Construct Validity of the Suboptimal Health Status Questionnaire-25 in a Ghanaian Population

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Research

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Abstract

Background

The Suboptimal Health Status Questionnaire-25 (SHS-Q-25) developed to measure suboptimal health status has been used worldwide, but its construct validity has only been tested in the Chinese population. In this article, we investigate aspects of the construct validity of the SHS-Q-25 to determine the interactions between SHS subscales in a Ghanaian population.

Methods

The study involved healthy Ghanaian participants (n = 263; aged 20-80 years; 63% female), who responded to the SHSQ-25. In an exploratory factor and parallel analysis, the study extracted a new domain structure and compared to the established five-domain structure of SHSQ-25. A confirmatory factor analysis (CFA) was conducted and the fit of the model further discussed. Invariance analysis was carried out to establish the consistency of the instrument across multi-groups.

Results

The extracted domains were reliable with Cronbach's B of 0.861, 0.821 and 0.853 respectively, for fatigue, immune-cardiovascular and cognitive, confirming the construct validity of the SHSQ-25 instrument. The CFA revealed that the model fit indices were excellent a The fit indices for the three-domain model were statistically superior to the five-domain model. There were, however, issues of insufficient discriminant validity as some average variance extracts (AVE) were smaller than the corresponding maximum shared variance (MSV). The three-domain model was invariant for all constrained aspects of the structural model across age, which is an important risk factor for most chronic diseases.

Conclusion

The validity tests provide evidence to endorse the credibility of the tool and suggest that the SHS-Q25 is robust tool for measuring SHS in a different population.

Background

Since the current testing and treatment of symptomatic chronic disease is considered a delayed response, it has become generally accepted that early detection provides better treatment options and ensures better quality of life (1, 2). Targeting at-risk individuals is critical, as they can be counselled and provided with prophylactic therapies that can potentially reduce or prevent their risk (1, 2). To achieve this, researchers have resorted to using health assessment or screening instruments or tools, usually subjective questionnaires, to measure individual's dietary habits (3), physical activities (4) and work productivity (5). Although reliance and usage of such questionnaires have promoted clinical diagnosis and lifestyle modifications, their clinical relevance has been eclipsed by the cumbersome and ambiguous

nature of some of the questions, the time required to complete the questionnaire and the challenges of interpreting the results. For these reasons, a more streamlined and targeted instrument is required.

Over the last few years, some advances in research have been made in the design of robust screening instruments, giving rise to the widely used Suboptimal Health Status Questionnaire-25 (SHSQ-25) (6-8). Popularly articulated and operationalised in 2009, the SHSQ-25 has had a leverage over the existing instruments due to its simplicity, clearly described questions and the simple scoring system (9, 10). Importantly, it encapsulates questions that comprehensively capture multiple indicators of good health, including fatigue, the cardiovascular system, the immune system, mental status and digestive tract (6, 9, 11). When completed, SHSQ-25 can reveal individuals who may be experiencing poor health that cannot be traced to a particular disease, referred to as Suboptimal Health Status (SHS) (6, 10-12).

SHS represents an intervening state, prior to chronic disease, that is often hallmarked by a lack of vitality, body weakness and loss of appetite (9, 13). It has become a major public health concern worldwide, as its link to different chronic diseases traverses across multiple populations (6, 8, 9, 12, 14, 15). Among the mainland Chinese, SHS was found to be associated with commonly known cardiovascular risk factors including psychosocial stress (10, 16), physical inactivity, increased blood pressure, plasma glucose and abnormal lipid profiles (9, 11). In a Russian population, SHS was associated with endothelial dysfunction (7) and among Ghanaians, it was a precursor to type II diabetes mellitus (7, 12). Following their analyses of hematobiochemical, sociodemographic and clinical data, Anto et al., (15) indicated the presence of SHS before preeclampsia among pregnant women in Ghana (15). Among Chinese youths, SHS was associated with altered intestinal microbiota (17). Furthermore, its association with objective markers including plasma cortisol, mRNA expression of glucocorticoid receptor α/β (10), plasma metabolites (13), N-glycosylation profiles (14), telomere length (18) and oxidative stress (19) as well as angiogenic growth mediators (19) have been reported.

Despite its widespread applications, studies that explore the psychometric properties of the SHSQ-25 are inadequate. The first and only study to date, that tested the validity and reliability of SHSQ25 was conducted in a Chinese population (6). In this study, they applied statistical methods such as test-retest reliability, internal consistency, convergent validity, along with factor and exploratory analysis to show that SHS-Q25 is capable of detecting SHS (6). Although this study highlights some psychometric testing, its construct validity has not been evaluated outside of China. This information is critically important because the relative validity and reliability of tools may not be the same in different populations, especially an African population such as Ghana.

On the one hand, Ghanaians in urban cities share similarities with Chinese in terms of urbanisation, increased work stress and pressures from home (20, 21). As such, the prevalence of SHS might be the same in both countries. On the other hand, Ghanaians have different genetic composition, varied job types, climatic conditions, different cultures and dietary differences that may make them susceptible to SHS or even a particular chronic disease (20). In addition, the extent of interactions and correlations

between the metrics or components in each of the five domains have not been properly reported. Taken together, these constitute a significant research interstice and provide a justification for this present study.

Following on our previous studies (6, 8, 10, 22), with the goal of exploring the cross-national comparability of SHSQ-25 and emphasising on the robustness of the SHSQ-25, this current study aims to investigate the aspects of construct validity of the SHS-Q25 by applying a Structural Equation Model (SEM) to determine the interactions between SHS subscales in a Ghanaian population.

Study Design And Methods

In a cross-sectional study, 263 apparently healthy individuals were recruited from the Kumasi Metropolis of Ghana using convenient sampling technique. The SHSQ-25 was used to measure SHS for all participants. It has 25 questions with five health domains: immune system (3 items), mental health (7 items), fatigue (9 items), digestive system (3 items), and cardiovascular system (3 items). Using a 5-point Likert type scale, participants indicated their health status by selecting the following options (1) never or almost never, (2) occasionally, 3) often, (4) very often and (5) always. The study excluded all participants with known clinical conditions such as hypertension, respiratory, genitourinary and haematological problems. Participants aged 18–80 years were included.

Clinical data

Systolic and diastolic blood pressures (SBP and DBP) were measured with a sphygmomanometer. Using a standard stadiometer (SECA, Hamburg, Germany), we measured the height (cm) and weight (kg). From these, body mass index (BMI) was calculated using the formula BMI = weight (kg)/height $(m)^2$. Tape measure was used to measure the waist and hip circumference. Prior to detecting fasting blood glucose (FPG), we collected blood samples from the antecubital vein into fluoride oxalate coated tubes. Levels of sugar were detected on an automated chemistry analyser (Roche Diagnostics, COBAS INTEGRA 400 Plus, USA).

Statistical analyses

The appropriateness of the data was assessed using the Kaiser-Meyer-Olkin (KMO) statistic and the Bartlett's test of sphericity. We investigated the domain structure of the SHSQ-25 instrument using an exploratory factor analysis (EFA). We conducted the principal component analysis to ascertain the domain structure and was confirmed in a parallel analysis. The component correlation matrix informed the varimax rotation to be performed on the extracted factors at a cut of 0.4. The reliability of the items in each domain was assessed by Cronbach's alpha. The Structural Equation Model (SEM) was used in a confirmatory factor analysis (CFA). The goodness-of-fit of models were assessed using appropriate indices such as comparative fit index (CFI), root mean square error of approximation (RMSEA), goodness-of-fit index (GFI), and Tucker-Lewis Index (TLI). We further calculated the composite reliability (CR) statistics to establish the construct validity or otherwise of the SHSQ-25 instrument. The average variance extract (AVE) and maximum shared variance (MSV) were used to assess the discriminant

validity of the instrument. The results reached statistical significance at an alpha level of 0.05. Invariance analysis was performed to assess the specification equivalence across various groupings in the dataset, namely; gender (male and female), age group (subjects above average age, subjects below average age) and marital status (married and not married) for unconstrained models, models constrained on the factor loadings, models constrained on the structural covariance loadings and models constrained on the residual covariance loadings.

IBM AMOS 25 was used for the CFA, SPSS Statistic 26, for the EFA and Stats Tools Package, an online resource available at *http://statwiki.kolobkreations.com/index.php*.

Results

The dataset consisted of 263 healthy Ghanaian individuals, male (n = 96) and female (n = 167), aged between 20 and 80 years (M = 51.32, SD = 12.25). In general, females had increased BMI (27.30 ± 5.24, p=0.0001) and waist-to height ratio (WHtR) (0.58 ± 0.08, p=0.0001) compared to males. However, there was no statistically significant difference in FPG, and SBP between males and females. Most males and females had some form of education and employment **(Table 1)**.

Baseline results: Conceptual model for the SHSQ-25 instrument

Figure 1 presents the conceptual model for the SHSQ-25 instrument showing the measures of the relationship between the latent variables and questionnaire items. The overall fit of the model is good with . There are high correlations between the latent variables. For instance, the correlational values are fatigue and immune system (R = 0.949), immune system and cardiovascular system (R = 0.904), fatigue and cardiovascular system (R = 0.873), digestive System and cardiovascular system (R=0.87), and digestive and fatigue (R= 0.70). However, there was a relatively low correlation between immune system and mental health (R=0.56), and mental health and cardiovascular system (R= 0.40). In terms of discriminant validity, except for mental health (AVE = 0.372, MSV = 0.317), the four other domains did not achieve satisfactory measure as the AVE scores were less than the MSV scores. There were also convergent validity issues as the AVE for the latent variables were below the 0.5 threshold: fatigue (0.339), immune system (0.296), cardiovascular system (0.437), mental health (0.372) and digestive system (0.335). The composite reliability (CR) measures for the latent variables were below 0.7 except for fatigue and mental health **(Figure 1)**.

New domain extraction

The sample adequacy was established using KMO = 0.889. The Bartlett's test of sphericity produced a *p*-value < 0.001, indicating that the dataset diverges significantly from the identity matrix, making the data set suitable for data reduction. The factor extraction process and a parallel analysis revealed that three factors are more appropriate (**Figure 2**). The cumulative variance explained by the factors is 60.46% and all items had factor loadings more than 0.4.

From the CFA, the three-domain model recorded excellent fit indices, . The rotated factor loadings for the new domain structure are presented in **Table 2.**

The internal consistency of the domains was assessed using the Cronbach's α and item-delete Cronbach's α. The internal consistency was good with Cronbach's α statistics lying between . **Table 3** presents the Cronbach's α and the item-delete Cronbach's α for the three-domain.

Figure 3 presents the standardized factor loadings from the structural model. All the regression weights for the items are statistically significant ($p < 0.001$). The composite reliability (CR) statistics indicate construct validity as they are all above the 0.7 threshold. In terms of convergent and discriminant validity, the average variance extract (AVE) are smaller than the maximum shared variance (MSV) for Domain A (AVE = 0.356, MSV = 0.701) and Domain C (AVE = 0.298, MSV = 0.701). The average variance extract (AVE) was greater than the maximum shared variance (MSV) for Domain B (AVE = 0.617, MSV = 0.285.

Invariance analysis

A multi-group analysis was performed to assess whether the three factors from the CFA are invariant across gender, age and marital status. Gender was categorised as male (n = 94) or female (n = 163), age was treated as a binary variable, with the dataset divided into those below (n = 123) or above (n = 134), mean of 51. Marital status was also treated as a binary variable, with the dataset split into married (n = 168) and not married (n = 89).

Table 4 shows the fit for the multi-group analyses. Constrained models were compared to a baseline model where no constrains were placed on any aspect of the three-factor structural model across multi-groups. Across age, the three-factor model was invariant when the factor loadings are constrained, structural covariance loadings are constrained, and residual covariance loadings constrained ($p > 0.05$). Across marital status, the three-factor model was invariant when the factor loadings and structural covariance loadings were constrained ($p > 0.05$), however, invariance was not achieved when the residual covariance loadings were constrained ($p = 0.001$). Across gender, the three-factor model was not invariant for any level constrained model ($p < 0.05$).

Discussion

The increasing interest in chronic disease prevention has fuelled a predilection for early intervention programmes and early detection instruments. The success of these tools largely depends on the robustness of the instrument, and to a lesser extent, the ease of completing it. The present study describes the psychometric properties of the SHSQ-25 in a Ghanaian population. In the construct validity assessment, we conducted exploratory factor and parallel analysis on the five health subscales of the SHS-Q25 **(Figure 1)**. It was shown that the five health domains of the SHSQ-25 had moderate-good internal consistency and reliability. After conducting confirmatory factor analysis (CFA), the results revealed that the fit indices for the three-domain model (A, B, C) were statistically superior to the five-domain model (**Figure 3**). Clearly, there is an overlap of the subscales of the SHS-Q25 in the Ghanaian

population and the resulting three-domain structure is resigned as fatigue (Domain A), immune-cardiovascular (Domain B) and cognition (Domain C). The findings are consistent with the results of our previous study among Chinese that reported $\chi 2$ (400) = 2517.41, P < 0.001 (6); RMSEA = 0.044 (95% CI, 0.042 to 0.045), GFI = 0.914 and an overall Cronbach's of 0.93.

Moreover, the present study reports low internal consistencies of the immune (0.553) and digestive systems (0.602) comparable to what was reported in our previous study (6). But in the Ghanaian context, a compelling reason for this could be due to language translation errors. The literature pinpoints that harmonisation of language is the cornerstone for cross-national comparability (23). In this study, a significant number of the participants lacked knowledge in the English language used in the questionnaire, thus warranting the need for translation from English to the local Ghanaian language. As is always the case, meaning of the questions were likely lost in translation and/or the translated questions were interpreted incorrectly. This could have been ameliorated with a machine translation device but unfortunately, this instrument was not available at the time of data collection.

Meanwhile, the overlap between the results of this study and that of the Chinese could own to the certain intrinsic similarities between the two nations (24). Like the Chinese economy, Ghana has also seen a tremendous growth in the last few decades, and this reflected in the significant positive changes in macroeconomic indicators including gross domestic product (GDP), consumer price index, stock market prices, industrial production, amongst others. This dramatic growth has paralleled globalisation, affluence and a relentless pace of industrialisation that has triggered sedentary lifestyles, physical inactivity and a quotidian appetite for more westernised diets (12, 14, 20).

Many of these factors, if not all, are stimulus for the incidence of multiple noncommunicable diseases (NCDs). Presently, NCDs account for the death of up to 43% of people, with 19% dying from cardiovascular diseases, 5% from cancers, 2% from chronic respiratory diseases, 3% from diabetes (20). However, the long latency period for these chronic diseases, coupled with limited health care resources, make it difficult to intervene in a timely fashion. Even when diagnosed, the cost associated with the treatment and management make it difficult to manage the symptoms and live to their full potential. That is why a robust instrument, such as the SHSQ-25 is an invaluable asset not only for the Chinese population but also for Ghanaians. A product of persistent conceptualisation, rigorous testing and evaluation, the SHSQ-25 is user-friendly, can be self-administered or can be completed with minimal assistance from health professional. Once completed, at-risk individuals can be identified for therapies that can prevent or at least delay the onset of these diseases.

The present study also shows that a significant number of participants experienced fatigue. This finding is plausible in the light of the literature that suggests urban dwellers including residents of Kumasi are confronted with daily life choices that leaves them with psychological and physiological distress. These include exertion from strenuous activities, work related problems and pressures, inadequate sleep, stress or an underlying medical condition. More intriguing is the statistically significant correlation between fatigue and the immune system **(Figure 3)**. Research has shown the bidirectional relationship between

immune system and the brain (25, 26). Inflammatory cytokines migrate through neural, humoral and cellular pathways to reach the brain where they interact with the cytokine network. The consequence of this interaction is the activation of the hypothalamic pituitary-adrenal axis (HPA) and the symptoms collectively called the sickness behaviour (25, 26). This eventually manifests as altered sleep patterns and decreased appetite (25, 26). Furthermore, our investigation also revealed the association between fatigue and the cardiovascular system. Peckerman indicated a negative correlation between chronic fatigue syndrome and cardiac output (27). Nelessen et al., (2008) found a negative relationship between fatigue and cardiac index and stroke index. However, the study could not find any relationship between fatigue and cardiovascular markers such as blood pressure and heart rate (28). Another important corollary from the study was that there is an association between the immune system and cardiovascular system. At the cellular level, it has been showed that the heart is interspersed with immune cells including macrophages, dendritic cells and mast cells where they interact with cardiomyocytes, perform housekeeping tasks and involved in cardiac remodelling (29).

The discussion on the robustness of the SHS-Q25 can be ongoing, but we need to highlight some limitations. Firstly, there is an overrepresentation of females which may have introduced some bias in the invariance analysis across gender. Secondly, the discriminant and convergent validity did not provide the desired results as anticipated. However, the three-factor was invariant across age, which is an important risk factor for diabetes. Invariance was achieved for all constrained aspects of the structural model, which establishes the consistency of the instrument. Lastly, the SHSQ-25 is only a subjective instrument and does not provide any objective information. Our previous studies have revealed the association between SHS and objective markers of chronic diseases including the increases of blood pressure, low-density lipoproteins plasma cortisol and mRNA expression of glucocorticoid receptor α/β in lymphocyte (10) and blood glucose (9, 18, 19), endothelial dysfunction (7), and also pregnancy-related disorders (15). Going forward, our research will seek to unravel and discern the link between SHS and objective biomarkers of dysfunctional immune, mental, cardiovascular and the digestive systems. Integrating these markers in SHS research can help to decipher the molecular underpinnings of chronic diseases.

Conclusion

The SHSQ-25 is a well-constructed health measure instrument evidenced by the excellent internal consistency and validity in a Ghanaian population. The SHSQ-25 is robust and thus can be recommended to be used as a generic screening tool to early detect possible chronic diseases across general populations particularly in developing countries where health promotion resources are limited.

List Of Abbreviation

SHS	Suboptimal health status
SHSQ-25	Suboptimal health status questionnaire

NCD	Non-communicable disease
CFA	Confirmatory factor analysis
AVE	Average variance extracts
MSV	Maximum shared variance
SEM	Structural equation model
SBP	Systolic blood pressure
DBP	Diastolic blood pressure
BMI	Body mass index
FPG	Fasting plasma glucose
KMO	Kaiser-Meyer-Olkin
EFA	Exploratory factor analysis
RMSEA	Root mean square error of approximation
GFI	Goodness-of-fit index
TLI	Tucker-Lewis Index
CR	Composite reliability
WHtR	Waist-to-height ratio

Declaration

Ethical approval

The study was conducted in agreement with the principles of the Declaration of Helsinki. The study was approved by the Human Research Ethics Committee, Edith Cowan University, Australia and the Committee on Human Research, Publication and Ethics, Kwame Nkrumah University of Science and Technology. An informed consent was obtained from every participant.

Competing interest

Authors have no competing interests to declare.

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Authors contribution

EA[1,2] and EAY[3] conceived the study; YX[7], YXW[7] and WW[1,7,8] designed the questionnaire. XT[1] made intellectual input. EA[1] collected data, processed blood samples, wrote and revised. EAY[3] performed statistical analyses and results. KF[1,3], EA[4], SPK[2], EOA[2], EA[6], XT[1] edited the ideas and concepts presented. All authors read and approved the final manuscript.

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Consent for publication

Not applicable

Availability of data

The data that support the findings of this study are available from Edith Cowan University, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are however available from the authors upon reasonable request and with permission of Edith Cowan University.

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Tables

Table 1. Characteristics of study participants stratified by gender

Variable	Male (n=96)	Female (n=167)	Statistic	p-value
Age (years) (n=262)	51.95 ± 11.99	50.97 ± 12.45	7742.5[u]	0.7027
BMI			43.149^	**0.0001**
Underweight	7(7.4)	5(3.0)		
Normal weight	58(61.1)	50(29.9)		
Overweight	28(29.5)	58(34.7)		
Obese	2(2.1)	54(32.3)		
Education			24.47^	**0.0001**
Tertiary	25(26.3)	10(6)		
Senior high school	25(26.3)	57(34.3)		
Junior high school	33(34.7)	58(34.9)		
Lower primary	6(6.3)	25(15.1)		
No formal education	6(6.3)	16(9.6)		
Occupation			19.53^	**0.0020**
Employed	73(76.8)	110(66.3)		
Retired	11(11.6)	10(6.0)		
Keeping house	1(1.1)	16(9.6)		
Unemployed	0(0)	15(9)		
Informal	10(10.5)	15(9)		
T2DM history			2.55^	0.2790
Yes	39 (41.1)	78(47.3)		
Clinical data				
WHtR	0.51 ± 0.06	0.58 ± 0.08	3833[u]	**0.0001**
BMI (kg/m^2)	23.15 ± 3.51	27.30 ± 5.24	4179.5[u]	**0.0001**
SBP (mmHg)	146.99 ± 26.96	141.58 ± 22.18	7248[u]	0.2230
DBP (mmHg)	81.94 ± 15.71	85.67 ± 13.46	6670.5[u]	**0.0281**
FPG (mmol/l)	5.73 ± 0.75	5.87 ± 0.99	7306.5[u]	0.3329

Data presented as Mean ± SD and n (%). ^χ^2 test of independence, [u] Mann Whitney U tests. Tests of significance were two tailed and bolded (*p <0.05).

Table 2: Rotated factor loadings results for the three-factor structural model

Label	Item (each question is preceded by i*n the past 3 months*)	Domain 1	Domain 2	Domain 3
SHSf13	How often were you exhausted without greatly increasing your physical activity?	0.797		
SHSf14	How often did you have fatigue which could not be substantially alleviated by rest?	0.776		
SHSf15	How often were you lethargic in your daily life?	0.722		
SHSf16	How often did you suffer from headaches?	0.487		
SHSf17	How often did you suffer from dizziness?		0.416	
SHSf18	How often did your eyes ache or feel tired?	0.441		
SHSf19	How often did your muscles or joints feel stiff?	0.663		
SHSf20	How often did you have pain in your shoulders/neck/back?	0.592		
SHSf21	How often did you have a heavy feeling in your legs when walking?	0.575		
SHSCS22	How often did you feel out of breath while resting?	0.459		
SHSCS23	How often did you suffer from chest congestion?		0.695	
SHSCS24	How often were you bothered by heart palpitations?		0.499	
SHSDS25	How often was your appetite poor?		0.600	
SHSDS26	How often did you suffer from heartburn?		0.632	
SHSDS27	How often did you suffer from nausea?		0.614	
SHSIS28	How often did you have difficulty tolerating hot and cold temperatures?	0.429		
SHSIS29	How often did you catch a cold?		0.467	
SHSIS30	How often did you suffer from a sore throat?		0.646	
SHSMH31	How often did you have difficulty falling asleep?		0.453	
SHSMH32	How often were you troubled by waking up during the night?		0.434	
SHSMH33	How often did you have trouble with your short-term memory?			0.766
SHSMH34	How often did you did you have difficulty responding to situations quickly or making decisions?			0.824
SHSMH35	How often did you have difficulty concentrating?			0.860
SHSMH36	How often were you distracted for no reason?			0.830
SHSMH37	How often did you feel nervous or jittery		0.636	

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Suboptimal Health Status (SHS); Mental Health (MH); Cardiovascular System (CS); Fatigue (F); Immune System (IS); Digestive System (DS).

Table 3: Internal consistency of the three-factors structure

Cronbach's α	Item (each question is preceded by i*n the past 3 months*)	Cronbach's α if item is deleted
	How often were you exhausted without greatly increasing your physical activity?	0.839
	How often did you have fatigue which could not be substantially alleviated by rest?	0.841
	How often were you lethargic in your daily life?	0.847
Domain A	How often did you suffer from headaches?	0.855
(0.861)	How often did your eyes ache or feel tired?	0.852
	How often did your muscles or joints feel stiff?	0.846
	How often did you have pain in your shoulders/neck/back?	0.846
	How often did you have a heavy feeling in your legs when walking?	
	How often did you feel out of breath while resting?	0.847
	How often did you have difficulty tolerating hot and cold temperatures?	
		0.852
		0.851
	How often did you suffer from dizziness?	0.809
	How often did you suffer from chest congestion?	0.792
	How often were you bothered by heart palpitations?	0.806
	How often was your appetite poor?	0.808
Domain B	How often did you suffer from heartburn?	0.804
(0.821)	How often did you suffer from nausea?	0.805
	How often did you catch a cold?	0.808
	How often did you suffer from a sore throat?	0.801
	How often did you have difficulty falling asleep?	0.817
	How often were you troubled by waking up during the night?	0.813
	How often did you feel nervous or jittery	0.803
	How often did you have trouble with your short-term memory?	0.863
	How often did you did you have difficulty responding to situations quickly or making decisions?	
Domain C	How often did you have difficulty concentrating?	0.802
(0.853)	How often were you distracted for no reason?	
		0.790
		0.808

Domain A: Fatigue, Domain B: Immuno-cardiovascular, Domain C: Cognition

Table 4: Multi-group analysis of fit indices by gender, age group and marital status for three-factor unconstrained model, and models constrained on factor loadings, structural covariance loadings and residual covariance loadings.

Model	^{2}	df	RMSEA	90% CI	SRMR	CFI	GFI	TLI	*p*-value
Unconstrained									
Across gender	742.385	526	0.040	[0.033, 0.047]	0.077	0.912	0.830	0.900	-
Across age group	778.907	526	0.043	[0.037, 0.050]	0.075	0.898	0.824	0.883	-
Across marital status	739.473	526	0.040	[0.033, 0.046]	0.063	0.912	0.828	0.899	-
Measurement weights									
Across gender	781.238	548	0.041	[0.034, 0.047]	0.081	0.896	0.821	0.896	0.015
Across age group	806.307	548	0.043	[0.037, 0.049]	0.078	0.895	0.819	0.885	0.196
Across marital status	759.372	548	0.039	[0.032, 0.045]	0.065	0.912	0.824	0.904	0.589
Structural covariance									
Across gender	793.156	554	0.041	[0.035, 0.047]	0.088	0.895	0.819	0.895	0.005
Across age group	810.555	554	0.043	[0.036, 0.049]	0.083	0.896	0.818	0.887	0.289
Across marital status	767.887	554	0.039	[0.032, 0.045]	0.075	0.911	0.823	0.904	0.443
Measurement residuals									
Across gender	870.873	588	0.043	[0.037, 0.049]	0.094	0.883	0.805	0.883	<0.001
Across age group	859.787	588	0.043	[0.036, 0.049]	0.084	0.890	0.811	0.888	0.054
Across marital status	841.491	588	0.041	[0.035, 0.047]	0.073	0.895	0.806	0.893	0.001

df = degrees of freedom; RMSEA = Root Mean Square Error of Approximation, CI = confidence interval; SRMR = Standardizedroot mean square residual; CFI = Comparative Fit Index; GFI = Goodness-of-Fit Index and TLI = Tucker-Lewis Index.

Figures

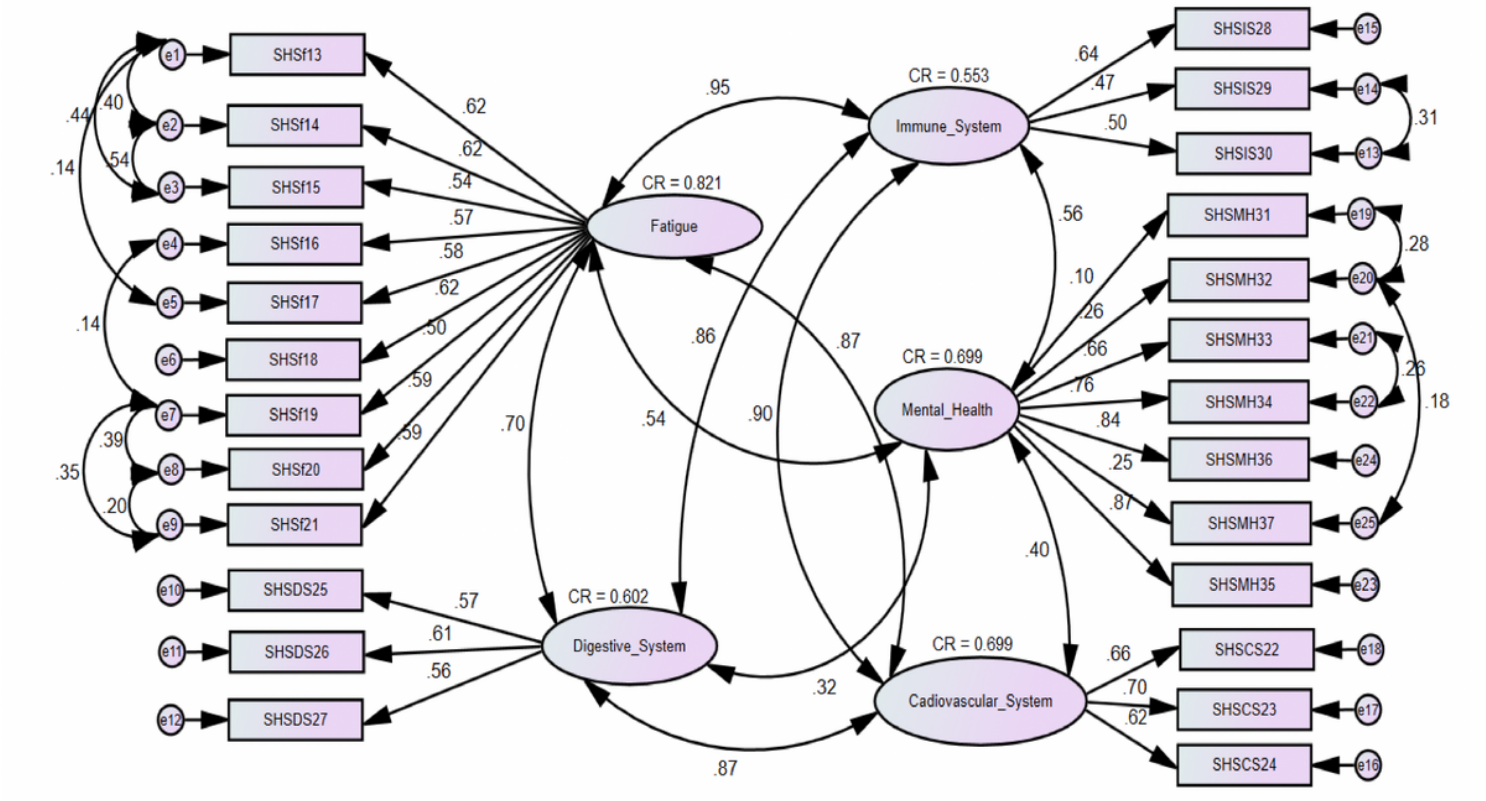

Figure 1

Confirmatory factor model showing the standardized factor loadings for the five-domain structure of the SHSQ-25 instrument. Each of the five domains showed a good-moderate reliability; Immune System (IS) (0.553); Fatigue (F) (0.821); Digestive System (DS)(0.602); Mental Health (MH)(0.699) and Cardiovascular System (CS)(0.699).

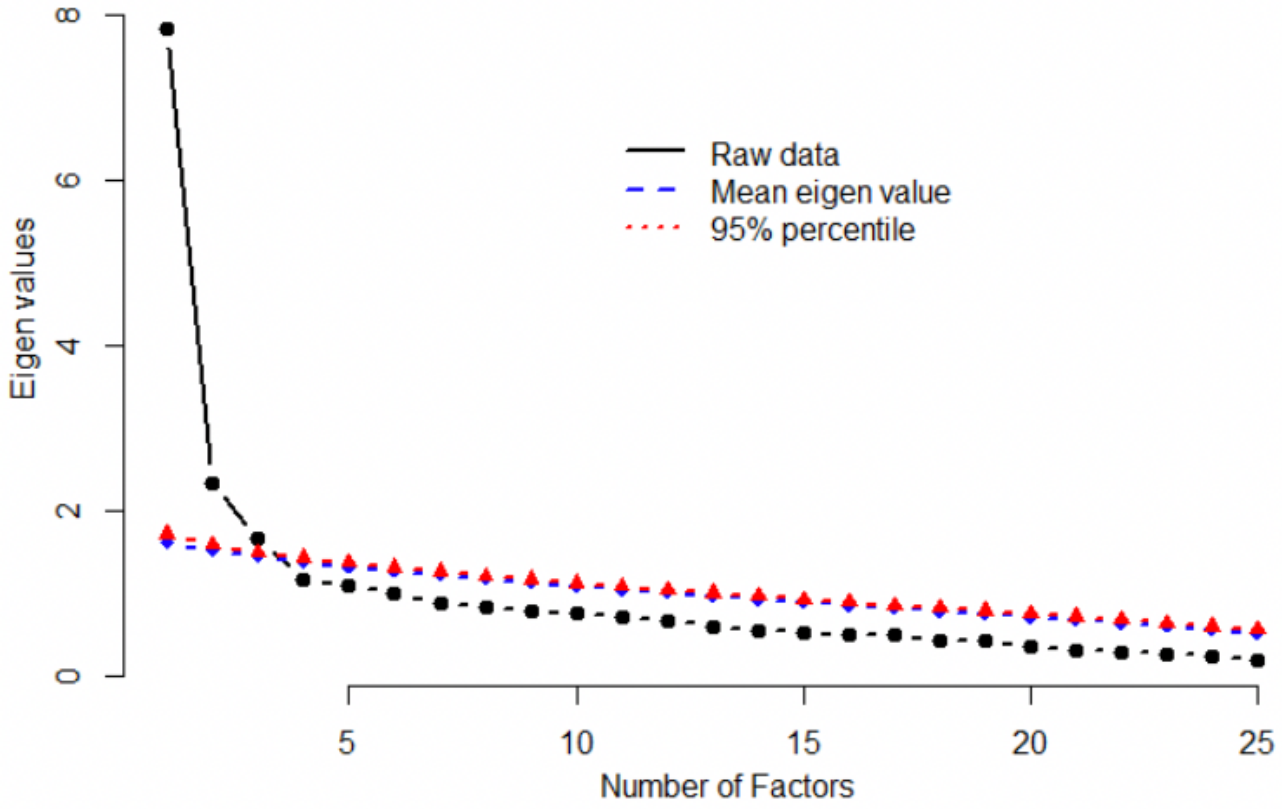

Figure 2

Scree plot and parallel analysis. The scree plot line (in black) indicates the amount of the total variance preserved by a principal component. The parallel analysis presents the mean eigen value (in blue) and the 95th percentile value (in red).

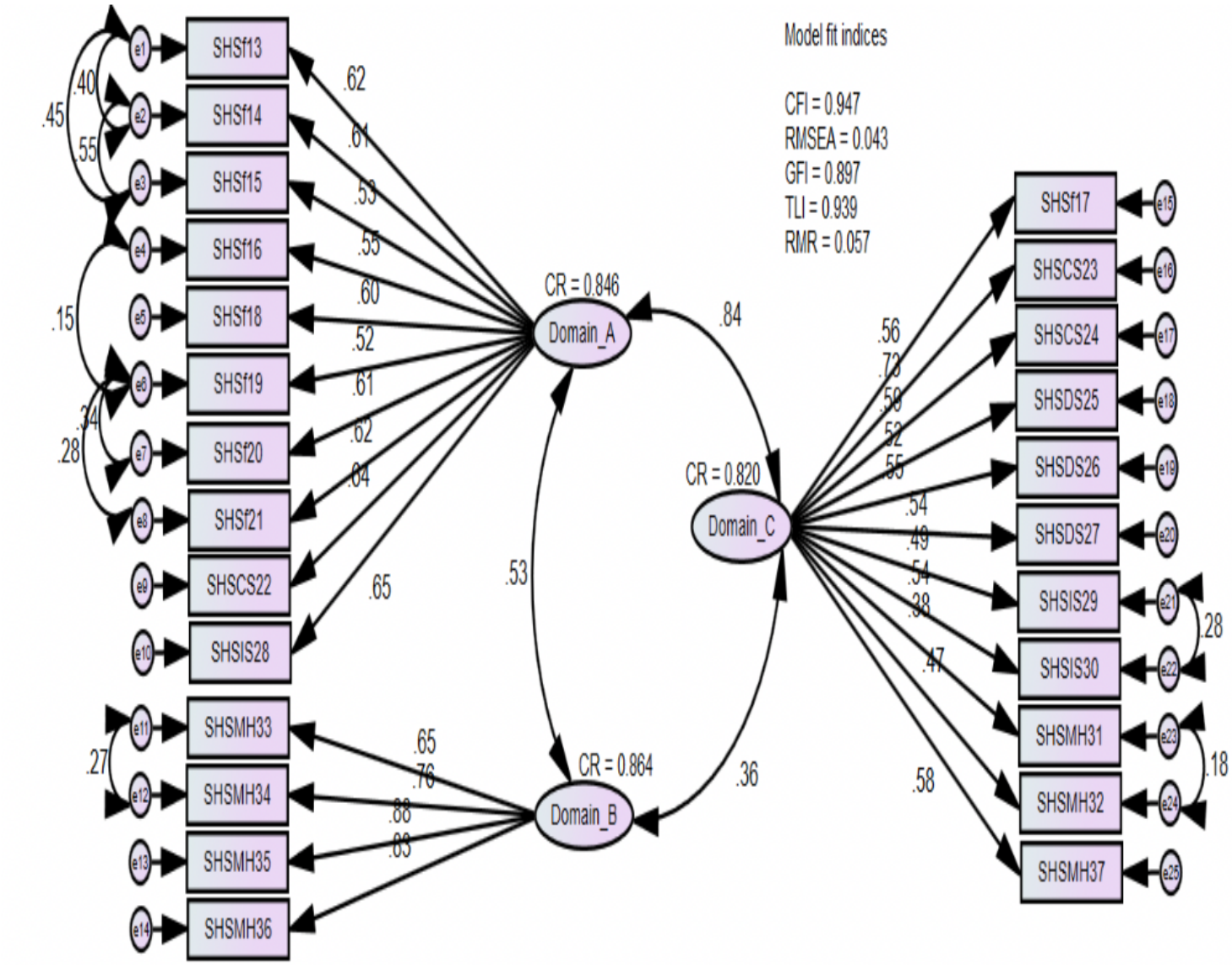

Figure 3

Confirmatory factor model for the three-domain solution. The standardized factor loadings are shown, and the model fit indices are also presented. Suboptimal Health Status (SHS), Mental Health (MH), Cardiovascular System (CS), Fatigue (F), Immune System (IS).