Modeling Determinants of Discriminatory Attitude towards HIV/AIDS Patients in Zambia: A Generalized Additive Mixed Model

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Abstract

The 2007 Zambia Demographic Health Survey (ZDHS) HIV/AIDS data was used to investigate the attitude of people to HIV/AIDS patients in Zambia using the generalized additive mixed model. The model was used to simultaneously measure the fixed, nonlinear and random effects. The fixed effects of categorical covariates were modelled using the diffuse prior, P-spline with second-order random walk for the nonlinear effect of continuous variable while the exchangeable normal priors were used for the random effects of the district. The Binomial distribution was used to handle the dichotomous nature of the three dependent variables considered. The dependent variables are stigmatization towards relative sick with HIV/AIDS, teacher who has HIV/AIDS but is not sick and a food vendor who has HIV/AIDS. We found that the people who seem to be responsible for discriminatory attitude towards PLWHA in Zambia are predominantly those who stay in the Southern and Lusaka provinces, the urban areas, who are from at least the middle class wealth index, elite, age 20^{+} and who either are married/living together with partner.

Keywords: Bayesian inference, binomial, generalized additive mixed model, HIV/AIDS, Zambia.

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1. Introduction

Zambia is an entirely land-locked sub-Saharan country sharing boundaries with the Democratic Republic of Congo and Tanzania in the North, Malawi and Mozambique in the East and Zimbabwe and Botswana in the South. Zambia is divided into nine provinces. The first Acquired Immunodeficiency Syndrome (AIDS) case in Zambia was diagnosed in 1984 which within the space of six years had increased to 20% among adults [1]. HIV prevalence in Zambia is 14.3% among the general population and 4.7% among those aged 15 – 19 [1]. By 2009, [2] estimated that 800,000 adolescents were living with HIV in Zambia.

The Antiretroviral (ARV) therapy has effectively changed AIDS from a terminal to manageable chronic illness [3]. However, PLWHA have an important factor to contend with, which is stigmatization [4]. Several studies conducted in sub-Saharan Africa have shown how fear, ignorance and lack of knowledge contributed to the negative attitudes and behaviours towards PLWHA [4, 5, 6]. Stigmatization[§] is a complex social phenomenon whose persistent occurrence has been described as "black box" and life-altering condition by so many researchers [7, 8, 9]. In Zambia, PLWHA still battle with stigmatization and discrimination in their interaction with people on daily basis, especially the sex workers, poor and single women [10]. Stigmatization, hostility and gossip take their toll on the health and psychological wellbeing of PLWHA [11]. [12] found that HIV/AIDS related stigma and its associated discrimination, is known to negatively affect HIV diagnosis, treatment and care. In order to offer palliative care to PLWHA in Zambia there is a need to identify

the factors responsible for stigmatization and discriminatory attitude towards them. It cannot be overemphasized that model-based analyses offer an objective outlook to empirical problems in sub-Saharan Africa especially in the absence of reliable national data. Many researchers have worked on stigmatization of PLWHA in different context, however, little is known about the set of factors which are responsible for discrimination against PLWHA in Zambia. This is the major gap intended to be filled in this study.

2. Data

The data used for this study were drawn from 2007 ZDHS HIV/AIDS data. The 2007 ZDHS is the second DHS that includes the collection of information on violence against women, syphilis and HIV testing. The two-stage stratified probability sample design was used for selection of the ZDHS sample. In the first stage, a representative of 8000 households was drawn consisting of 320 standard enumeration areas selected with probability proportional to size. In the second-stage selection, an average number of 25 households were selected in every cluster, by equal probability systematic sampling. A total of 7969 households were selected for the sample of which 7326 were occupied. Of the 7326 existing households, 7164 were interviewed which gave a 98% response rate. This study is based on the survey data with all participant identifiers removed. There was no ethical consent other than the permission granted by ZDHS to use the data. Although, different covariates were presented in ZDHS 2007, we focused on attitude of people to relative of a family who is sick with HIV/AIDS, teacher infected with HIV/AIDS and food vendor who is living with HIV/AIDS. The covariates considered are: place of residence, province, wealth index, educational attainment, marital status, age and district. The three dependent variables considered in this study are: Dependent 1: If a relative became sick with HIV/AIDS, would you be willing to care for him or her?

Dependent 2: If a teacher has HIV/AIDS, should s/he be allowed to continue teaching in school?

Dependent 3: If you knew a vendor has HIV/AIDS, would you buy vegetables from him?

We explore the Generalized Additive Mixed Model to simultaneously handle the categorical, continuous and random variables of the explanatory variables as well as the dichotomous nature of the dependent variables in turn.

3. Generalized Additive Mixed Model

Consider the generalized additive mixed model given as

$$\eta_r = f_1(x_{r1}) + \ldots + f_k(x_{rk}) + u_r'\gamma + b_g \quad (1)$$

Where

η_r is the generalized additive mixed model predictor

$f_{i,i=1,\ldots,k}$ is the nonlinear effect of metrical or continuous covariates x

u is the fixed effect of categorical variables γ

$b_g g \in \{1,\ldots,G\}$ are uncorrelated (unstructured) random effects to model unobserved heterogeneity

For the continuous/metrical covariates, we assume Penalized Splines (P-spline) prior with second order random walk [13, 14].

$$f(x) = \sum_{t=1}^{k} \alpha_t B_t(x) \quad (2)$$

where

$B_t(x)$ are B-splines, α_t are defined to follow a first order or second order random walk prior. The second order random walk is given as

$$\alpha_t = 2\alpha_{t-1} - \alpha_{t-2} + \varepsilon_t \quad (3)$$

with Gaussian errors $\varepsilon_t \sim N(0, \tau_\varepsilon^2)$ where τ_ε^2 controls the smoothness of f. This variance is estimated jointly with the coefficients of the basis function by assigning a weakly informative inverse Gamma prior with $\tau_\varepsilon^2 \sim IG(\varepsilon, \varepsilon)$. A suitable choice of diffuse prior is assumed for the fixed effect of categorical covariates given as

$$p(\gamma) \propto const \quad (4)$$

The random effects b_g were modelled from exchangeable normal priors,

where τ_b^2 is the variance that accounts for overdispersion and heterogeneity. We assigned highly dispersed but proper prior for all variance components. An inverse Gamma distribution with hyperparameters *a* and *b* is chosen, such that $\tau^2 \sim IG(a,b)$. Standard choices of hyperparameters are $a = 1$ and $b = 0.005$ or $a = b = 0.001$(which is close to Jeffrey's non-informative prior) [14, 15]. These values can be varied to know the sensitivity of the choices of hyperparameters to the inverse Gamma distribution.

Letting α represent the nonlinear effect of *f*, τ to represent the vector of all variance components, and β the vector of fixed effects parameters, then the posterior probability distribution is

$$p(\alpha, \tau, \beta \mid y) \propto p(y \mid \alpha, \beta, \tau) p(\alpha) p(\beta) p(\tau) \quad (5)$$

where

$p(y|\alpha, \tau, \beta)$ is the likelihood function of the data given the parameters of the model (based on the dependent variable)

$p(\alpha)p(\beta)p(\tau)$ are the prior densities of all the parameters

The Bayesian framework based on Markov Chain Monte Carlo (MCMC) simulation techniques from full conditionals for nonlinear, spatial, fixed effects and smoothing parameters will be used for the posterior analysis.The

$$b_{ij} \sim N(0, \tau_b^2)$$

Deviance Information Criterion (DIC) is employed for comparison of the models [16]. The DIC is defined as

$$DIC = \bar{D}(\theta) + pD \quad (6)$$

where

$\bar{D}$ is the posterior mean of the deviance

pD is the effective number of parameters (not equal to degrees of freedom)

Small values of $\bar{D}$ and pD indicate a better and parsimonious model respectively. The model with the lowest DIC is the best.

4. Data Analysis and Presentation of Results

4.1 Data Analysis

We used the dichotomous dependent variables as defined in section 2. Each dependent variable follows a binomial distribution whose dependence is modelled through logit link model given as:

$$y_{ij} \mid \gamma, b_i \sim Bin(n_i, \pi_i) \quad (7)$$

$$\pi_i = \Pr(Y_i = 1 / \eta_i) = \frac{e^{\eta_i}}{1 + e^{\eta_i}}$$

$$\log it(\pi_i) = \log\left(\frac{\pi_i}{1 - \pi_i}\right) = \eta_i$$

$$\eta_i = w^{'}\gamma + f^{'}x + b_i \quad (8)$$

Where

η_i is the mean number of people according to dependent 1, dependent 2 and dependent 3

$w^{'}\gamma$ is the vector of fixed effect of all the covariates which are categorical except age

$f^{'}x$ is the vector of unknown smooth function of age which is continuous and nonlinear

b_i is the random effect of district

We used effect coding for all the categorical variables. The BayesX version 2.1 [17] was used for the analysis. We carried out 20000 iterations with the first 2000 considered as a burn-in sample. We thinned every 10^{th} iteration of the remaining 18000 used for parameter estimation. Convergence and mixing were monitored through plotting and estimation of sampling paths and autocorrelation. Sensitivity analysis was carried out by varying the hyperparameters. The different choices of hyperparameters considered were a = 1 and b = 0.005, $a = b = 0.005$ and a = b = 0.001. We reported the latter as the results were less sensitive to variation of the choices of the parameters [18].

4.2 Presentation and Discussion of Results

The results of the three dependent variables considered are given in Tables 1, 2 and 3 respectively. Table 1 gives the posterior estimates of dependent variable 1(if a relative became sick with HIV/AIDS, would you be willing to care for him or her?). The stigmatization of relative sick with HIV/AIDS by those who stay in the urban area is 28% [OR: 1.2801, CI: 1.0256, 1.6610] more than respondents in the rural areas. Stigmatization is significantly associated with people who stay in the urban areas. Zambia is demarcated by nine provinces. The discriminatory attitude in each province are: Central [OR: 0.4583, CI: 0.2776, 0.7379], Copperbelt [OR: 1.1382, CI: 0.6323, 2.2076], Eastern [OR: 1.2657, CI: 0.9422, 2.5374], Southern [OR: 2.6732, CI: 1.9023, 2.9013], Luapala [OR: 0.4622, CI: 0.2905, 0.7371], Lusaka [OR: 3.2791, CI: 1.5104, 4.1973], North [OR: 0.5424, CI: 0.3497, 0.8562], Northwest [OR: 0.3320, CI: 0.2098, 0.5508]. The result of Lusaka province reported the highest likelihood of discriminatory attitude towards a relative sick with HIV/AIDS than the Western province. Respondents who stay in Central, Luapala, North and Northwest are 46%, 46%, 54% and 33% respectively are significantly less likely to report that they will not take care of a relative who is infected with HIV/AIDS than respondents who stay in the Western province. The Southern and Lusaka provinces are significantly more likely to discriminate against a relative who is sick with HIV/AIDS. The wealth index quintiles show that the richest/richer [OR: 1.9824, CI: 1.2919, 2.0735] are 98% significantly more likely to discriminate against a relative who is sick with HIV/AIDS than the poorest/poorer group.

The middle class is 7% more likely to be unwillingly to take care of a relative who is sick with HIV/AIDS, although this is insignificant. Respondents with primary education [OR: 0.8668, CI: 0.6868, 1.0838] are 86% less likely to discriminate against their relative who is sick with HIV/AIDS than respondents with no education. The respondents with secondary education [OR: 1.3513, CI: 1.0082, 1.8880] are 35% significantly more likely to discriminate against PLWHA than respondents with no education. The highest odds was given by respondents with higher education [OR: 1.7919, CI: 1.5923, 2.2304], which is about two times more than respondents with no education. This informs us that the educated stigmatize PLWHA more than people with no education. The

married/living together [OR: 9.2952, CI: 1.2434, 12.1122] will significantly discriminate nine times more than respondents who were never married while those who are separated or divorced are 55% less likely to discriminate against a relative who are sick with HIV/AIDS more than those who were never married. The posterior odd ratio of nonlinear effect of age [OR: 1.0588, CI: 1.0014, 1.2872] and the random effect of district show positive significant association between age and district on the discriminatory attitude of respondents toward their relatives who are sick with HIV/AIDS. The discriminatory attitude according to respondents age shows that from ages 30+ to about 62 years, respondents will be unwilling to care for relative sick with HIV/AIDS (Fig. 1).

We also considered dependent variable 2 (if a teacher has HIV/AIDS, should s/he be allowed to continue teaching in school?), to estimate the level of stigmatization of PLWHA in Zambia. Table 2 gives a summary of the reactions of respondents to a teacher who is living with HIV/AIDS. Respondents living in the urban [OR: 1.4715, CI: 1.2941, 1.6869] areas discriminate more against a teacher who is sick with HIV/AIDS and believe s/he should not be allowed to continue teaching in school more than respondents who reside in rural areas. Respondents who live in the Southern province [OR: 1.8365, CI: 1.6971, 1.9098] are 84% more likely to discriminate against teacher who is sick with HIV/AIDS than respondents who stay in the Western province. Also respondents who stay in Central [OR: 1.3711, CI: 0.5404, 2.0915] and Lusaka [OR: 1.2700, CI: 0.9114, 1.7186] are 37% and 27% more likely to report that teacher infected with HIV/AIDS should not be allowed to teach, although these results are not significant. Respondents who stay in Copperbelt, Eastern, Luapala, North and Northwest provinces are 74%, 92%, 92%, 83% and 61% less likely to report that teacher sick with HIV/AIDS should not be allowed to teach respectively. The richest/richer class [OR: 2.0034, CI: 1.9819, 2.4751] are twice as much more likely to discriminate against teacher sick with HIV/AIDS than the poorest/poorer class. The middle class [OR: 1.0168, CI: 0.9151, 1.1377] are just about 2% more likely to report that teacher who is sick with HIV/AIDS should not be allowed to teach, although at 95% CI this is not significant. As the Zambians increase in academic knowledge, so is the increase in the discriminatory attitude toward PLWHA. Respondents with primary education are 83% less likely to report that teacher infected with HIV/AIDS should not be allowed to teach. The respondents with secondary education are 117% more likely to report that teacher sick with HIV/AIDS should not be allowed to teach. The highly educated are 185% likely to discriminate more. People that are well educated have the highest odds of stigmatization. Respondents who are married or living together with partner [OR: 6.1973, CI: 5.6669, 7.1233] are six times more likely to report that teachers sick with HIV/AIDS should not be allowed to continue to teach than respondents who were never married. The nonlinear effect of age [OR: 1.0172, CI: 1.0014, 1.0689] and random effect of district [OR: 1.3838, CI: 1.1922, 1.6418] imply that there is positive association between age and district on the discriminatory attitude of respondents toward a teacher who is sick with HIV/AIDS. The nonlinear effects of age on teacher who is sick with HIV/AIDS are shown in Fig 2. Respondents who are less than 18years are less likely to discriminate against a teacher who is sick with HIV/AIDS. However, a steady increase is noted from about 20+ with its peak around 40years, which decreased drastically from age 60+. This implies that respondents within the age bracket 20 to 60 years are more likely to discriminate against a teacher who is sick with HIV/AIDS with the highest level of stigmatization from respondents who are about 40 years of age.

The dependent variable 3, that we explored to estimate the stigmatization trend is "if you knew a vendor had HIV/AIDS, would you buy vegetables from him/her?" The results are summarized in Table 3. The discriminatory attitude toward a vendor sick with HIV/AIDS by those who stay in the urban area is 30% [OR: 1.3030, CI: 1.1844, 1.4395] (highly significant at 95%) more likely than respondents in the rural areas. Respondents who stay in Central, Copperbelt, Eastern, Southern, Luapala, Lusaka are North provinces are 27%, 37%, 54%, 79%, 59%, 10% and 23% more likely to report that they will not buy vegetables from a vendor who is sick with HIV/AIDS. The middle class [OR:

1.1316, CI: 1.0271, 1.2412] and richest/richer [OR: 2.0114, CI: 1.8754, 2.6518] are 13% and 101% more likely to report that they will not buy vegetables from a vendor who is sick with HIV/AIDS. People with higher education [OR: 2.1173, CI: 1.7987, 2.6753] are 118% more likely to discriminate against a vendor who is sick with HIV/AIDS more than respondents with no education, this is significant at 95% CI. Respondents with primary are 82% less likely to discriminate against a vendor who is sick with HIV/AIDS, while respondents with secondary education are more likely to discriminate twice as much than respondents without education. Respondents who are married or living together with partner [OR: 6.7770, CI: 5.7823, 13.7834] are six times more likely to report that they will not buy vegetables from a vendor who is sick with HIV/AIDS than respondents who were never married. The divorced or separated respondents are 78% less likely to report that they will not buy vegetables from vendor who is sick with HIV/AIDS. The odds of the nonlinear effect of age and random effect of district suggest that discriminatory attitude will be displayed towards a vendor who is sick with HIV/AIDS. Figure 3 also corroborated that the discriminatory attitude towards a vendor who is sick with HIV/AIDS is from age group 20 to 60years.

Table 1: Posterior estimates of Dependent Variable 1 within 95% Credible Interval (CI)

Variable	OR	SD	95% CI
Constant	3.1648	5.6536	(1.0069, 9.6359)
Place of Residence			
Rural (ref)	1.0000		
Urban	1.2801	0.1220	(1.0256, 1.6610)
Province			
Western	1.0000		
Central	0.4583	0.2496	(0.2776, 0.7379)
Copperbelt	1.1382	0.3150	(0.6323, 2.2076)
Eastern	1.2657	0.4182	(0.9422, 2.5374)
Southern	2.6732	0.2102	(1.9023, 2.9013)
Luapala	0.4622	0.2402	(0.2905, 0.7371)
Lusaka	3.2791	0.4252	(1.5104, 4.1973)
North	0.5424	0.2331	(0.3497, 0.8562)
Northwest	0.3320	0.2370	(0.2098, 0.5508)
Wealth Index			
Poorest/Poorer (ref)	1.0000		
Middle Class	1.07110.	0973	(0.8936, 1.3175)
Richest/Richer	1.98240.	0793	(1.2919, 2.0735)
Educational Attainment			
No Education (ref)	1.0000		
Primary	0.8668	0.1167	(0.6868, 1.0838)
Secondary	1.3513	0.1692	(1.0082, 1.8880)
Higher	1.7919	0.8966	(1.5923, 2.2304)
Marital Status			
Never Married (ref)	1.0000		
Married/Living Together	9.2952	5.6515	(1.2434, 12.1122)
Divorced/Separated	0.5539	0.3389	(0.2877, 1.0094)
Continuous Covariate			
Age	1.0588	0.1160	(1.0014, 1.2872)
Random Component			
District	2.0511	0.2536	(2.0511, 3.5719)

*OR- Odd Ratio **SD- Standard Deviation

Table 2: Posterior estimates of Dependent Variable 2 within 95% Credible Interval (CI)

Variable	OR	SD	95% CI
Constant	7.8586	2.8365	(3.7753, 14.0218)
Place of Residence			
Rural (ref)	1.0000		
Urban	1.4715	0.0674	(1.2941, 1.6869)
Province			
Western	1.0000		
Central	1.3711	0.1646	(0.5404, 2.0915)
Copperbelt	0.7353	0.1586	(0.6323, 0..9894)
Eastern	0.9174	0.1312	(0.7138, 1.2061)
Southern	1.8365	0.3451	(1.6971, 1.9098)
Luapala	0.9205	0.1487	(0.6892, 1.2365)
Lusaka	1.2700	0.1619	(0.9114, 1.7186)
North	0.8268	0.1489	(0.6074, 1.1021)
Northwest	0.6084	0.1440	(0.4577, 0.8223)
Wealth Index			
Poorest/Poorer (ref)	1.0000		
Middle Class	1.0168	0.0559	(0.9151, 1.1377)
Richest/Richer	2.0034	0.1954	(1.9819, 2.4751)
Educational Attainment			
No Education (ref)	1.0000		
Primary	0.8294	0.0627	(0.7319, 0.9348)
Secondary	2.1669	0.0959	(1.8025, 2.6052)
Higher	2.8453	0.4166	(1.9873, 3.4151)
Marital Status			
Never Married (ref)	1.0000		
Married/Living Together	6.1973	0.3115	(5.6669, 7.1233)
Divorced/Separated	0.3453	0.1728	(0.3156, 0.8876)
Continuous Covariate			
Age	1.0172	0.0227	(1.0014, 1.0689)
Random Component			
District	1.3838	0.0810	(1.1922, 1.6418)

Table 3: Posterior estimates of Dependent Variable 3 within 95% Credible Interval (CI)

Variable	OR	SD	95% CI
Constant	6.0001	3.9845	(5.6367, 7.4607)
Place of Residence			
Rural (ref)	1.0000		
Urban	1.3030	0.1220	(1.1844, 1.4395)
Province			
Western	1.0000		
Central	1.2715	0.1192	(1.0049, 1.5834)
Copperbelt	1.3664	0.1267	(1.0637, 1.7515)
Eastern	1.5442	0.1060	(1.2621, 1.8906)
Southern	1.7921	0.3145	(1.3125, 1.9100)
Luapala	1. 5876	0.1170	(0.9626, 1.5416)
Lusaka	1.1039	0.1167	(0.8749, 1.3882)
North	1.2269	0.1107	(0.9928, 1.5233)
Northwest	0.4638	0.1168	(0.3665, 0.5802)
Wealth Index			
Poorest/Poorer (ref)	1.0000		
Middle Class	1.1316	0.0490	(1.0271, 1.2412)
Richest/Richer	2.0114	0.1246	(1.8754, 2.6518)
Educational Attainment			
No Education (ref)	1.0000		
Primary	0.8196	0.0516	(0.7413, 0.9038)
Secondary	1.9022	0.0705	(1.6563, 2.1933)
Higher	2.1173	0.3189	(1.7987, 2.6753)
Marital Status			
Never Married (ref)	1.0000		
Married/Living Together	6.7770	3.9838	(5.7823, 13.7834)
Divorced/Separated	0.7819	0.1671	(0.5923, 0.9917)
Continuous Covariate			
Age	1.0045	0.0068	(1.0004, 1.0245)
Random Component			
District	1.1488	0.0435	(1.0624, 1.2597)

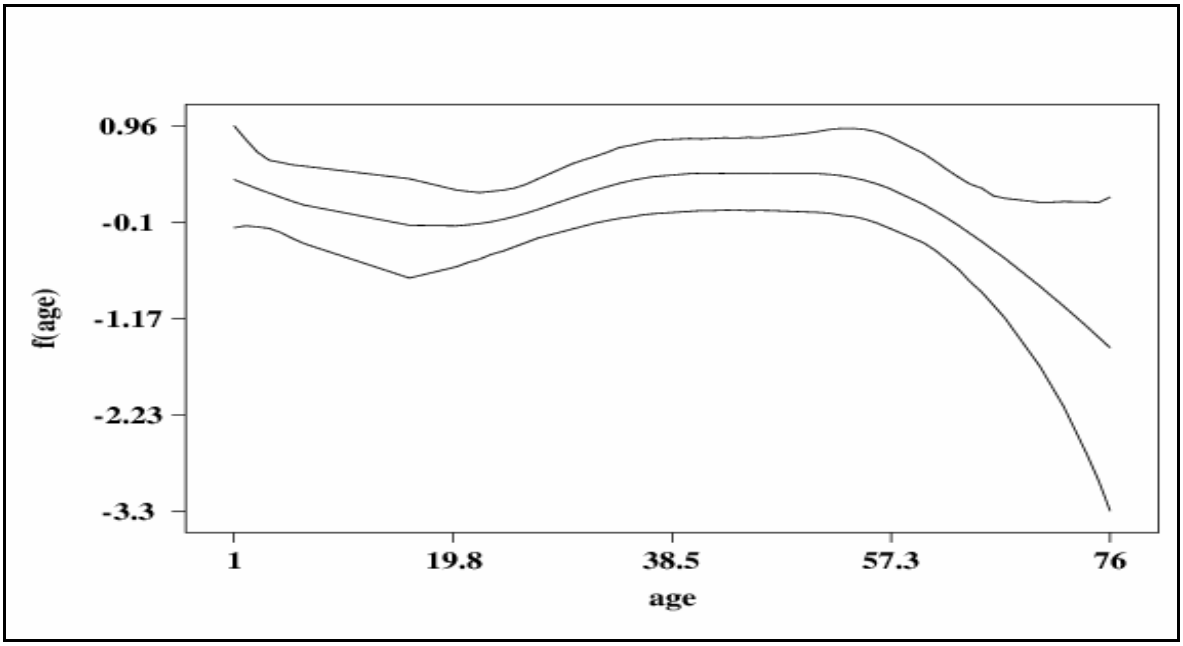

Figure 1: Stigmatization of if a family member is sick with HIV/AIDS will you be willingly to take care of him

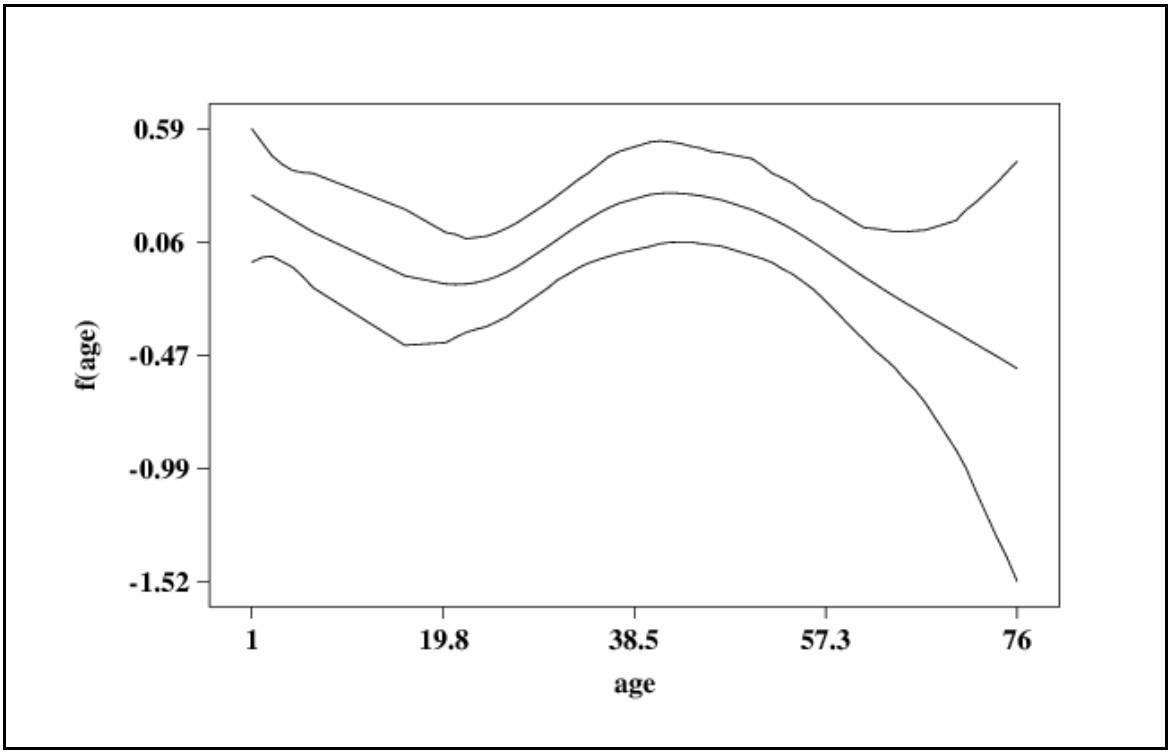

Fig 2: Stigmatization of if a teacher has HIV/AIDS but is not sick, should s/he be allowed to continue teaching in school?

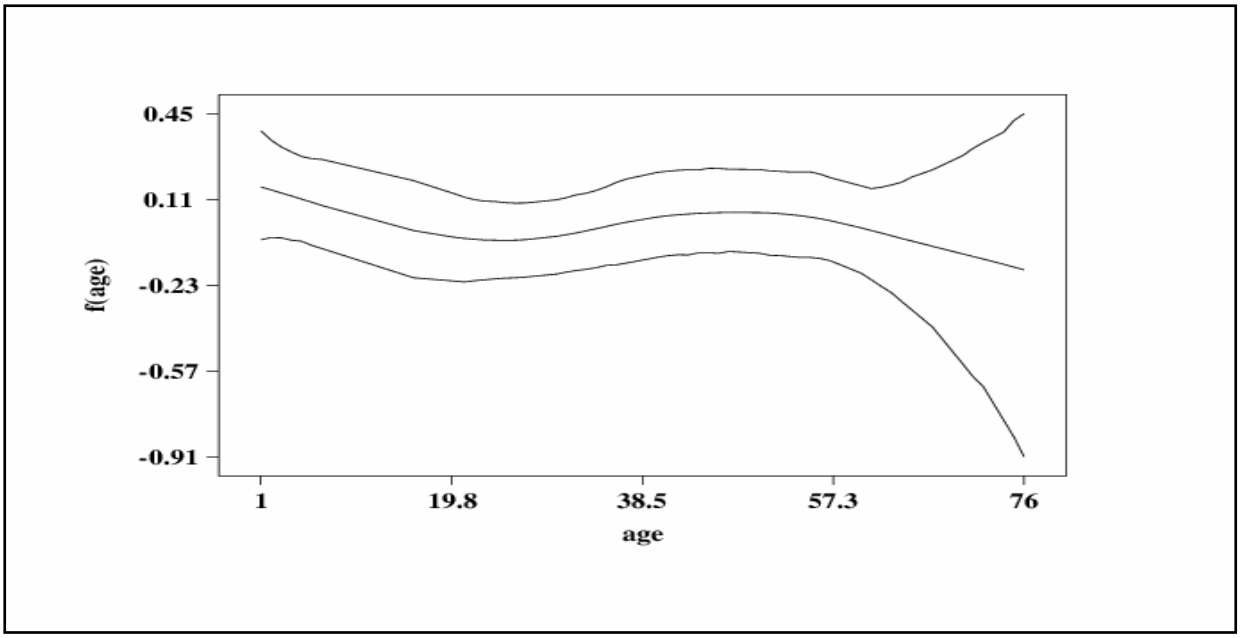

Figure 3: Stigmatization of if you knew a vendor had HIV/AIDS, would you buy vegetables from them?

5. Summary

The generalized additive mixed model was used to investigate the factors responsible for stigmatization of PLWHA in Zambia. The Binomial distribution was used to handle the dichotomous nature of the three dependent variables considered. The dependent variables are stigmatization towards relative sick with HIV/AIDS, teacher who has HIV/AIDS and a food vendor who has HIV/AIDS by using the 2007 ZDHS data.

The diffuse prior was used for the fixed effect of categorical variables, penalized spline with second random walk for the continuous variables and the exchangeable normal priors were used for the random effect of the district. The Bayesian framework based on Markov Chain Monte Carlo (MCMC) simulation techniques was used for estimation of the unknown posterior distribution.

Respondents who are likely to discriminate against a relative who is sick with HIV/AIDS are those who live in urban areas; stays in Eastern, Southern and Lusaka provinces; middle, richer/richest class; who have at least secondary school education; married/living together with partner and aged 20 – 62 years. Respondents who are more likely to discriminate against a teacher who is infected with HIV/AIDS are those who stay in the urban areas; stays in Central, Southern and Lusaka provinces; middle, richer/richest class; who have secondary or higher education; married/living together with partner and aged between 20 – 60 years. The third dependent variable considered was whether respondents will buy vegetables from a food vendor who is infected with HIV/AIDS. Respondents living in the urban area; all the provinces except Northwestern province; middle, richer/richest class; who have at least secondary education; married/living together with partner and aged 20 – 60 years reported that they will not buy vegetables from a vendor who is infected with HIV/AIDS.

6. Conclusion

We found that the people who are responsible for discriminatory attitude towards PLWHA in Zambia are predominantly those who stay in the Southern and Lusaka provinces, the urban areas, who are from at least the middle class wealth index, elite, age 20^{+} and who either are married/living together with partner.

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