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ORIGINAL RESEARCH

Beta Inflated Regression Models on the Physical and Mental Health of Nigerian Stroke Survivors

Oritogun KS*[1], Oyewole OO[2]

[1]Department of Community Medicine and Primary Care, Faculty of Clinical Sciences, Obafemi Awolowo College of Health Sciences, Olabisi Onabanjo University, Sagamu, Ogun State, Nigeria
[2]Department of Physiotherapy, Olabisi Onabanjo University Teaching Hospital, Sagamu, Ogun State, Nigeria

*Correspondence: Dr KS Oritogun, Department of Community Medicine and Primary Care, Faculty of Clinical Sciences, Obafemi Awolowo College of Health Sciences, Olabisi Onabanjo University, Sagamu, Ogun State, Nigeria. E-mail: oritogunks@yahoo.co.uk, ksoritogun@gmail.com; ORCID - https://orcid.org/0000-0003-0335-0770.

Abstract

Background: Stroke is one of the major public health problems worldwide. Physical and mental health data of stroke survivors are often expressed in proportions. Therefore, the Beta Regression models family for data between zero and one will be appropriate.
Objectives: To identify a suitable model and the likely risk factors of physical and mental health of stroke survivors.
Method: Secondary data of stroke survivors from two tertiary health Institutions in Ogun State, Nigeria, were analysed. Inflated Beta (BEINF) and Inflated-at-one-Beta (BEINF1) models were compared using Deviance (DEV), Akaike Information Criterion (AIC) and Bayesian Information Criteria (BIC) for model selection. The model with minimum DEV, AIC and BIC was considered to be better.
Results: The deviance (-86.0604,), AIC (-46.0604) and BIC (6.4391) values of the BEINF1 model for physical health and the deviance (-20.1217), AIC (19.8783) and BIC (72.3778) values of BEINF1 model for mental health were smaller than BEINF models. Therefore, BEINF1 was the better model to identify the health risk factors of stroke survivors. Age, marital status, diastolic blood pressure, disability duration and systolic blood pressure had a significant association with physical health, while BMI had a significant positive association with mental health.
Conclusion: The beta-inflated-at-one (BEINF1) model is suitable for identifying health risk factors of stroke survivors when the outcome variable is a proportion. Both demographic and clinical characteristics were significantly associated with the health of stroke survivors. This study would assist researchers in knowing the appropriate model for analysing proportion or percentage response variables.

Keywords: Inflated at one Beta, Inflated Beta, Mental health, Physical health, Stroke survivors.

Introduction

Stroke, also called cerebrovascular accident (CVA), can be defined as a brain attack, which happens when there is no flow of blood to parts of the brain which eventually results in brain cell death. [1, 2] In both developed and developing countries, stroke is the second leading cause of death. [3] The two types of stroke are ischaemic and haemorrhagic strokes which occur when blockages cut off the blood supply to parts of the brain or when a weakened vessel ruptures and

bleeds into the surrounding brain. [1] There are combinations of many risk factors contributing to the development of stroke. [4] Globally, people living and have experienced a stroke are more than 80 million, with about 60% under 70 years of age. [5] A higher proportion of people who have experienced and survived a stroke are women (51%). More than half (56%) of health life was lost due to stroke-related death and disability among men. [5] A study revealed that 65% of the respondents had an ischaemic stroke with a mean age of 55 years.[6] That study also showed that the most common risk factor of stroke was hypertension. As revealed by the logistic regression model, other factors included alcohol intake, previous stroke, family history of stroke, HIV infection, and tobacco smoking/sniffing. [7] Another study examined the direct cost of stroke management and suggested that the economic burden may be higher in stroke management. [8] Post-stroke depression is a global issue among stroke survivors and sometimes unrecognised and undertreated. It was noted that if proper attention is given to stroke patients, some of the causes may be prevented.[8] Some of the risk factors are modifiable; these include high blood pressure, smoking, diabetes mellitus, hypercholesterolaemia, physical inactivity and obesity, carotid or other artery diseases, certain blood disorders, excessive alcohol intake, illegal drug use and sleep apnoea, among others. Factors that cannot be controlled include increasing age, gender, heredity and race, and prior stroke. [9]

There are many studies on stroke survival data with a diverse use of statistical analysis methods. The Chi-Square test was used in a study to identify risk factors for stroke in the elderly. [4] It was shown that the mean age of the respondents was 69.7 years with some risk factors such as obesity, heart disease in the family, smoking and the female gender. [4] A case-control study on haemorrhagic and ischaemic stroke risk was carried out in Bangladesh using multivariate logistic regression. [10] The study showed that fruit consumption, table salt intake, psychosocial stress, abnormal ECG and increased Waist-Hip Ratio (WHR), among others, were significantly associated with stroke. [10] Mulat and others made use of logistic regression to identify factors associated with stroke in Ethiopia. [11] Older age, hypertension, diabetes mellitus, cardiac diseases, alcohol intake and cigarette smoking, were associated with stroke. [11] Also, a previous study analysed data collected from the elderly using log-binomial regression and reported that depression, sex and age were significantly associated with stroke. [12]

Analysis of Variance (ANOVA) for repeated measures was used to assess patient education intervention on lifestyle risk factors in another study. [13] Hypertension, physical inactivity, unhealthy diet, excessive alcohol intake and smoking, among others, were factors associated with stroke. [2,13–19] In Nigeria, the Chi-Square test was used to identify gender variations in the risk factors of acute stroke. Smoking, education and alcohol were significantly associated with the gender of stroke patients. [20] Another study in India also used the Chi-square test to identify factors associated with return to work after stroke. [21] Some other studies used descriptive statistics such as frequency percentages, cross-tabulations, logistic regression and survival curves to identify some risk factors. [2,16–19,22,23]

However, some of the stroke data are in proportions or percentages. Therefore, while modelling such data, the appropriate model must be applied to obtain the correct estimate and the likely risk factors. Beta regression models family will be adequately fit for such data. [24] The response variable has values ranging between zero and one. Swearingen and others analysed ischaemic stroke volume using the beta regression model. [25] They reported that age, weight, systolic blood pressure, diastolic blood pressure, self-reported alcohol usage and cardio-

embolic phenomenon were significantly associated with stroke. [25] Other studies have applied beta regression models to data other than physical and mental health. [26–28] The objective of this study was to model the physical and mental health of stroke survivors using Beta Inflated Regression models.

Methods

Settings and data

The secondary data of 102 stroke survivors from two tertiary health institutions in Ogun State (the Olabisi Onabanjo University Teaching Hospital, Sagamu and the Federal Medical Centre, Abeokuta.) were used for the study. A detailed description of the design and sampling technique has been reported elsewhere. [29]

Ethical consideration

This study employed secondary data, and therefore, ethical approval was not required. However, the primary research got ethical approval, as documented elsewhere.[29]

Outcome variables and covariates

The physical and mental health scores of the respondents were the outcome variables expressed in proportions or percentages. Assessment and the constituents of physical and mental health have been reported elsewhere. [29] Independent variables were demographic (age: X_1, sex: X_2, marital status: X_3, religion: X_4, occupation: X_5, education: X_6) and clinical (disability duration: X_7, Height: X_8, weight: X_9, systolic blood pressure: X_{10}, diastolic blood pressure: X_{11} and body mass index: X_{12}) characteristics.

Models [28]

Inflated at zero and one beta (BEINF) model

The BEINF model is appropriate when the outcome or response variable has a restricted interval, including the two endpoints [0, 1]. Let Y be the response variable, then zero and one have non-zero probabilities ρ_0 and ρ_1, respectively. The probability density function of the inflated beta distribution, BEINF (μ,σ,υ,τ) can be defined as:

$$fY(y \setminus \mu,\sigma,\upsilon,\tau) = \begin{cases} \rho_0 & if \quad y = 0 \\ (1-\rho_0-\rho_1)\dfrac{1}{B(\alpha,\beta)} y^{\alpha-1}(1-y)^{\beta-1} & ,if \quad 0 < y < 1 \\ \rho_1 & if \quad y = 1 \end{cases} \qquad (1)$$

$\Sigma = (\alpha+\beta+1)^{1/2}$, $E(y)=\frac{\tau+\mu}{1+\upsilon+\tau}$

Inflated-at-one-beta (BEINF1) model

The BEINF1 model is appropriate when the outcome variable has a restricted interval that includes only one of the endpoints (0,1]. In this model, 1 is taking as part of the values of the response variable.

$$fY(y \setminus \mu,\sigma,\upsilon) = \begin{cases} (1-\rho_1)\dfrac{1}{B(\alpha,\beta)} y^{\alpha-1}(1-y)^{\beta-1} & if \quad 0 < y < 1 \\ \rho_1 & if \quad y = 1 \end{cases} \qquad (2)$$

$\Sigma = (\alpha+\beta+1)^{-1/2}$, $E(y)=\frac{\upsilon+\mu}{1+\upsilon}$

Statistical analysis

The R programming package and Statistical Package for Social Sciences (SPSS version 23) were used to analyse. Two models: Inflated Beta (BEINF) and Inflated-at-one-beta (BINF1) regression models, were applied in this study. Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC) and Deviance were employed to select the better of the two models. The model with the minimum value of Deviance, AIC and BIC was considered the better model. *P* values < 0.05 were statistically significant.

Results

Table I shows the criteria for model selection for inflated beta regression and inflated-at-one-beta regression model. The values of deviance (-86.0604), AIC (-46.0604) and BIC (6.4391) in the BEINF1 model for physical health for combined (demographic and clinical) characteristics were smaller than those of the BEINF model. Therefore, BEINF1 was the better model. The values of deviance (-20.1217), AIC (19.8783) and BIC (72.3778) in the BEINF1 model for mental health for combined (demographic and clinical) characteristics were smaller than those of the BEINF model. Therefore, BEINF1 was the better model. The same results applied for deviance, AIC and BIC values for BEINF1 regression for physical health and mental health when demographic and clinical characteristics were modelled separately, as shown in Table I.

The estimates of the Inflated-at-one-Beta Regression (BEINF1) model, the better model in this study, are shown in Tables II-V. With combined (demographic and clinical) characteristics, disability duration and diastolic blood pressure had a significant positive association (p = 0.0116 and 0.0241 respectively) with physical health in Table II. Weight had a negative statistically significant association (p = 0.0351), whereas BMI had a significant positive association (p = 0.0354) with the respondents' mental health, as shown in Table III. These suggest that an increase in disability duration and diastolic blood pressure increase physical health.

Table I: Model selection criteria for comparison of Inflated Beta Regression Model and Inflated-at-one-Beta Regression model

Characteristics	*Inflated Beta Regression (BEINF) model*			*Inflated-at-one-Beta Regression (BEINF1) model*		
	Deviance	**AIC**	**BIC**	**Deviance**	**AIC**	**BIC**
Physical Health (PCS)						
Demographic & Clinical characteristics	-86.0604	-44.0604	11.0641	-86.0604	-46.0604	6.4391
Demographic characteristics	-73.9215	-43.9215	-4.5469	-73.9216	-45.9216	-9.1719
Clinical characteristics	-66.5344	-46.5344	-20.2846	-66.5345	-48.5345	-24.9097
Mental Health (MCS)						
Demographic & Clinical characteristics	-20.1216	21.8784	77.0029	-20.1217	19.8783	72.3778
Demographic characteristics	-13.1001	16.8999	56.2745	-13.1002	14.8998	51.6494
Clinical characteristics	-11.5271	8.4729	34.7227	-11.5272	6.4729	30.0976

The estimates of the Inflated-at-one-Beta Regression (BEINF1) model on physical health by demographic and clinical characteristics are shown in Table IV. The age of the respondents had a significant negative association (p = 0.0354). In contrast, marital status (other types of marital status apart from being single or married) had a positive association (p = 0.0447) with physical health considering demographic characteristics alone. The disability duration and diastolic blood pressure were positively associated with physical health (p = 0.0221 and

0.0051, respectively). In contrast, systolic blood pressure was negatively associated with physical health (p = 0.0333) considering clinical characteristics alone.

Table V gives the results for mental health when demographic and clinical characteristics were introduced to the model separately. None of the characteristics had a statistically significant association with mental health.

Table II: Estimates of Inflated-at-one-Beta Regression (BEINF1) model on physical health with combined demographic and clinical characteristics

Parameters	*Estimate (β)*	*Standard Error*	*t*	*p-value*
Intercept	-1.219	12.120	-0.10	0.9201
Age	-0.015	0.008	-1.79	0.0777
Sex				
Female	Ref.			
Male	-0.066	0.190	-0.35	0.7304
Marital status				
Married	Ref.			
Others	0.397	0.220	1.81	0.0745
Single	-0.087	0.511	-0.17	0.8647
Religion				
Christianity	Ref.			
Islam	-0.007	0.161	-0.04	0.9679
Others	0.137	0.865	0.16	0.8744
Occupation				
Teaching/Professional	Ref.			
Trading/Artisan	-0.352	0.217	-1.63	0.1077
Unemployed/Retired	-0.414	0.227	-1.83	0.0714
Education				
Illiterate	Ref.			
Primary	0.202	0.263	0.77	0.4451
Secondary	0.313	0.276	1.14	0.2595
Tertiary	0.381	0.314	1.21	0.2291
Disability duration	0.005	0.002	2.58	0.0116
Height	0.799	7.355	0.11	0.9138
Weight	-0.030	0.083	-0.36	0.7214
Systolic blood pressure	-0.009	0.006	-1.52	0.1331
Diastolic blood pressure	0.019	0.008	2.30	0.0241
Body Mass Index	0.075	0.224	0.33	0.7396

Discussion

This study has considered two Beta regression models, inflated at both zero and one, namely: Beta Regression (BEINF) and Inflated-at-one-Beta Regression (BEINF1) models and the factors associated with these models. The deviance, AIC and BIC values for the BEINF1 regression model were the minimum compared with the inflated values at both zero and one Beta Regression. The model with the smaller values of the above model selection criteria is considered the better model. Therefore, BEINF1 seems to model the physical and mental health of stroke survivors better. This is similar to the study of Swearingen and others, where the BEINF1 model was found to be the better model for data that have values between zero and one. [24,25,28]

The results revealed that physical and mental health data for stroke follow beta inflated at one model. Beta regression models were applied to proportion and percentage response variables, as also found in previous studies. [24,26,27,30,31]

Table III: Estimates of Inflated at one Beta Regression (BEINF1) model on mental health with combined demographic and clinical characteristics

Parameters	*Estimate (β)*	*Standard Error*	*t*	*p-value*
Intercept	-30.584	16.774	-1.82	0.0719
Age	-0.017	0.011	-1.50	0.1365
Sex				
Female	Ref.			
Male	-0.163	0.245	-0.67	0.5072
Marital status				
Married	Ref.			
Others	0.390	0.288	1.35	0.1805
Single	-1.153	0.684	-1.69	0.0956
Religion				
Christianity	Ref.			
Islam	0.165	0.207	0.80	0.4267
Others	0.754	1.035	0.73	0.4685
Occupation Teaching/Professional				
	Ref.			
Trading/artisan	-0.174	0.280	-0.62	0.5363
Unemployed/retired	-0.141	0.295	-0.48	0.6337
Education				
Illiterate	Ref.			
Primary	-0.180	0.332	-0.54	0.5887
Secondary	0.046	0.349	0.13	0.8952
Tertiary	0.217	0.400	0.54	0.5899
Disability duration	0.002	0.002	0.81	0.4225
Height	19.634	10.186	1.93	0.0574
Weight	-0.248	0.116	-2.14	0.0351
Systolic Blood Pressure	-0.008	0.007	-1.09	0.2797
Diastolic Blood Pressure	0.005	0.011	0.46	0.6493
Body Mass Index	0.671	0.313	2.14	0.0354

When both demographic and clinical characteristics were analysed, only clinical variables of disability duration and diastolic blood pressure were significantly associated with physical health. On the other hand, only anthropometric variables of weight and body mass index were associated with mental health. The longer the duration of disability, the better the physical health. It is worth noting that the participants in this study were undergoing treatment in a teaching hospital. Therefore, the treatment being received might attenuate the effect of disability on their physical health. Better still, stroke survivors might have adjusted to their disability. However, previous studies have suggested that the longer the disability duration, the more positive attitude stroke survivors have toward the disability [32–34]; hence, the better physical health observed in this study. It is unclear why the increase in diastolic blood pressure should result in better physical health. There are likely intrinsic variables that were not controlled for that influenced this relationship. As expected, the increase in body weight leads to a decrease in mental health. This might suggest the importance of health education on weight reduction for stroke survivors.

However, when demographic and clinical characteristics were analysed separately, there was a negative association between age and physical health in the present study. It shows that the physical health of respondents decreases as age increases. An increase in age has been shown to impact the physical and psychosocial health of stroke survivors. [35] Ageing usually leads to a decrease in muscle mass and strength. There was also evidence from other reports that age was significantly associated with the outcome of stroke. [25] It is worthy of mentioning that marital status improved the physical health of the participants. Since most of the participants in this study are older, their partners likely provide the needed social supports.

Table IV: Estimates of Inflated at one Beta Regression (BEINF1) model on physical health by demographic and clinical characteristics

Parameters	*Estimate (β)*	*Standard Error*	*t*	*p-value*
Demographic characteristics				
Intercept	0.905	0.596	1.52	0.1323
Age	-0.018	0.009	-2.14	0.0354
Sex	Ref.			
Female				
Male	-0.132	0.179	-0.74	0.4609
Marital status				
Married	Ref.			
Others	0.455	0.224	2.04	0.0447
Single	-0.246	0.532	-0.46	0.6448
Religion				
Christianity	Ref.			
Islam	0.013	0.162	0.08	0.9364
Others	-0.127	0.860	-0.15	0.8830
Occupation Teaching/Professional				
	Ref.			
Trading/Artisan	-0.412	0.222	-1.85	0.0670
Unemployed/Retired	-0.368	0.235	-1.56	0.1214
Education				
Illiterate	Ref.			
Primary	0.020	0.257	0.08	0.9373
Secondary	0.179	0.275	0.65	0.5175
Tertiary	0.256	0.323	0.79	0.4297
Clinical characteristics				
Intercept	-1.774	12.686	-0.14	0.8891
Disability duration	0.005	0.002	2.33	0.0221
Height	0.691	7.687	0.09	0.9286
Weight	-0.023	0.087	-0.26	0.7944
Systolic Blood Pressure	-0.012	0.005	-2.16	0.0333
Diastolic Blood Pressure	0.025	0.009	2.87	0.0051
Body Mass Index	0.050	0.235	0.21	0.8320

Also, the present study results showed that the diastolic and systolic blood pressures had positively and negatively significant associations with physical health, respectively. High systolic blood pressure is not only a risk factor of stroke or results in a stroke but even post-stroke, it increases ischaemic stroke lesion volume. [25] Therefore, adequate blood pressure monitoring and control should be ensured among stroke survivors. The effect of high blood pressure and other risk factors on stroke survivors have been reported by previous studies. [36, 37]

The present study has some clinical significance. Beta-inflated-regression-at-one model percentages are better, allowing a more straightforward and intuitive transformation of discrete data usually generated among stroke survivors. More importantly, this study offers inference regarding odd ratio, allowing for a previously unavailable treatment effect interpretation. Therefore, beta inflated regression is an appropriate model analysing proportion data among stroke survivors.

Conclusion

The present study has revealed the beta-inflated-at-one (BEINF1) model as suitable for identifying physical and mental health risk factors among stroke survivors. Some of the factors associated with both health conditions may include age, marital status, disability duration, weight, Body Mass Index, diastolic blood pressure and systolic blood pressure at different regression analysis combinations. However, this study would assist researchers in knowing the appropriate model suitable for modelling proportion or percentage response variables.

Table V: Estimates of Inflated-at-One-Beta Regression (BEINF1) model on mental health by demographic and clinical characteristics

Parameters	*Estimate (β)*	*Standard Error*	*t*	*p-value*
Demographic characteristics				
Intercept	1.272	0.748	1.70	0.0924
Age	-0.018	0.011	-1.66	0.1012
Sex	Ref.			
Female				
Male	-0.248	0.225	-1.10	0.2735
Marital status	Ref.			
Married				
Others	0.358	0.288	1.24	0.217
Single	-1.047	0.702	-1.49	0.1394
Religion	Ref.			
Christianity				
Islam	0.124	0.207	0.60	0.5498
Others	0.050	1.005	0.05	0.9604
Occupation	Ref.			
Teaching/Professional				
Trading/Artisan	-0.135	0.279	-0.48	0.6295
Unemployed/Retired	-0.020	0.298	-0.07	0.9477
Education	Ref.			
Illiterate				
Primary	-0.358	0.323	-1.11	0.2703
Secondary	-0.119	0.345	-0.34	0.7314
Tertiary	0.094	0.402	0.23	0.8155
Clinical characteristics				
Intercept	-24.928	16.443	-1.52	0.1329
Disability duration	0.002	0.002	0.90	0.3728
Height	15.423	9.956	1.55	0.1247
Weight	-0.206	0.114	-1.81	0.0738
Systolic Blood Pressure	-0.011	0.007	-1.69	0.0939
Diastolic Blood Pressure	0.011	0.010	1.10	0.2724
Body Mass Index	0.562	0.309	1.82	0.0723

Authors' Contributions: OKS conceived the study, retrieved the data, analysed the statistical, and wrote the manuscript draft. OOO participated in data collection and critically revising the manuscript for sound intellectual content. Both authors approved the final version of the manuscript.

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References

1. Stroke Association. State of the Nation, Stroke Statistics. 2017. Accessed 19 May 2021. https://www.stroke.org.uk/sites/default/files/state_of_the_nation_2017_final_1.pdf

2. Khan MI, Khan JI, Ahmed SI, Haq U. The Epidemiology of Stroke in a Developing Country (Pakistan). J Neurol Stroke 2018; 8: 00275. https://doi.org/10.15406/jnsk.2018.08.00275

3. Wittenauer BR, Smith L. Background Paper 6.6. Ischaemic and Haemorrhagic Stroke. In: Priority Medicines for Europe and the World. A Public Health Approach to Innovation. 2012. Update. WHO; 2012:6.6-1-6.6-46. https://www.who.int/medicines/areas/priority_medicines/BP6_6Stroke.pdf Accessed 25 September 2021.

4. Costa VSP, Guimarães PSR, Fernandes KBP, Probst VS, Marquez AS, Fujisawa DS, *et al.* Prevalence of risk factors for the occurrence of strokes in the elderly. Fisioter Em Mov 2014; 27: 555-563. https://doi.org/10.1590/0103-5150.027.004.AO07

5. World Stroke Organization. Global Stroke Fact sheet. Published online 2019: 1-12.

6. Atadzhanov M, Mukomena PN, Lakhi S, Ross OA, Meschia JF. Stroke Characteristics and Outcomes of Adult Patients Admitted to the University Teaching Hospital, Lusaka,

Zambia. Open Gen Intern Med J 2012; 5: 3-8. https://doi.org/10.2174/1874076601205010003

7. Cheah WK, Hor CP, Zariah AA, Looi I. A Review of Stroke Research in Malaysia from 2000 - 2014. Med J Malaysia 2016; 71(Suppl 1): 58-69.

8. Sangam S. Post-stroke Depression: Epidemiology, Diagnosis, Risk Factors, and Management. Neurol Disord 2018; 6: 1-5. https://doi.org/10.4172/2329-6895.1000394

9. American Heart Association & American Stroke Association. Let's talk about risk Factors for Stroke. https://www.stroke.org/-/media/stroke-files/lets-talk-about-stroke/risk-factors/lets-talk-about-risk-factors-for-stroke-ucm_309713.pdf?la=en Accessed 19 May 2021.

10. Riaz BK, Chowdhury SH, Karim MN, Feroz S, Selim S, Rahman MR. Risk factors of hemorrhagic and ischemic stroke among hospitalised patients in Bangladesh--A case-control study. Bangladesh Med Res Counc Bull 2015; 41: 29-34. https://doi.org/10.3329/bmrcb.v41i1.30231

11. Mulat B, Mohammed J, Yesenia M, Alamirew M, Dermello M, G/Michael N, *et al.* Magnitude of stroke and associated factors among patients who attended the medical ward of Felege Hiwot Referral Hospital, Bahir Dar town, Northwest Ethiopia. Ethiop J Health Dev 2016; 30: 129-134.

12. Hörnsten C, Lövheim H, Nordström P, Gustafson Y. The prevalence of stroke and depression and factors associated with depression in older adults with and without stroke. BMC Geriatr 2016; 16: 174. https://doi.org/10.1186/s12877-016-0347-6

13. Sowtali S, Harith S, Rabiaah C. Secondary Stroke Prevention through Patient Education Intervention on Lifestyle Risk Factors: A Review. Health Environ J 2013; 4: 127-151.

14. Sarecka-Hujar B, Kopyta I. Risk Factors for Recurrent Arterial Ischemic Stroke in Children and Young Adults. Brain Sci 2020; 10. https://doi.org/10.3390/brainsci10010024

15. Alharbi AS, Alhayan MS, Alnami SK, Traad RS, Aldawsari MA, Alharbi A, *et al.* Epidemiology and Risk Factors of Stroke. Arch Pharm Pract 2019; 10: 60-66.

16. Mehryar HR, Khaffafi B, Shadfar F, Khoshakhlagh H, Rezazadeh F, Anzali BC. The Potential risk factors of Ischemic stroke incidence and mortality. Int J Res Appl Basic Med Sci 2019; 5: 50-68.

17. Venketasubramanian N, Yoon BW, Pandian J, Navarro JC. Stroke Epidemiology in South, East, and South-East Asia: A Review. J Stroke 2017; 19: 286-294. https://doi.org/10.5853/jos.2017.00234

18. Rathore JA, Kango ZA, Nazir M, Mehraj A. Risk factors for stroke: a prospective hospital-based study. J Ayub Med Coll Abbottabad 2013; 25: 19-22.

19. Fekadu G, Chelkeba L, Kebede A. Risk factors, clinical presentations and predictors of stroke among adult patients admitted to stroke unit of Jimma university medical center, southwest Ethiopia: prospective observational study. BMC Neurol 2019; 19: 187. https://doi.org/10.1186/s12883-019-1409-0

20. Watila MM, Nyandaiti Y, Bwala S, Ibrahim A. Gender variation in risk factors and clinical presentation of acute stroke, Northeastern Nigeria. J Neurosci Behav Health 2011; 3: 38-43. https://doi.org/10.5897/JNBH.9000011

21. Bonner B, Pillai R, Sarma PS, Lipska KJ, Pandian J, Sylaja PN. Factors predictive of return to work after stroke in patients with mild-moderate disability in India. Eur J Neurol 2016; 23: 548-553. https://doi.org/10.1111/ene.12887

22. Adebimpe WO. Knowledge and Risk Factors for Stroke Among Undergraduates in Southwestern Nigeria. Marshall J Med 2018; 4: 25. http://dx.doi.org/10.18590/mjm.2018.vol4.iss3.4

23. Heshmatollah A, Mutlu U, Rojas-Saunero LP, Portegies MLP, Wieberdink RG, Koudstaal PJ, *et al.* Unspecified Strokes: Time Trends, Determinants, and Long-Term Prognosis in the General Population. Neuroepidemiology 2020; 54: 334-342. https://doi.org/10.1159/000506130

24. Ünlü H, Aktaş S. Beta Regression for the Indicator Values of Well-Being Index for Provinces in Turkey. J Eng Technol Appl Sci 2017; 2: 101-111. https://doi.org/10.30931/jetas.321165

25. Swearingen CJ, Tilley BC, Adams RJ, Rumboldt Z, Nicholas JS, Bandyopadhyay D, et al. Application of beta regression to analyse ischemic stroke volume in NINDS rt-PA clinical trials. Neuroepidemiology 2011; 37: 73-82. https://doi.org/10.1159/000330375

26. Baum CF. Stata Tip 63: Modeling Proportions. Stata J 2008; 8: 299-303. https://doi.org/10.1177/1536867X0800800212

27. Cribari-Neto F, Zeileis A. Beta Regression in R. Published 2009. https://cran.r-project.org/web/packages/betareg/index.html Accessed 06 May 2021.

28. Williams R. Analyzing Proportions: Fractional Response and Zero One Inflated Beta Models.2019. https://www3.nd.edu/~rwilliam/stats3/FractionalResponseModels.pdf

29. Oyewole OO, Ogunlana MO, Gbiri CAO, Oritogun KS, Osalusi BS. Impact of post-stroke disability and disability-perception on health-related quality of life of stroke survivors: the moderating effect of disability-severity. Neurol Res 2020; 42: 835-843. https://doi.org/10.1080/01616412.2020.1785744

30. Mahmood SW, Seyala N, Algamal Z. Adjusted R 2 -type measures for beta regression model. Electron J Appl Stat Anal 2020; 13: 350-357. https://doi.org/10.1285/i20705948v13n2p350

31. Ospina R, Ferrari SLP. A general class of zero-or-one inflated beta regression models. Comput Stat Data Anal 2012; 56: 1609-1623.

32. Zheng Q, Tian Q, Hao C, Gu J, Tao J, Liang Z, *et al.* Comparison of attitudes toward disability and people with disability among caregivers, the public, and people with disability: findings from a cross-sectional survey. BMC Public Health 2016; 16: 1024. https://doi.org/10.1186/s12889-016-3670-0

33. Zheng Q-L, Tian Q, Hao C, Gu J, Lucas-Carrasco R, Tao J-T, *et al.* The role of quality of care and attitude towards disability in the relationship between severity of disability and quality of life: findings from a cross-sectional survey among people with physical disability in China. Health Qual Life Outcomes 2014; 12: 25. https://doi.org/10.1186/1477-7525-12-25

34. Oyewole OO, Odusan O, Bodunde OT, Thanni LOA, Osalusi BS, Adebanjo AA. Self-acceptance and Attitude towards Disability among People with Disability Attending a Nigerian Tertiary Health Facility. J Adv Med Med Res 2017; 21: 1-10. https://doi.org/10.9734/BJMMR/2017/33268

35. Oyewole O, Ogunlana M, Gbiri C, Oritogun K. Prevalence and Impact of Disability and Sexual Dysfunction on Health-Related Quality of Life of Nigerian Stroke Survivors. Disabil Rehabil 2017; 39: 2081-2086. https://doi.org/:10.1080/09638288.2016.1219395

36. Araki A, Ito H. Psychological Risk Factors for the Development of Stroke in the Elderly. J Neurol Neurophysiol 2013; 04: 147. https://doi.org/10.4172/2155-9562.1000147

37. Kariyawasam PN, Pathirana KD, Hewage DC. Factors associated with health-related quality of life of patients with stroke in Sri Lankan context. Health Qual Life Outcomes 2020; 18: 129. https://doi.org/10.1186/s12955-020-01388-y