic populations.

The study by Hwang and Shon (2014) looked at the connection between type 2 diabetes and socioeconomic position. The relationship between SES and type 2 diabetes was identified using logistic regression after adjusting for variables such as age, income, gender, marital status, geography, body

weight, physical activity, smoking, and high-risk drinking. After adjusting for covariates, their results revealed that those with the lowest earnings had a higher likelihood of having type 2 diabetes than those with the highest incomes (OR 1.35; 95% CI 1.08 to 1.72). In order to ascertain the relationship between type 2 diabetes and obesity, Tol *et al.* (2013) carried out a descriptive-analytical study on 384 people with diabetes who were admitted to a diabetes center in the city of Isfahan. The study found an association between type 2 diabetes and education, profession, and income across all age groups of adults.

Materials and methods

Study samples and Data source

Outpatients with Type 2 diabetes made up of the study population. These statistics were gathered from the outpatient morbidity record systems of the Seventh-day Adventist Hospital, Kabsad Scientific Hospital and Tamale Teaching Hospital. Concerning the total number of patients with type 2 diabetes recorded in the medical record systems of the various hospitals, 632 cases were collected from Tamale Teaching Hospital, 271 cases from Kabsad Scientific Hospital and 300 cases from Seventh-day Adventist Hospital, respectively.

Study Area

The study was carried out in the Tamale Metropolis, Ghana. Tamale Metropolis is one of the 26 districts in the Northern Region of Ghana. It shares its borders with the Sagnarigu District to the West and North, the Mion District to the East, the East Gonja District to the South, and the Central Gonja District to the South-West. It is situated in the region's center. An approximated 646.90180 square kilometers of land make up the Metropolis (Ghana Statistical Service, 2021). In terms of latitude and longitude, the Metropolis is situated between 9º16 and 9º 34 north and 0º 36 and 0º 57west. A total of 374,744 people live in the Metropolis, including 189,693 women and 185,051 men (49.4% and 50.6% respectively). The population of the region and the country, respectively, are roughly 16.2% and 1.2% (Ghana Statistical Service, 2021). Surrounded by Tamale are the neighboring districts and metropolises, the likes of Kpandai, Saboba, Bolgatanga, Wa, and Navrongo.

Statistical Analysis

R console and stata version 14, were used to analyze all the data collected. The data was analysed using descriptive and inferential statistics. Descriptive statistics involves cross tabulation, mean and percentages. Proportional odds model as an inferential method was employed to model the socio-economic factors associated with Type 2 diabetes.

Model Specification

There are several regression models in the literature that are used to evaluate data with an ordinal response variable (McCullagh and Nelder, 1989; Brant, 1990; Ananth and Kleinbaum, 1997). Constrained and unconstrained partial odds models, continuation ratio models, polytomous logistic models, stereotype logistic models, and adjacent-category logistic models are a few of them. Ordinal refers to the order of the categories in ordinal logistic regression. So, when the dependent variable is measured at the ordinal level and there are one or more explanatory factors, which may be ordinal, continuous, or categorical, the regression method utilized is called the ordinal logistic regression (Sesay, 2021). As a result, the ordinal logistic regression model is the model of choice when the outcome variable is polychotomous and ordinal in nature, as it preserves information about the categories' ordering (Sesay, 2021).

Proportional Odds Model

Let Y denote an ordinal response variable with j levels (1, · · ·, j), and let X be a vector of p explanatory

variables, hereafter referred to as covariates. The proportional odds model uses j − 1 logits to compare the probabilities of an equal or smaller response ($Y \leq$ j) and a larger response ($Y >$ j), both conditional on the covariates.

$$\log(P(Y \leq j) = \log\left[\frac{Y \leq j}{Y > j}\right] = \alpha_j + \beta X \quad (1)$$

α_j (Intercepts) can differ with β (slope) being constant. The effect of X is the same for all $j-1$ ways to collapse Y into dichotomous outcomes (cumulatively).

Model Diagnosis

Residual Analysis

To determine whether the proportional odds model was adequate, residual analysis was performed to investigate the residuals. The residuals were computed using the cumulative logits or probabilities of the observed and anticipated data. In order to spot patterns or departures from the assumed proportionate odds assumption, the residuals were plotted against the expected values.

Proportional Odds Assumption

Verification was made of the proportional odds assumption, which postulates that the relationship between the explanatory factors and the response variable is constant at all levels of the ordinal response. Utilizing graphical methods like plot pairings and the diagnostic plot, this assumption was evaluated.

Sensitivity Analysis

The stability of the model estimates was investigated using sensitivity analysis. In order to determine the impact of these changes on the outcomes, the model may need to be re-estimated with new assumptions or alterations, such as the inclusion or exclusion of particular variables. Sensitivity analysis was used as a tool for assessing the accuracy and reliability of a model and its output.

Ethical Considerations

The research is carried out with much consideration to ethical issues (Bryman and Bell, 2015). The study achieved a standard of ethics such as seeking consent for the release of data from the Health Information Officers of the three hospitals within the Tamale metropolis. An introductory letter was taken from the Head of Statistics and Actuarial Science Department, C. K. Tedam University of Technology and Applied Sciences (CKT-UTAS), Ghana, which served as ethical backing for the study. Written permission was sought from managements of Tamale Teaching Hospital, Kabsad Scientific Hospital and Seventh-day Adventist Hospital before collection of data was done.

Results

Demographic characteristics of type 2 diabetes patients

Table 1 shows the socio-demographic features of patients who were diagnosed with type 2 diabetes at Seventh-day Adventist Hospital, Tamale. As shown in Table 1, the overall mean ages of Type 2 diabetes patients is 63 years. The average weights of type 2 diabetes patients from the hospital is 66 kg. More than half (67.0%) of the type 2 diabetes patients from the SDA hospital were females as against their male counterpart (33.0%). The majority (53.0%) of the patients have severe blood glucose level whilst few (18.7%) have mild blood glucose level. About (67.0%) of the respondents are from informal employee class as against few (2.0%) who are pensioners. The majority (68.0%) of the patients have not had any

formal education before with only 2.7% of the patients who have had their tertiary education. Most (52.7%) of the type 2 diabetes patients reside within Tamale Metropolis with few (1.7%) residing in Yendi. Table 2 shows the socio-demographic features of 632 patients who were diagnosed with type 2 diabetes at Tamale Teaching Hospital. The overall mean ages of type 2 diabetes patients is 63 years as shown in the results above. The average weights of type 2 diabetes patients from the hospital is 69 kg. More than half (63.9%) of the type 2 diabetes patients were females as against their male counterpart (36.1%). The majority (51.1%) of the patients have severe blood glucose level whilst few (21.8%) have mild blood glucose level. Most (51.1%) of the respondents are from informal employee class as against few (7.4%) who are pensioners.

More than half (72.3%) of the patients have not had any formal education before with only 4.1% of the patients who have had their basic education. Most (59.2%) of the type 2 diabetes patients reside within Tamale Metropolis with few (0.8%) residing in Kassena-Nankana District.

Table 3 shows the socio-demographic characteristics of 271 patients who were diagnosed with type 2 diabetes at Kabsad Scientific hospital. The overall mean ages of type 2 diabetes patients is 62 years as shown in the results above. The average weights of type 2 diabetes patients from the hospital is 71 kg. More than half (65.7%) of the type 2 diabetes patients from Kabsad hospital were females as against their male counterpart (34.3%). A larger proportion (73.4%) of the patients have severe blood glucose level whilst few (7.0%) have mild blood glucose level. Majority (58.7%) of the respondents are from informal employee class as against few (1.1%) who are pensioners. A good number (64.0%) of the patients have not had any formal education before with only 7.4% of the patients who have had their tertiary education. Most (58.7%) of the type 2 diabetes patients reside within Tamale Metropolis with few (0 .7%) residing in Yendi.

Table 1: Demographic characteristics of the type 2 diabetes patients from Seventh-day Adventist Hospital

	Mean (SD)	**N**	**%**
Age (Years)	63.18 (17.621)		
Weight (Kg)	66.09 (14.935)		
Gender			
Male		99	33.0
Female		201	67.0
Blood Glucose level			
Mild		56	18.7
Moderate		85	28.3
Severe		159	53.0
Occupation			
Unemployed		82	27.3
Informal employee		201	67.0
Formal Employee		11	3.7
Pensioner		6	2.0

Educational level		
None	204	68.0
Primary	39	13.0
JHS	23	7.7
SHS	26	8.7
Tertiary	8	2.7
Location		
East Gonja District	10	3.3
Saboba	19	6.3
Sagnarigu	100	33.3
Savelugu	5	1.7
Yendi	8	2.7
Tamale Metro	158	52.7

Table 2: Demographic characteristics of the type 2 diabetes patients from Tamale Teaching Hospital

Variables	Mean (SD)	N	%
Age (Years)	62.59 (14.01)		
Weight (Kg)	68.70 (14.30)		
Gender			
Male		228	36.1
Female		404	63.9
Blood Glucose level			
Mild		138	21.8
Moderate		171	27.1
Severe		323	51.1
Occupation			
Unemployed		221	35.0
Informal employee		323	51.1
Formal Employee		41	6.5
Pensioner		47	7.4
Educational level			
None		457	72.3
Primary		26	4.1
JHS		37	5.9
SHS		41	6.5
Tertiary		70	11.1
Location			
Bawku		6	0.9
Bole		26	4.1
Bolgatanga		28	4.4

East Gonja	15	2.4
Kassena-Nankana	5	0.8
Kpandai District	42	6.6
Mamprusi West	27	4.3
Sagnarigu	95	15.0
Savelugu Municipal	8	32.5
Tamale Metro	374	59.2
Tolon District	6	0.9

Table 3: Demographic characteristics of the type 2 diabetes patients from Kabsad Scientific Hospital

	Mean (SD)	N	%
Age (Years)	61.90 (14.51)		
Weight (Kg)	70.86 (19.73)		
Gender			
Male		93	34.3
Female		178	65.7
Blood Glucose level			
Mild		19	7.0
Moderate		53	19.6
Severe		199	73.4
Occupation			
Unemployed		159	58.7
Informal employee		105	38.7
Formal Employee		4	1.5
Pensioner		3	1.1
Educational level			
None		175	64.6
Primary		24	8.9
JHS		28	10.3
SHS		24	8.9
Tertiary		20	7.4
Location			
Kpandai		5	1.8
Saboba		6	2.2
Sagnarigu		88	32.5
Savelugu		11	4.1
Yendi		2	0.7
Tamale Metro		159	58.7

Diagnostic test for proportional odds model for Seventh-day Adventist Hospital

Table 4 shows the test of parallel assumption for this model at 5% significance level. From the omnibus test ($\chi^2 = 289.44, df = 11, p = 1 > 0.05$), parallel line assumption holds which means that the odds are the same across each of the cumulative logit.

Table 4: Test of parallel lines

	χ^2	df	probability
Omnibus	289.44	11	1
Weight	8.89	1	0
Age	9.84	1	0
Gender Female	0.41	1	0.52
Residence (Kpandai)	0	1	1
Residence (Saboba)	0	1	1
Residence (Sagnarigu)	0	1	1
Residence (Savelugu)	0	1	1
Residence (Yendi)	0	1	1
Occupa (Informal)	13.59	1	0
Occupa (formal)	42.25	1	0
Occupa (Pensioner)	0	1	0.95

*H_0 : Parallel Regression Assumption holds

It can be interpreted from Table 5 that the inclusion of Age and Residence in the final model (AIC=573.43, P=0.04<0.05) significantly provide better fit to the data than the null model (AIC=575.01).

Table 5: Model fitting information for Seventh-day Adventist Hospital

Parameters	Df	AIC	LRT	Pr(Chi)
Null		575.01		
Age+Residence	5	573.43	11.5857	0.04093 *
Age+Occupation	3	576.34	4.6728	0.19738
Residence+Occupation	7	582.88	6.1345	0.52414

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The results in Table 6 can be interpreted as meaning that for one unit increase in age, the log odds of having a mild blood glucose level decrease by 0.025. For type 2 diabetes patients living in Kpandai District who have a mild or moderate condition, the log odds of having a severe type 2 diabetes condition increased by 1.640 compared to those living in Tamale Metropolis. For those living in Saboba District with mild or moderate conditions, the log odds of having a severe type 2 diabetes condition decrease by 4.1 compared to those living in Tamale Metropolis. Again, for those living in Sagnarigu district with mild or moderate conditions, the log odds of having a severe type 2 diabetes condition decrease by 2.66 compared to those living in Tamale Metropolis. Furthermore, for those living in Savelugu Municipality with a mild condition, the log odds of having a moderate or severe type 2 diabetes condition increase by 6.32 compared to those living in Tamale Metropolis. For type 2 diabetes patients who are informal employees and have a mild or

moderate condition, the log odds of having a severe type 2 diabetes condition increase by 0.66 compared to those who are unemployed.

Interpretation of odds ratio for Seventh-day Adventist Hospital

The odds ratio for age is 0.975, which means that for every one unit increase in age, the odds of a patient having severe type 2 diabetes are as low as the odds of having mild type 2 diabetes. The odds ratio for this is statistically significant since the confidence interval does not include 1. The odds ratio for patients

Table 6: Proportional Odds Analysis of socio-economic factors of type 2 diabetes for Seventh-day Adventist Hospital

Variables	B	S.E.	t value	P-value	Exp(B)	95%C.I.for EXP(B)	
						Lower	Upper
α_1(Mild|Moderate)	-3.665	0.756	-4.849	0.000			
α_2 (Moderate|Severe)	-2.389	0.744	-3.211	0.001			
Weight	0.012	0.007	1.626	0.104	1.005	-0.002	0.026
Age	-0.025	0.006	-4.107	0.000***	0.975	-0.037	-0.013
Gender (Female)	-0.153	0.209	-0.735	0.462	0.857	-0.546	0.277
Residence (Kpandai)	1.640	0.408	4.019	0.000***	5.157	0.626	1.564
Residence (Saboba)	-4.119	0.314	-13.117	0.000***	0.016	-1.582	-0.432
Residence (Sagnarigu)	-2.662	0.443	-6.003	0.000***	0.069	-0.756	0.284
Residence (Savelugu)	3.588	0.400	8.966	0.000***	36.197	-0.823	0.306
Residence (Yendi)	6.323	0.236	26.703	0.000 ***	5.575	-0.330	1.041
Occupa (Informal)	0.663	0.221	2.991	0.002**	1.940	0.222	1.094
Occupa (formal)	0.477	0.609	0.783	0.433	1.612	-0.560	1.911
Occupa (Pensioner)	-0.389	0.559	-0.695	0.486	0.677	-1.387	0.863

within Kpandai District is 5.157, which means that for a patient living within the enclave of Kpandai District, the odds of having severe type 2 diabetes are five times as high as the odds of having mild type 2 diabetes. Again, the odds ratio for patients within Saboba District is 0.016, which indicates that for a patient living within Saboba District, the odds of having severe type 2 diabetes are as low as the odds of having mild type 2 diabetes. Finally, the odds ratio for patients who are informal employees is 1.940, which means that for a patient who is within the informal employee category, the odds of having severe type 2 diabetes are 1.940 times as high as the odds of having mild type 2 diabetes**.**

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Table 7 shows the diagnostics accuracy and effectiveness of the proportional odds models through sensitivity and specificity of the model. Sensitivity is the proportion of people with type 2 diabetes that have a positive blood test. Sensitivity of 89.7% shows that a good number of the type 2 diabetes cases are correctly identified as type 2 diabetes cases. Specificity is the proportion of people without type 2 diabetes that have a negative blood test. Specificity of 48.5% indicates that all healthy individuals are correctly identified as healthy. Positive Predictive Value indicates that, out of all positive findings, 86.1% are true positives. Negative Predictive Value also shows that, out of all the negative findings, 57.1% are true negatives. The Likelihood ratio of a Positive Test is 1.7 which indicates that the particular test result is more likely to

occur in type 2 diabetes patients with severe blood glucose level than in those with mild/moderate blood glucose level. Likelihood ratio of a Negative Test is 0.2 indicates that the particular test result is less likely to occur in type 2 diabetes patients with severe blood glucose level than in those with mild/moderate blood glucose level.

The overall performance of the model classification for type 2 diabetes cases is 80.7% which indicates a good diagnostic accuracy.

Table 7: Diagnostic accuracy and effectiveness of the Proportional Odds Model for Seventh-day Adventist Hospital

Parameter	Estimate	95% C.I.
Sensitivity	89.74%	(85.19, 93.01)
Specificity	48.48%	(36.85, 60.29)
Positive Predictive Value	86.07%	(81.16, 89.85)
Negative Predictive Value	57.14%	(44.14, 69.23)
Diagnostic Accuracy	80.67%	(75.82, 84.74)
Likelihood ratio of a Positive Test	1.742	(1.64, 1.85)
Likelihood ratio of a Negative Test	0.2115	(0.19, 0.25)
Diagnostic Odds	8.235	(4.34, 15.64)

Diagnostics of the model for Seventh-day Adventist Hospital

Figure 1 shows a diagnostic plot used to assess the model's fit. The plot assist in the assessment of the validity of the proportional odds assumption for the model. Since the plot shows no pattern, such as a U-shape, it indicates that the proportional odds assumption is not violated and that the model fit data.

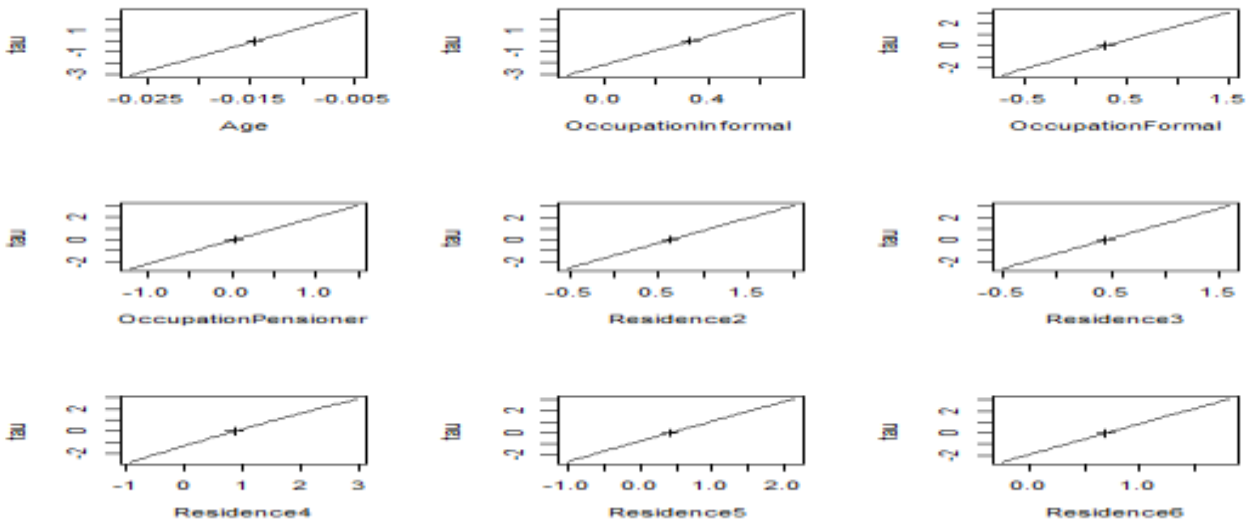

Figure 1: Diagnostic plot for Seventh-day Adventist Hospital

Figure 2 shows a random distribution of points with no discernible pattern, demonstrating the model's good fit and the fulfillment of the linearity and homoscedasticity presumptions. The scatter plot's lack of any discernible structure, such as a U-shape or a curve, indicates that the model is inadequate

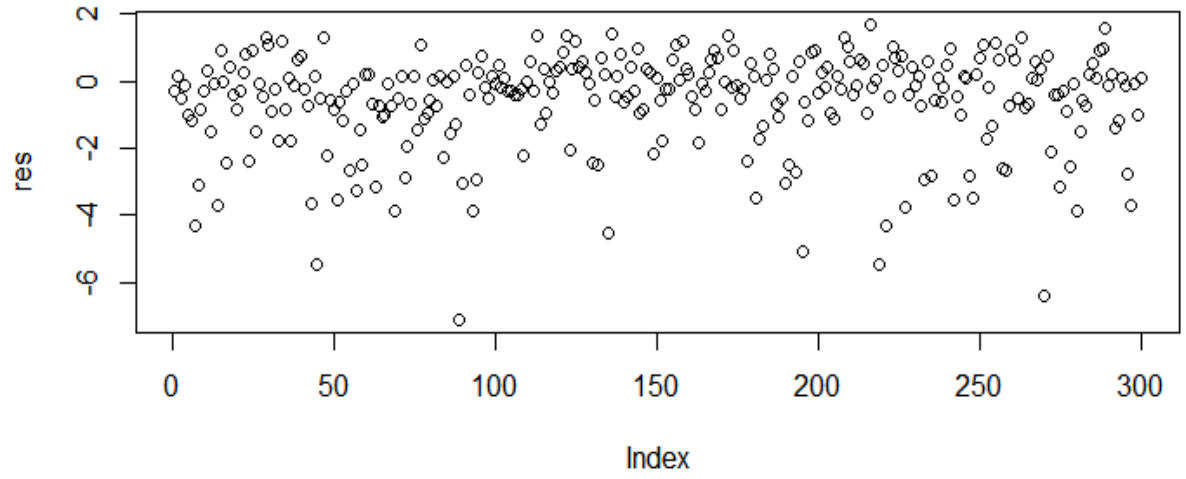

Figure 2: Residual plot for Seventh-day Adventist Hospital

Parallel assumption for this model was tested at 5% significance level as shown in Table 7. From the omnibus test ($\chi^2 = 52.28, df = 16, p = 1 > 0.05$), parallel line assumption holds which means that the odds are the same across each of the cumulative logit of the respondent variable (Glucose).

Table 8: Test of parallel lines for Tamale Teaching Hospital

	χ^2	df	probability
Omnibus	52.28	16	1
Age	3.04	1	0.08
Weight	3.46	1	0.06
Occupation (Informal)	2.16	1	0.14
Occupation (Formal)	4.45	1	0.03
Occupation (Pensioner)	1.1	1	0.29
Gender (Female)	3.69	1	0.05
Residence (Bolga)	0	1	0.99
Residence (East Gonja)	0	1	0.99
Residence (Kassena)	0	1	0.99
Residence (Kpandai)	0	1	0.99
Residence (Mamprusi)	0	1	0.99
Residence (Nanton)	0	1	0.99
Residence (Nanumba)	0	1	0.99
Residence (Sagnarigu)	0	1	0.99
Residence (Savelugu)	0	1	0.99
Residence (Tamale metro)	0	1	1

*H_0 : Parallel Regression Assumption holds

From Table 9 below, it can be observed that the final model (AIC=1093.1, P=0.000<0.05) significantly

provide better fit to the data than the null model (AIC=1100.3), as indicated by the small AIC value and the significant p-value.

Table 9: Model fitting information for Tamale Teaching Hospital

Parameters	Df	AIC	LRT	Pr(Chi)
Null		1100.3		
Residence+Gender	9	1093.1	25.186	0.002772 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The results below can be interpreted as meaning that the log odds of a female having severe type 2 diabetes increase by 0.260 relative to a male having a severe condition. For those living in Gonja East, the log odds of having a severe type 2 diabetes condition increase by 0.782 compared to those living in Bawku District. For those living in Kpandai district, the log odds of having a severe type 2 diabetes condition increase by 0.674 compared to those living in Bawku District. For type 2 diabetes patients living in Mamprusi District, the log odds of having a severe type 2 diabetes condition increase by 1.171 compared to those in Bawku District. Again, for type 2 diabetes patients residing in Nanton District, the log odds of having a severe condition increase by 0.945 compared to those in Bawku District.

Furthermore, for those living in Savelugu Municipality, the log odds of having a severe type 2 diabetes condition increase by 1.858 compared to those living in Bawku District. Finally, for those living in Tamale Metropolis, the log odds of having a severe type 2 diabetes condition increase by 1.858 compared to those living in Bawku District.

Interpretation of odds ratio for Tamale Teaching Hospital

The odds ratio for females having type 2 diabetes is 1.297, which means that the odds of having severe type 2 diabetes are 1.297 times as high as the odds of having mild type 2 diabetes. The odds ratio for patients within East Gonja District is 0.187, which indicates that for a patient living within East Gonja District, the odds of having severe type 2 diabetes are as low as the odds of having mild type 2 diabetes. The odds ratio for patients within Kpandai District is 1.962, which indicates that for a patient living within Kpandai District, the odds of having severe type 2 diabetes are as high as the odds of having mild type 2 diabetes. The odds ratio for patients within Mamprusi District is 3.227, which indicates that for a patient living within Mamprusi District, the odds of having severe type 2 diabetes are as high as the odds of having mild type 2 diabetes. Moreover, the odds ratio for patients within Nanton District is 2.573, which indicates that for a patient living within Nanton District, the odds of having severe type 2 diabetes are as high as the odds of having mild type 2 diabetes.

Table 10: Proportional Odds Analysis of socio-economic factors of type 2 diabetes Tamale Teaching Hospital

Variables	**B**	**Std. Error**	**t value**	**p value**	**Exp(B)**	**95%C.I.for EXP(B)**	
						Lower	**Upper**
α_1(Mild|Moderate)	0.301	0.654	0.461	0.644			
α_2 (Moderate|Severe)	1.294	0.656	1.969	0.048			

Age	-0.004	0.004	-1.087	0.276	0.995	-0.012	0.004
Weight	-0.001	0.004	-0.052	0.958	0.999	-0.007	0.007
Occupation(Informal)	0.134	0.109	1.223	0.221	1.143	-0.080	0.349
Occupation(Formal)	0.273	0.226	1.208	0.226	1.314	-0.165	0.723
Occupation(Pensioner)	-0.290	0.200	-1.454	0.145	0.747	-0.683	0.101
Gender(Female)	0.260	0.107	2.437	0.014*	1.297	0.051	0.469
Residence(Bolga)	0.773	0.556	1.388	0.165	2.166	0.626	1.564
Residence(East Gonja)	0.782	0.554	1.412	0.000**	0.187	-1.582	-0.432
Residence(Kassena)	-0.058	0.609	-0.096	0.922	0.942	0.756	0.284
Residence(Kpandai)	0.674	0.737	0.914	0.000***	1.962	-0.823	0.306
Residence(Mamprusi)	1.171	0.539	2.172	0.029*	3.227	-0.330	1.041
Residence(Nanton)	0.945	0.559	0.991	0.002**	2.573	0.222	1.094
Residence(Nanumba)	0.477	0.529	0.0846	0.433	1.045	-0.560	1.911
Residence(Sagnarigu)	0.810	0.633	1.279	0.200	2.249	-0.405	2.089
Residence(Savelugu)	1.858	0.519	3.575	0.003**	6.414	0.877	2.931
Residence(Tamale metro)	5.781	0.001	8805.958	0.000***	324.137	N.A	

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The diagnostics accuracy and effectiveness of the proportional odds models through sensitivity and specificity of the model is shown in Table 11. Sensitivity is the proportion of people with type 2 diabetes that have a positive blood test. Sensitivity of 79.1% shows that a good number of the type 2 diabetes cases are correctly identified as type 2 diabetes cases. Specificity is the proportion of people without type 2 diabetes that have a negative blood test. Specificity of 23.86% indicates that about 23.86% of all healthy individuals are correctly identified as healthy. Positive Predictive Value indicates that, out of all positive findings, 69.4% are true positives. Negative Predictive Value also shows that, out of all the negative findings, 34.1% are true negatives. The Likelihood ratio of a Positive Test is 1.0 which indicates that the particular test result

is more likely to occur in type 2 diabetes patients with severe blood glucose level than in those with mild/moderate blood glucose level. Likelihood ratio of a Negative Test is 0.9 indicates that the particular test result is less likely to occur in type 2 diabetes patients with severe blood glucose level than in those with mild/moderate blood glucose level.

The overall performance of the model classification for type 2 diabetes cases is 61.9% which indicates a good diagnostic accuracy.

Table 11: Diagnostic accuracy and effectiveness of the Proportional Odds Model for Tamale Teaching Hospital

Parameter	Estimate	95% CIs
Sensitivity	79.08%	(75.01, 82.64)
Specificity	23.86%	(18.44, 30.27)
Positive Predictive Value	69.64%	(65.44, 73.53)
Negative Predictive Value	34.06%	(26.68, 42.3)
Diagnostic Accuracy	61.87%	(58.02, 65.57)
Likelihood ratio of a Positive Test	1.039	(1.02, 1.05)
Likelihood ratio of a Negative Test	0.8768	(0.75, 1.02)
Diagnostic Odds	1.184	(0.79, 1.77)

Diagnostics of the model for Tamale Teaching Hospital

Figure 3 shows a diagnostic plot used to assess the model's fit. The plot assist in the assessment of the validity of the proportional odds assumption for the model. Since the plot shows no pattern, such as a U-shape, it indicates that the proportional odds assumption is not violated and that the model is appropriate for the data.

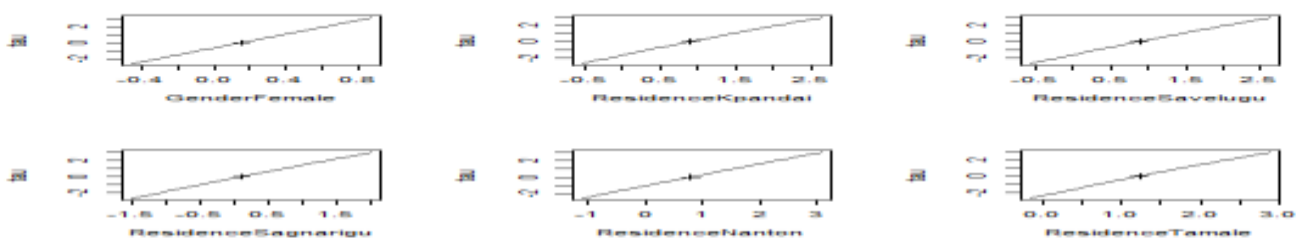

Figure 3: Diagnostic Plot for Tamale Teaching Hospital

Figure 4 displays a random distribution of points with no discernible pattern, demonstrating the model's good fit and the fulfillment of the linearity and homoscedasticity presumptions. The scatter plot's lack of any discernible structure, such as a U-shape or a curve, indicates that the model is inadequate.

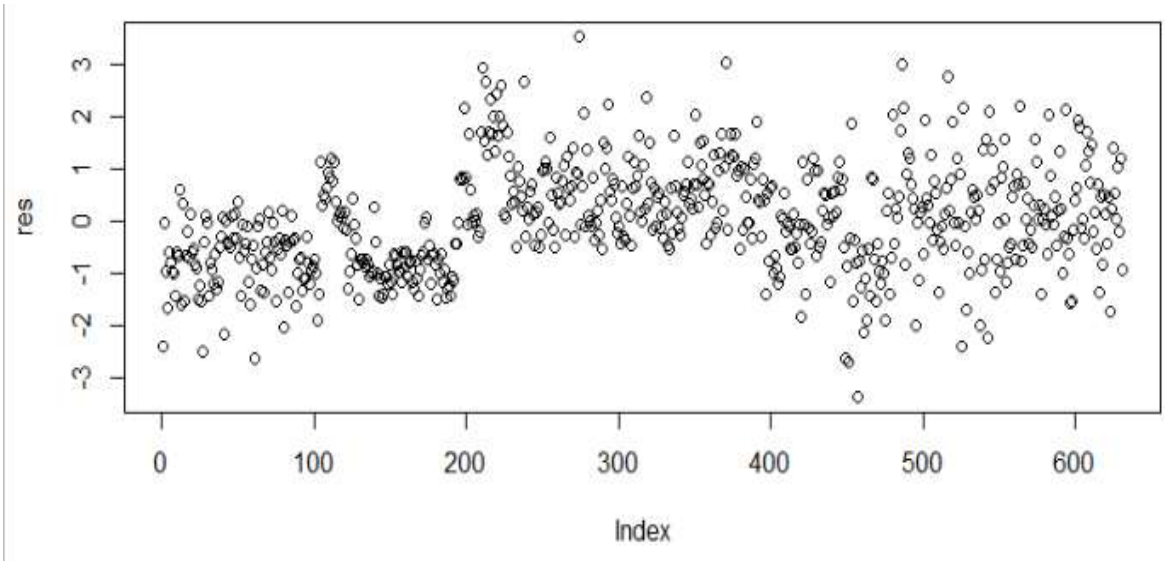

Figure 4: Residual Plot for Tamale Teaching Hospital

Parallel assumption for this model was tested at 5% significance level. From the omnibus test ($\chi^2 = 1.69\,, df = 6, p = 0.95 > 0.05$), parallel line assumption holds which means that the odds are the same across each of the cumulative logit.

Table 12: Test of parallel lines Kabsad Scientific Hospital

	χ^2	df	probability
Omnibus	1.69	6	0.95
Weight	0.01	1	0.91
Age	1.19	1	0.27
Occupation Informal	0.11	1	0.74
Occupation Formal	0	1	1
Occupation Pensioner	0	1	1
Gender Female	0.18	1	0.68

*H_0:Parallel Regression Assumption holds

From the results below, it can be observed that the final model (AIC=391.01, P=0.0204<0.05) significantly provide better fit to the data than the null model (AIC=391.83), as indicated by the small AIC value and the significant p-value.

Table 13: Model fitting information for Kabsad Scientific Hospital

Parameters	**df**	**AIC**	**LRT**	**Pr (Chi)**
Null		391.83		
Age+Occupation	3	391.01	3.1762	0.0204*

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

The results below can be interpreted as meaning that for every one-year increase in age, the log odds of having a mild blood glucose level decrease by 0.018. For type 2 diabetes patients who are formal employees and have a mild condition, the log odds of having a moderate or severe type 2 diabetes condition increase by 7.446 compared to those who are unemployed. Again, for type 2 diabetes patients who are pensioners with mild type 2 diabetes conditions, the log odds of having moderate or severe type 2 diabetes conditions increase by 5.206 compared to those who are unemployed.

Interpretation of odds ratio for Kabsad Scientific Hospital

The odds ratio for age is 0.982, which means that for every one unit increase in age, the odds of a patient having a severe type 2 diabetes are as low as the odds of having a mild type 2 diabetes. The odds ratio for is statistically significant since the confidence interval does not include 1. Again, for a patient who is within the formal employee category, the odds of having severe type 2 diabetes are as high as the odds of the having a mild type 2 diabetes. Finally, for a patients who are pensioners, the odds of having severe type 2 diabetes are as high as the odds of the having a mild type 2 diabetes.

Table 14: Proportional Odds Analysis of socio-economic factors of type 2 diabetes for Kabsad Scientific Hospital

Variable	B	S.E.	t value	P-value	Exp(B)	95%C.I.for EXP(B)	
						Lower	Upper
α_1(Mild|Moderate)	-3.4402	1.138	-3.020	0.002			
α_2 (Moderate|Severe)	-1.883	1.112	-1.693	0.090			
Weight	0.005	0.008	0.650	0.515	1.005	-0.010	0.021
Age	-0.018	0.010	-1.671	0.040*	0.982	-0.039	0.003
Gender (Female)	-0.117	0.160	-0.439	0.660	0.889	-0.596	0.579
Occupa (informal)	-0.016	0.298	-0.056	0.955	0.983	-0.012	0.671
Occupa (Formal)	7.446	0.000	1.647	0.000***	1714.6	-0.584	1.830
Occupa (Pensioner)	5.206	0.000	1.070	0.000 ***	182.2	-1.511	0.627

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Sensitivity is the proportion of people with type 2 diabetes that have a positive blood test. Sensitivity of 96.94% shows that a good number of the type 2 diabetes cases are correctly identified as type 2 diabetes cases. Specificity is the proportion of people without type 2 diabetes that have a negative blood test. Specificity of 29.27% indicates that all healthy individuals are correctly identified as healthy. Positive Predictive Value indicates that, out of all positive findings, 88.45% are true positives. Negative Predictive Value also shows that, out of all the negative findings, 63.16% are true negatives. The Likelihood ratio of a Positive Test is 1.37 which indicates that the particular test result is more likely to occur in type 2 diabetes patients with severe blood glucose level than in those with mild/moderate blood glucose level. Likelihood ratio of a Negative Test is 0.10 indicates that the particular test result is less likely to occur in type 2 diabetes patients with severe blood glucose level than in those with mild/moderate blood glucose level.

Table 15: Diagnostic accuracy and effectiveness of the Proportional odds model for Kabsad Scientific Hospital

Parameter	Estimate	95% C.I
Sensitivity	96.94%	(93.83, 98.51)
Specificity	29.27%	(17.61, 44.48)
Positive Predictive Value	88.45%	(83.9, 91.83)
Negative Predictive Value	63.16%	(41.04, 80.85)
Diagnostic Accuracy	86.67%	(82.09, 90.21)
Likelihood ratio of a Positive Test	1.371	(1.28, 1.467)
Likelihood ratio of a Negative Test	0.1044	(0.05, 0.21)
Diagnostic Odds	13.12	(4.78, 36.01)

Diagnostics of the model for Kabsad Scientific Hospital

Figure 5 shows a diagnostic plot used to assess the model's fit. The plot assist in the assessment of the validity of the proportional odds assumption for the model. Since the plot shows no pattern, such as a U-shape, it indicates that the proportional odds assumption is not violated and that the model is appropriate for the data.

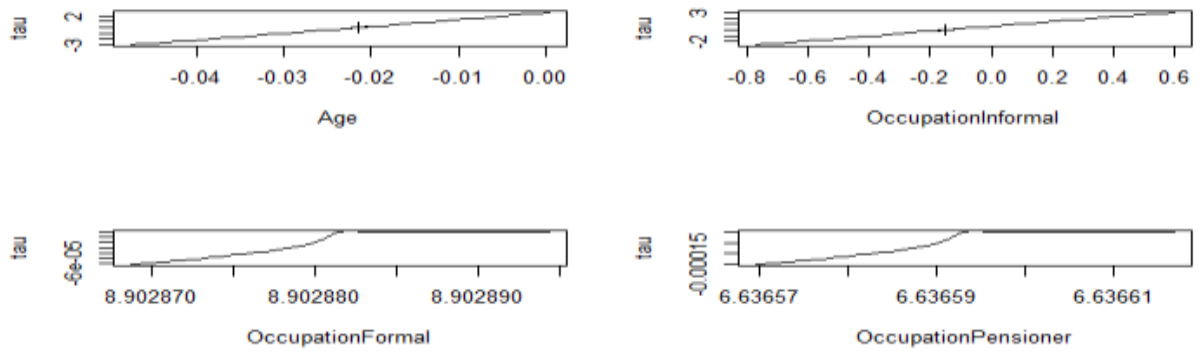

Figure 5: Diagnostic plot for Kabsad Scientific Hospital

The model is well-fitting and the requirements of linearity and homoscedasticity are met because Figure 6 displays a random dispersion of dots with no pattern. The lack of a distinct pattern in the scatter plot, such as a U-shape or a curve, indicates that the model is inadequate

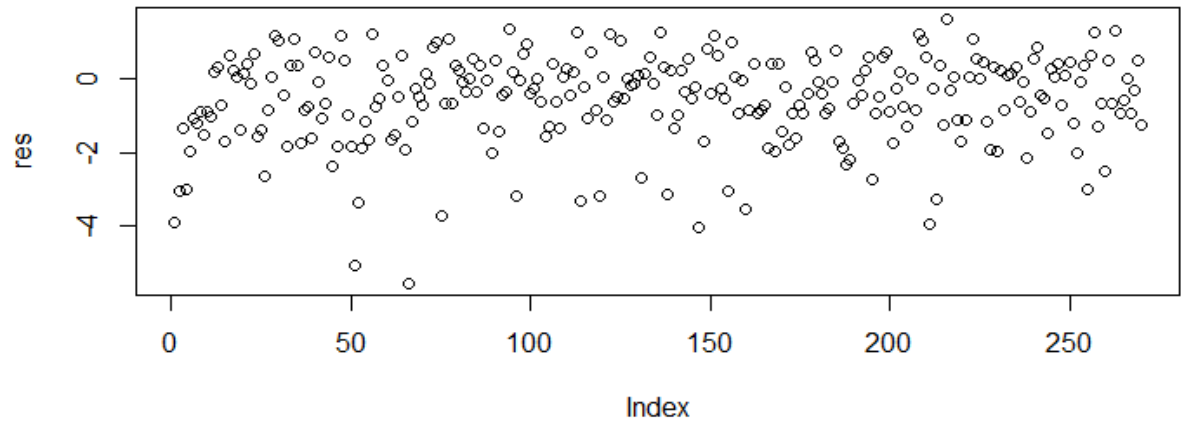

Figure 6: Residual Plot

Discussion of findings study

The study revealed that age emerged as a noteworthy socio-economic factor associated with type 2 diabetes across all the three hospitals in the Tamale metropolis. This finding aligns with prior research, which has consistently shown an elevated prevalence of type 2 diabetes among older individuals (Nguyen et al., 2012). Occupation was identified as a significant socio-economic factor linked to type 2 diabetes in patients from Kabsad Scientific Hospital. It's noteworthy that this association is relatively less explored in the existing literature. Further investigations are warranted to comprehensively elucidate the intricate relationship between occupation and type 2 diabetes risk. The research uncovered residence as a substantial socio-economic factor influencing type 2 diabetes among patients from both Seventh-day Adventist (SDA) Hospital and Tamale Teaching Hospital. This observation coincides with findings from the Centers for Disease Control and Prevention (CDC) suggesting regional disparities in type 2 diabetes rates. These variations are likely attributable to disparities in healthcare accessibility and lifestyle factors (Centers for Disease Control and Prevention, 2023).

Furthermore, the study recognized gender as a significant socio-economic factor contributing to type 2 diabetes risk in patients from Tamale Teaching Hospital. This finding is in accordance with previous studies demonstrating a higher incidence of type 2 diabetes among women compared to men (Silva et al., 2018). The study also found that the proportional odds model exhibited good diagnostic accuracy, with classification accuracy above 60%.

Conclusion and recommendation

The key socio-economic factors of type 2 diabetes are age, occupation, residence and gender. The Proportional odds model has sensitivity and specificity and a good classification accuracy to the type 2 diabetes data.

Healthcare professionals work with dieticians, fitness experts, and mental health specialists to create individualized programs that take the patients' socioeconomic situation into account. Healthcare professionals should take socioeconomic aspects into account when creating individualized treatment plans because age, weight, and gender can affect the prescription choices, dosage adjustments, and lifestyle changes.

References

1. Amoah, A. G., Owusu, S. K., and Adjei, S. (2002). Diabetes in Ghana: a community based prevalence study in Greater Accra. *Diabetes Research and Clinical Practice*, 56(3), 197-205.
2. Amoah, A. G., Owusu, S. K., Saunders, J. T., Fang, W. L., Asare, H. A., Pastors, J. G., and Osei, K. (1998). Facilities and resources for diabetes care at regional health facilities in southern Ghana. *Diabetes Research and Clinical Practice*, 42(2), 123-130.
3. Ananth, C. V., and Kleinbaum, D. G. (1997). Regression models for ordinal responses: a review of methods and applications. *International Journal of Epidemiology*, 26(6), 1323-1333.
4. Arnett, D. K., Blumenthal, R. S., Albert, M. A., Buroker, A. B., Goldberger, Z. D., Hahn, E. J., and Ziaeian, B. (2019). 2019 ACC/AHA guideline on the primary prevention of cardiovascular disease: executive summary: a report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines. *Journal of the American College of Cardiology*, 74(10), 1376-1414.

5. Azizi, F., Hatami, H., and Janghorbani, M. (2000). Epidemiology and Control of Prevalent Disease in Iran. *Khosravi Publication*, 6 (2), 265-79.
6. Brant, R. (1990). Assessing proportionality in the proportional odds model for ordinal logistic regression. *Biometrics*, 46, 1171-11788.
7. Bryman, A., and Bell, E. (2015). Business research methods. *Oxford University Press*, USA.7 (6).
8. Centers for Disease Control and Prevention. National diabetes statistics report (2017). Estimates of diabetes and its burden in the United States. Atlanta: Centers for Disease Control and Prevention.https://www.cdc.gov/diabetes/data/statistics-report/index.html.Accessed (12/03/2023).
9. Ghana Statistical Service (2021). Population and Housing Census report, Accra, Ghana.
10. Gudjinu, H. Y., and Sarfo, B. (2017). Risk factors for type 2 diabetes mellitus among out-patients in Ho, the Volta regional capital of Ghana: a case–control study. *BioMed Central Research Notes*, 10(1), 1-10. https://www.cdc.gov/diabetes/basics/type2.html.
11. International Diabetes Federation (2019). Diabetes at a glance Middle East and North Africa.
12. International Diabetes Federation (2021). IDF Diabetes Atlas 10th edition scientific committee. 13, 978
13. Lara-Rojas, C. M., Pérez-Belmonte, L. M., López-Carmona, M. D., Guijarro-Merino, R., Bernal-López, M. R., and Gómez-Huelgas, R. (2019). National trends in diabetes mellitus hospitalization in Spain 1997–2010: Analysis of over 5.4 million of admissions. *European Journal of Internal Medicine*, 60, 83-89.
14. Mbaye, M. N. (2014). The diabetes Africa foot initiative (DAFI). *Diabetes Research and Clinical Practice*, (103), 5-6.
15. McCullagh, P. and Nelder, J.A (1989). Generalized Linear Models New York: Chapman and Hall. http://dx.doi.org/10.1007/978-1-4899-3242-6. Accessed (2/2/2023).
16. Nguyen, Q. M., Xu, J. H., Chen, W., Srinivasan, S. R., and Berenson, G. S. (2012). Correlates of age onset of type 2 diabetes among relatively young black and white adults in a community: the Bogalusa Heart Study. *Diabetes care*, *35*(6), 1341–1346. https://doi.org/10.2337/dc11- 1818.
17. Olaiya, M. T., Knowler, W. C., Sinha, M., Kobes, S., Nelson, R. G., Baier, L. J., Muller, Y. L., and Hanson, R. L. (2020). Weight tracking in childhood and adolescence and type 2 diabetes risk. *Diabetologia*, *63*(9), 1753–1763. https://doi.org/10.1007/s00125-020- 05165-w
18. Sarfo-Kantanka, O., Asamoah-Boaheng, M., Arthur, J., Agyei, M., Barnes, N. A., Tenkorang, E. Y., and Midodzi, W. (2022). Trends in type 1 diabetes diagnosis in Ghana. *International Health*, 14(4), 442-446.
19. Sarfo-Kantanka, O., Sarfo, F. S., Oparebea Ansah, E., Eghan, B., Ayisi-Boateng, N. K., and Acheamfour-Akowuah, E. (2016). Secular trends in admissions and mortality rates from diabetes mellitus in the central belt of Ghana: a 31-year review. *Public Library of Science One*, 11(11), 16.
20. Sesay, R. B. A. (2021). Logistic Regression Model to Identify Factors Influencing Secondary School Students' University Attendance Decision in the Southern Part of Sierra Leone. 5, 7-10.
21. Silva A., Fida B., Margaret G., Marsha D. Marcus, Neil H. W. and Philip Z. (2018). Evaluation and Management of Youth-Onset Type 2 Diabetes: A Position Statement by the American Diabetes Association. *Diabetes Care*; 41 (12): 2648–2668. https://doi.org/10.2337/dci18-0052
22. Spinaci, S., Crowell, V., Currat, L., Kehler, J., Shetty, P., and World Health Organization. (2006). Tough choices: investing in health for development: experiences from national follow-up to

the Commission on Macroeconomics and Health. World Health Organization. https://apps.who.int/iris/handle/10665/43422. Accessed (1/4/2023).

23. Tol, A., Sharifirad, G., Shojaezadeh, D., Tavasoli, E., and Azadbakht, L. (2013). Socio-economic factors and diabetes consequences among patients with type 2 diabetes. *Journal of Education and Health Promotion*. 2(1), 12
24. Tomlin, A. M., Tilyard, M. W., Dovey, S. M., and Dawson, A. G. (2006). Hospital admissions in diabetic and non-diabetic patients: a case-control study. *Diabetes Research and Clinical Practice*, 73(3), 260-267.
25. World Health Organization (2021). Diabetes. https://www.who.int/news-room/fact-sheets/detail/diabetes. Accessed (2/3/2023).
26. Zimmet, P. Z. (2017). Diabetes and its drivers: the largest epidemic in human history? *Clinical Diabetes and Endocrinology*, 3(1), 1-8.