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Structural Equation Modeling of the Relationship between Quality of Life and Satisfaction with Life Scale among HIV Positive Population

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Abstract. In this work, we propose appropriate models for assessing the relationships among the observed items in quality of life (QoL) and satisfaction with life scale (SWLS) instruments using structural equation modeling (SEM). Generalized least square (GLS) method was used as against the most used maximum likelihood (ML) to generate the estimates for real life data with non-normal distribution. A detailed description of the confirmatory factor analysis, path diagram and SE models were recorded. We use an underlying non-normal distribution using generalized least square (GLS) estimation method with the statistical package AMOS version 21.

Résumé. Nous proposons des modèles appropriés pour établir des fonctionnelles entre objets observés par rapport à la qualité de vie et aux instruments de mesure d'échelle de satisfaction basées sur la méthode du maximum de vraisemblance en vue d'obtenir des estimations sur des données réelles non gaussiennes. Une description complète d'analyse de conformité factorielle, de diagrammes de parcours et de modèles SE est fournie.

Key words: Quality of life, structural equation, modeling, latent factor.
AMS 2010 Mathematics Subject Classification : 97K80, 97M70.

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1. Introduction

Human immunodeficiency virus (HIV) is a member of a group of viruses called retroviruses. Globally, HIV/AIDS infection is one of the leading causes of mortality among young adults. Current statistics on the number of people living with HIV/AIDS (PLWHA) worldwide now stands at 34.2 million with 15.2 million children estimated to have been orphaned as a result of AIDS [UNAIDS Fact sheet (2016)] and Nigeria has the second highest number of HIV infected people in the world [Mabayoje and Akinleye (2016)]. Following the acceptability of QoL as a multidimensional concept that is best evaluated by a number of different latent concepts such as physical function, health status, mental status and social relations [Lee *et al.* (2005)], QoL therefore includes overall subjective feelings of well-being that are closely related to morale, happiness and satisfaction. Health is generally cited as one of the most important determinants of overall quality of life and it has been suggested that quality of life may be uniquely affected by specific disease process such as AIDS [Friedland *et al.* (1996)]. Since there is an increasing acceptance of the need to measure quality of life (QoL) in the health sector and medical research, hence, the implementation of useful and more comprehensive tools like structural equation modelling (SME) for analysing QoL and other measuring scales like the satisfaction with life scale (SWLS). Structural equation modeling (SEM) is a statistical methodology used in many scientific fields as it provides researchers with a comprehensive method for the quantification and testing of substantive theories. SEM uses various types of models to depict relationships among observed variables, with the same basic goal of providing a quantitative test of a theoretical model hypothesized by the researcher [Schmaker *et al.* (2010)]. The goal of SEM analysis is to determine the extent to which the theoretical model is supported by sample data [Schmaker *et al.* (2010)]. Other major characteristics of SEMs are that they explicitly take into account measurement error that is ubiquitous in most disciplines, and typically contain latent variables.

QoL items are not only measured using the discrete ordinal scale, but are also highly skewed [Lee *et al.* (2005)] which signifies non-normality. Hence, the results produced by the normal theory maximum likelihood (ML) approach may be misleading [Lee *et al.* (2005)]. While many work carried out under SEM in line with QoL had been by the use of normal theory maximum likelihood (ML) approach.

The present study therefore was designed to find the appropriate models for assessing the relations among the observed items in QoL & SWLS instruments using structural equation modeling (SEM). Generalized least square (GLS) method was used as against the most used maximum likelihood (ML) to generate the estimates. Also a larger population of HIV patients were used.

2. Methodology

The instruments used were the WHOQoL-HIV (BREF) and SWLS. WHOQoL-HIV (BREF) was established to evaluate six latent domains. The Domain 1 with 4 items addressed the Physical health; Domain 2 with 5 items addressed the Psychological health; Domain 3 with 4 items addressed the Level of independence; Domain 4 with 4 items addressed the Social relationship; Domain 5 with 8 items addressed the Environmental health and Domain 6 with 4 items addressed the Spirituality, religion and personal beliefs of the patients. The instrument also include 2 items for the overall QoL and general health, giving a total of 31 items. Domain scores were scaled in a positive direction with higher scores denoting higher QOL. Each item was rated on a 5 point likert scale where 1 indicates low, negative perception and 5 indicates high, positive perception. SWLS contains five statements which are measured on a 7-point scale from strongly disagree to strongly agree.

These instruments were administered to 564 adult patients attending Haematology/Virology clinics at Ondo and Ekiti States. Ethical approvals were sought and obtained from the research ethic committees of Ondo State Ministry of Health and Ekiti State University Teaching Hospital with protocol numbers AD 4693/79 and EKSUTH A 67/2014/02/004.

QoL analyses usually start with an exploratory factor analysis (EFA) model which is confirmed through confirmatory factor analysis (CFA) by testing the goodness of fit of the data. SEM which is used for ordinal categorical data was computed through path diagram with the use of statistical tool called AMOS version 21. It is divided into two parts: measurement model and structural model.

$$\text{Measurement Model: } \underbrace{X}_{p\times 1} = \underbrace{\Lambda}_{p\times m}\underbrace{\xi}_{m\times 1} + \underbrace{\delta}_{p\times 1}$$

where X is a $p \times 1$ vector of observable indicators of the independent latent variables xi; Λ is a $p \times m$ matrix of coefficients relating X to ξ; where ξ is a $m \times 1$ vector of independent (exogenous) latent variables; δ is a $p \times 1$ vector of measurement errors for X.

$$\text{Structural Model: } \underbrace{\eta}_{m\times 1} = \underbrace{\beta}_{m\times m}\underbrace{\eta}_{m\times 1} + \underbrace{\Gamma}_{m\times n}\underbrace{\xi}_{n\times 1} + \underbrace{\zeta}_{m\times 1}$$

where η is a $m \times 1$ vector of dependent (endogenous) latent variables; ξ is a $n \times 1$ vector of independent (exogenous) latent variables; ζ is a $m \times 1$ vector of latent (structural) errors; Γ is a $m \times n$ matrix of coefficients for the latent exogenous variables; β is a $m \times m$ matrix of coefficients for the latent endogenous variables.

The general measurement model for this study is

$$\begin{pmatrix} X_{i1} \\ X_{j2} \\ \vdots \\ X_{n6} \end{pmatrix} = \begin{pmatrix} \lambda_{i1} & & & & & \\ & \lambda_{j2} & & & & \\ & & \lambda_{k3} & & & \\ & & & \lambda_{l4} & & \\ & & & & \lambda_{m5} & \\ & & & & & \lambda_{n6} \end{pmatrix} \begin{pmatrix} \xi_1 \\ \xi_2 \\ \vdots \\ \xi_6 \end{pmatrix} + \begin{pmatrix} \delta_1 \\ \delta_2 \\ \vdots \\ \delta_{29} \end{pmatrix},$$

where X_{i1} is a column vector $(i = 1, 2, 3, 4)$, X_{j2} is column vector $(j = 5, 6, 7, 8, 9)$, X_{k3} is a column vector $(k = 10, 11, 12, 13)$ X_{l4} is a column vector $(l = 14, 15, 16, 17)$, X_{m5} is a column vector $(m = 18, 19, 20, 21, 22, 23, 24, 25)$, X_{n6} is a column vector $(n = 26, 27, 28, 29)$.

The details of Models 1&2.

Model 1: X are the 29 indicators, that is, the questions on WHOQoL-HIV (BREF) questionnaire, ξ are the six domains and δ are the error terms for X. 29 observed exogenous variables and 6 latent exogenous variables

$$X_{29\times1} = \Lambda_{x(29\times6)}\xi_{(6\times1)} + \delta_{(29\times1)}$$

Model 2: Y are the 7 questions for both two overall QoL questions and 5 questions on SWLS, other terms are as in Model 1. 29 observed exogenous variables, 6 latent exogenous variables, 7 observed endogenous variables and 2 latent endogenous variables

$$\begin{aligned} X_{(29\times1)} &= \Lambda_{x(29\times6)}\xi_{(6\times1)} + \delta_{(29\times1)} \\ Y_{(7\times)} &= \Lambda_{y(7\times2)}\eta_{1(2\times1)} + \epsilon_{(7\times1)} \\ \eta_{(2\times1)} &= B_{(2\times2)}\eta_{1(2\times1)} + \Gamma_{(2\times6)}\xi_{(6\times1)} + \zeta_{(2\times1)} \end{aligned}$$

3. Analysis and Results

Model 1

Analysis was carried out on the theoretical 6-component WHOQOL-HIV (BREF) the solution was admissible with minimum iteration, hence a single model was proposed. The chi-square goodness-of-fit test of the model was significant, an indication that there is difference between the observed and expected covariance matrices. However the chi-square indicator is highly dependent on sample size, so relative chi-square $\chi^2(\chi^2/df < 3 = 2.994)$ which adjusted for the sample size was also considered. The fit indices (GFI = 0.871, AGFI = 0.840, RMSEA = 0.060) and the information criteria (AIC = 1219.935, BIC = 1579.749 and CAIC = 1662.745) confirmed that the modified model fit the independent dataset.

The completely standardized GLS estimates of the factor loadings and factor correlations in the CFA model with six correlated factors are given in Figure 1. The latent factors were interpreted as physical health, ξ_1 (Domain 1); psychological, ξ_2 (Domain 2); level of independence, ξ_3 (Domain 3); social relation, ξ_4 (Domain 4); environment, ξ_5 (Domain 5); and spirituality and religious and personal believe, ξ_6 (Domain 6).

The latent constructs were moderately and highly correlated between −0.78 and 0.93. Under the first level or direct correlation between the domains, the path diagram showed that Domain 5 and Domain 6 had a very weak relationship while Domain 2 and Domain 3 had a very strong relationship. Figure 1 also showed that most of the indicators contributed significantly to the different domains, except for that corresponding to life being meaningful (QB7) and Domain 6.

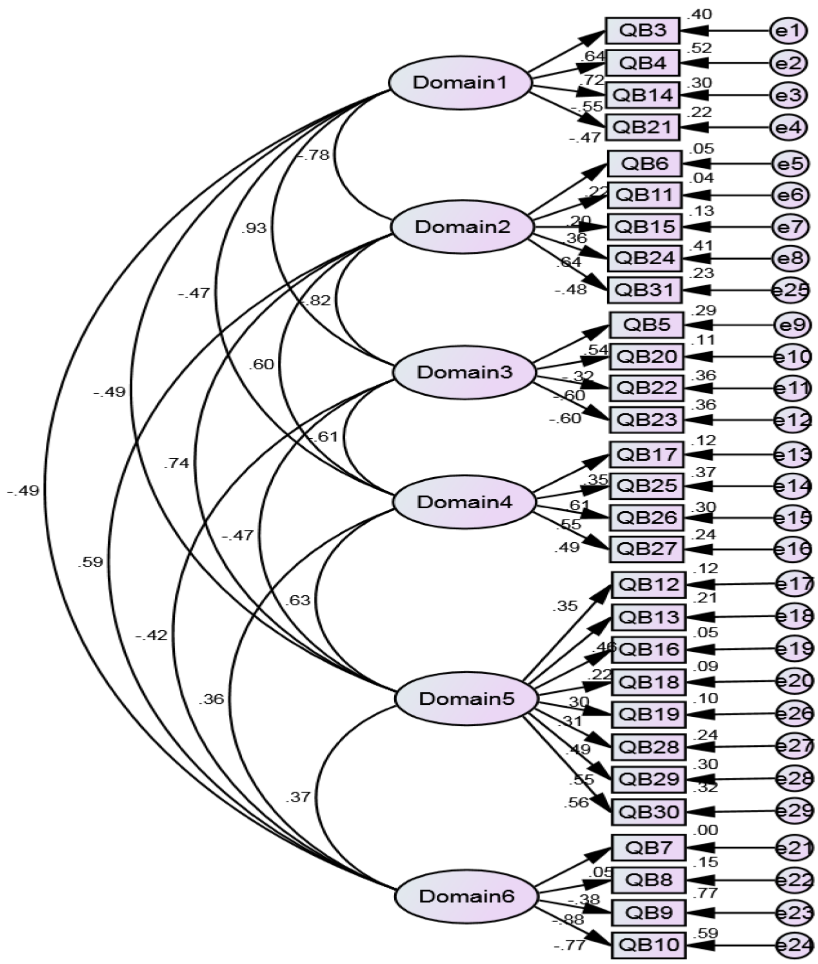

Fig. 1. Path diagram and standardized GLS estimates of the parameters in the CFA model.

Model 2

Analysis was carried out on the theoretical 6-component WHOQoL-HIV (BREF), 5-component endogenous SWLS and 2-component endogenous overall QoL, the solution was admissible with minimum iteration, hence a single model was proposed. The chi-square goodness-of-fit test of the model was significant, an indication that there is difference between the observed and expected covariance matrices. However, chi- square indicator is highly dependent on sample size so relative chi-square $\chi^2(\chi^2/df <= 2.879)$ which adjusted for sample size was also considered. This shows that the model best fit the dataset. The fit indices (GFI = 0.837 AGFI = 0.811 PRATIO = 0.910 RMSEA = 0.058) and information criteria (AIC = 1835.484 and BIC = 2238.644) confirmed that the model fit the independent dataset.

To address the causations of the six identified latent constructs to the two QoL questions and SWLS, we applied SEM to the database. The path diagram of the proposed structural equation model is in Figure 2. The latent constructs were moderately and highly correlated between −0.85 and 0.94. The model recorded a very high relationship between domain 1 and domain 3 and a weak relationship between domain 4 and domain 6. It further showed that most of the indicators contributed significantly to their corresponding domains. Though, the estimates of the factor correlation and factor loadings were different from that of CFA model, the patterns of difference were the same.

The model also gave information on the structural part as follows: the two indicator variables QB1 and QB2 had very high impact on QoL, while, QC1 (In most ways my life is close to my ideal) and QC5 (If I could live my life over, I would change almost nothing) had little impact on SWLS. Where β coefficient is 0.42 indicating an averagely high impact of SWLS on the QOL of an infected person. The estimated structural equation is:

$$\begin{aligned}\eta \;=\; & 0.42\eta_1 + 0.75\xi_1 + 0.48\xi_2 - 0.95\xi_3 \\ & -0.25\xi_4 - 0.075\xi_5 + 0.06\xi_6 + \zeta,\end{aligned}$$

with an estimated residual variance of 0.175.

4. Discussion and Conclusion

The application of SEM to finding appropriate model between latent constructs and other health related indicators with ordinal categorical observation is on the increase in the measure of quality of life in medical research. In this study, the data that corresponded to the ordinal items that reflected the latent constructs of the QoL were used. Six correlated factors for accessing the domains: physical, psychological, level of independence, social relationship, environmental, and spirituality religion and personal believe for WHOQoL-HIV questionnaire as seen the path diagram in Figure 1. To access its goodness-of fit, GLS estimates of the parameters in the models were obtained by AMOS version 21. Hence, the observed data gave strong support to the CFA model with six correlated factors. The standardized GLS estimates of the factor loadings and factor correlations in the CFA model with six correlated factors were given in Figure 1. Most of the factor loading estimates, except for the corresponding the extent you feel your life to be meaningful for domain 6, were averagely high. This indicates a strong association between each of the latent constructs and its respective items as shown in Figure 1.

The associations of the domains with QOL and SWLS among the populations were assessed with the application of SEM to the dataset which already contained the overall QOL and

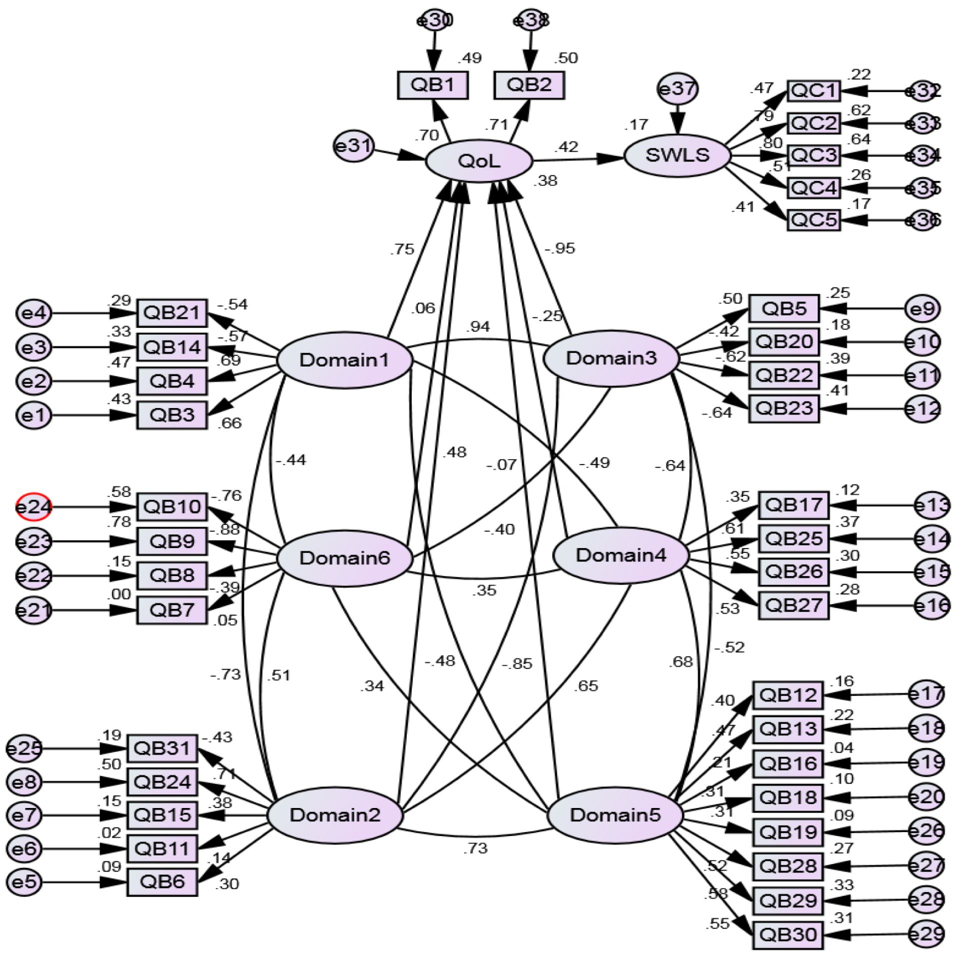

Fig. 2. Path diagram and standardized GLS estimates of parameters in the structural equation model for health related Quality of Life with two indicators for overall QOL and Satisfaction with Life Scale (SWLS).

general health related question. The path diagram of the proposed structural equation model is shown in Figure 2. This structural equation model, defines a covariance structure for the 36 ordinal categorical items. The structural equation model was different from the CFA model, the estimates of the factor correlations among the six latent constructs were not the same. The estimated structural equation in relation to the endogenous latent construct QOL (η) and the exogenous latent indicated that physical domain (ξ_1) had the most substantial causal effect on QoL (η) which was more than psychological domain (ξ_2) which was in turn higher than the causal effect of spirituality, religion and personal believe domain (ξ_6), where level of independence (ξ_3), social relationship domain (ξ_4)and environmental domain (ξ_5) had negative causal effects on QoL with a correlation between

QoL and SWLS.

These results showed that the physical aspect of life has a high impact on the quality of life of an infected person [Lee *et al.* (2005)]. Furthermore, the quality of life of an infected person influences the variation in his/her satisfaction with life.

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