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Analysis of Intergenerational Health-Related Quality of Life using Multiple Group Confirmatory Factor Analysis

Ismail Husein[1*], Novyra Tedi Natasya[1], Rina Widyasari[1]
[1]Department of Mathematics, Universitas Islam Negeri Sumatera Utara, Indonesia
husein_ismail@uinsu.ac.id

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ABSTRACT

Health-Related Quality of Life (HRQoL) is a broad concept that includes physical, mental, emotional, and social aspects of well-being. Because different generations often view health in distinct ways, this study compared HRQoL among Generations X, Y, and Z in Medan using a quantitative, cross-sectional design. The main goal was to test and validate the factor structure of the SF-36 questionnaire and examine whether it measures HRQoL consistently across these groups through Multi-Group Confirmatory Factor Analysis (MG-CFA). The initial analysis supported a reliable four-factor model with 12 items covering Physical Functioning, Role Limitations due to Physical Health, Emotional Well-being, and Role Limitations due to Emotional Health. This model showed strong convergent validity. However, further testing revealed that the SF-36 does not maintain structural equivalence across the three generations, indicating that people interpret its items differently depending on their generational cohort. This finding highlights a key methodological issue: direct comparisons of HRQoL scores across generations are statistically invalid without adjustments. As a result, researchers must apply partial invariance techniques or refine the model before making meaningful cross-generational comparisons.

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A. INTRODUCTION

Health issues are best understood through a multidimensional perspective that extends beyond clinical indicators. The World Health Organization (WHO) defines health as a state of complete, physical, mental, and social well-being, not merely the absence of disease. Health-related quality of life (HRQoL) is a multidimensional concept that focuses on how health status affects an individual's ability to live a fulfilling life. It goes beyond traditional medical measurements by incorporating the subjective experiences of patients regarding their health and well-being. HRQoL captures this broader view by reflecting individual's self-reported functioning and perceived well-being across the physical, mental, and social domains (Karimi & Brazier, 2016). To measure these dimensions, the Short-Form 36 (SF-36) is widely recognized as the most commonly used generic health status tool worldwide (Hossain et al., 2023).

The Short Form-36 (SF-36) is a widely used 36-item survey that measures health-related quality of life across eight domains, providing a comprehensive assessment of physical and mental health. The SF-36, developed by RAND as part of the Medical Outcomes Study in 1922, is a generic, patient-reported survey designed to assess overall health status and quality of life across multiple dimensions. It is widely used in clinical research, epidemiology, and routine healthcare to evaluate the impact of chronic conditions, treatments, and interventions on patient well-being. Its reliability and validity have been thoroughly tested across diverse populations. Because it is often applied in cross-population studies, ensuring the structural integrity and validity of the SF-36 remains a critical requirement in international health research (Arovah & Heesch, 2020).

Measuring HRQoL with instruments, such as the SF-36, is naturally influenced by demographic and social factors, particularly across different generations. Modern society is characterized by rapid changes that shape distinct health profiles for Generation X, Generation Y (Millennials), and Generation Z. Differences in mental health across these groups are largely linked to broad societal shifts, such as technological advances and socioeconomic pressures, that create unique risk factors for each generation (Botha et al., 2023; Lee et al., 2020). For instance, Generation Z often shows greater vulnerability to mental health challenges, while Millennials frequently experience stress related to prolonged career and financial instability (Heo et al., 2024). These generational distinctions highlight that each cohort faces unique health challenges and experiences HRQoL in different ways. As a result, comparative research for developing tailored public health interventions that address the specific needs of diverse generations (Lee et al., 2020).

This complexity of intergenerational HRQoL dynamics is particularly prominent in rapidly developing urban centers such as Medan, North Sumatra. As one of the largest metropolitan areas in Western Indonesia, Medan serves as a critical case study of accelerated urbanization and socioeconomic transformation in the region (Setiawan & Sunarharum, 2020). Rapid growth has resulted in high population density and significant infrastructural strain, while the fast-faced urban lifestyle, characterized by intense digital connectivity and professional competition, poses additional challenges to overall quality of life (Zhao, 2025). Because Southeast Asian metropolitan areas are predominantly populated by young adults from Generations Y and Z, this environment creates conditions in which lifestyle changes may strongly influence HRQoL outcomes across the three generations (Setiawan & Sunarharum, 2020). Comparative research in this urban context is therefore highly relevant for designing targeted public health interventions.

Despite the critical global focus on generational well-being and the pressing socio-economic transformations in Indonesia, comparative research on Health-Related Quality of Life (HRQoL) across distinct generational cohorts (Generation X, Y, and Z) remains scarce in the national context. Existing published literature in Indonesia, particularly concerning health metrics and psychosocial well-being, predominantly adopts a narrow focus, typically examining specific health behaviors or confining their analysis to single-generation outcomes (Arovah & Heesch, 2020). Crucially, even in the limited studies that employ standard instruments such as the SF-36, the results are often difficult to interpret because no studies have compared HRQoL across generational cohorts. Consequently, current public health policies lack the nuanced, evidence-based understanding required to design targeted interventions that effectively address the unique lifestyle and mental health challenges experienced by each distinct age cohort within

Indonesia's urban centers, thereby creating a crucial substantive gap that must be addressed by rigorous contemporary research.

The lack of robust comparative data on HRQoL is closely tied to methodological weaknesses in cross-group research. In particular, the validity of HRQoL data is compromised when studies fail to examine the measurement properties of the instruments employed. For example, it remains unclear whether the Indonesian version of the SF-36 meets the scoring assumptions required for its multi-subscale structure across diverse demographic groups, underscoring the need for rigorous testing of its structural equivalence (Arovah & Heesch, 2020). Furthermore, current literature emphasizes the difficulty of disentangling age effects from cohort effects in mental health research, a complex linear dependency that requires explicit methodological controls to ensure score comparability (Botha et al., 2023). Without such safeguards, , using raw SF-36 scores to compare generational cohorts is scientifically unsound, exposing a major gap in public health research across the region (Selvi, 2021).

To address the methodological and substantive gaps identified in prior research, this study pursues a dual aim: strengthening scientific rigor while generating meaningful insights into generational differences in HRQoL within the urban context of Medan, Indonesia. A major limitation of earlier comparative studies is the omission of Measurement Invariance testing, which prevents researchers from determining whether observed differences in HRQoL scores truly reflect substantive variation or are simply artifacts of generational differences in interpreting SF-36 items (Lau et al., 2021). To overcome this, the present study applies Multiple Group Confirmatory Factor Analysis (MG-CFA) to rigorously evaluate the consistency of the SF-36 factor structure across generational cohorts. This approach is widely recognized as a necessary methodological step before any valid intergenerational comparison of latent variables can be made (Selvi, 2021).

The ultimate goals of this research are clearly defined and structured specifically to address the methodological and substantive limitations encountered in cross-generational health studies in Medan, Indonesia. This study aims to achieve the following three primary objectives: First, to identify and test the latent dimensions of Health-Related Quality of Life (HRQoL) as measured by the Indonesian version of the SF-36 instrument. Second, to test the confirmatory validity of the identified HRQoL factor structure on the entire research sample, thereby establishing a statistically robust measurement model. Third, to critically analyze the structural equivalence or Measurement Invariance of the SF-36 among Generation X, Generation Y, and Generation Z cohorts using Multiple-Group Confirmatory Factor Analysis. Achieving these objectives will generate scientifically sound data for intergenerational comparison and provide an important methodological benchmark for future public health research in North Sumatra's metropolitan context.

B. METHODS

1. Research Design

This study employs a quantitative survey design utilizing a comparative cross-sectional approach (Krishna et al., 2025), enabling the simultaneous measurement and comparison of Health-Related Quality of Life (HRQoL) outcomes across generational cohorts at a single point in time. The research was conducted in Medan City, North Sumatra, Indonesia, with participants drawn from three cohorts: Generation X (born 1965–1980), Generation Y (Millennials, born 1981–1996), and Generation Z (born 1997–2012). Respondents were selected using non-probability quota sampling to ensure equal representation across the three groups (Li et al., 2023). The primary data were collected through questionnaires employing a Likert scale.

The target sample size was N=180, with 60 participants per generation. This number was determined based on established guidelines for multivariate analysis, which recommend a minimum ratio of five respondents per item in the measurement instrument (Mindrila, 2023). Given that the SF-36 instrument comprises 36 items, the minimum required sample size was calculated as 5×36=180 respondents. The inclusion criteria required participants to be (1) residents of Medan, (2) categorized into one of the three specified generational cohorts based on their year of birth, and (3) provide voluntary informed consent.

2. Data Analysis

a. Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) was conducted to identify the latent factor structure within the dataset and to confirm the instrument's dimensionality prior to cross-group invariance testing (Akoul et al., 2021; Cudeck, 2000). Data sustainability was first assessed through Pearson correlation analysis, followed by the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's Test of Sphericity. A KMO value greater than 0.5 indicated that the data were appropriate for factor analysis , while Bartlett's test confirmed the presence of significant correlations among variables (Guci et al., 2024). Factors were extracted using the Maximum Likelihood (ML) method. Because theoretical interrelationships were expected among dimensions, Promax rotation, an oblique method, was applied to allow for moderate correlations between factors (Brown, 2018). Factor retention was guided by the Kaiser criterion (eigenvalues > 1.0), and items were retained if they demonstrated a minimum loading of 0.40 on their primary factor.

b. Confirmatory Factor Analysis

Following the Exploratory Factor Analysis (EFA), Confirmatory Factor Analysis (CFA) was conducted to evaluate the hypothesized measurement model derived from both the EFA results and the theoretical framework of the SF-36 (Baharum et al., 2023; Ocy & Sarifah, 2025). CFA was performed using the lavaan package in R software, utilizing the Maximum Likelihood (ML) estimation method. The Goodness of Fit (GoF) of the model was assessed using a set of established indices. The model was considered to have an adequate fit if the Chi-square (χ^2) statistic was non-significant (P > 0.05). The primary cut-off criteria for acceptable fit were: Root Mean Square Error of Approximation (RMSEA≤0.08), Standardized Root Mean Square Residual (SRMR≤0.08), Comparative Fit Index (CFI I≥0.90), and Tucker-Lewis Index (TLI≥0.90) (Kim et al., 2017). After establishing model fit, the individual model parameters were evaluated. Standardized Factor Loadings (Std.all output) were examined, with items retained if loadings were high (typically ≥0.50, ideally ≥0.70) and statistically significant (P < 0.05) (Brown, 2018). Factor correlations were also reviewed to identify potential discriminant validity issues. Finally, the internal quality of the constructs was assessed. Construct Reliability was evaluated using Composite Reliability (CR), with a value greater than 0.70 required to demonstrate acceptable internal consistency. Convergent Validity was assessed using the Average Variance Extracted (AVE). The construct was considered valid if the AVE value was greater than 0.50, indicating that more than 50% of the variance in the items is explained by the latent construct (Shau, 2017).

c. Measurement Invariance Test
Structural equivalency, alternatively referred to as measurement invariance, is a crucial step in Multiple Group Confirmatory Factor Analysis (MGCFA) to ensure the instrument functions consistently across groups (Boz, 2025). The entire testing process will be conducted using R software, specifically a package that supports Structural Equation Modeling (SEM) (Martín & Indelicato, 2023; Poteralska & Perek, 2025). The general measurement model that forms the basis of measurement invariance testing is:

$$y_{ij} = \tau_{ij} + \lambda_{ij}\eta_{ij} + \epsilon_{ij} \tag{1}$$

where y_{ij} is the observed item score, $\tau_{ij}$is the Intercept, λ_{ij} is the Factor Loading, η_{ij} is the latent factor score, and ϵ_{ij} is the error for item i in group j. This testing process is conducted in three sequential stages. The first stage, Configural Invariance, ensures that the basic pattern of the instrument's factor structure remains consistent across all groups. If this stage is not achieved, the instrument may be measuring different things across groups, rendering further invariance testing irrelevant. Once Configural Invariance is established, Metric Invariance is evaluated by constraining the strength of the association between each item and its latent factor (factor loadings, λ) to be equal across groups. Finally, Scalar Invariance constrains the starting point (intercept, τ) of each item to be the same across all groups. When Scalar Invariance is satisfied, it indicates that observed variations in mean scores can be directly linked to genuine disparities in their latent factor mean scores, thereby enabling valid comparisons of the measured concept's means between the groups. Conversely, if Scalar Invariance fails, comparisons of latent factor means will be invalid (Boz, 2025; Kim et al., 2017; Kline, 2016).

C. RESULT AND DISCUSSION

Preliminary analysis indicated that the survey data was appropriate for factor analysis, satisfying the necessary conditions (KMO = 0.83; Bartlett's Test $p < 0.001$). Following Exploratory Factor Analysis (EFA) and item refinement, the subsequent Confirmatory Factor Analysis (CFA) confirmed a four-factor structure consisting of 12 selected items at the combined data level. The four confirmed latent HRQoL dimensions are defined as Physical Functioning, Role Limitations Due to Physical Condition, Emotional Well-being, and Role Limitations Due to Emotional Condition (see Table 1). This confirmed model structure is presented in Figure 1.

Table 1. Final factor structur

Item	Factor 1	Factor 2	Factor 3	Factor 4	Communality
X2	0,89	0	0,07	0,02	0,8
X3	0,93	0,01	0	0	0,87
X4	0,82	0,06	0,03	0,15	0,7
X8	0,75	0,03	-0,06	0,27	0,64
X12	0,06	0,91	-0,02	0,04	0,83
X14	0,2	0,69	-0,08	0,24	0,58
X28	0,2	-0,05	0,15	0,76	0,64
X29	0,17	0,05	0,15	0,75	0,62
X31	0,16	-0,12	0,67	0,16	0,51
X33	-0,14	0,15	0,82	0,14	0,73
X34	0,01	0	0,95	-0,05	0,91
X35	0,01	0	0,77	0,2	0,63

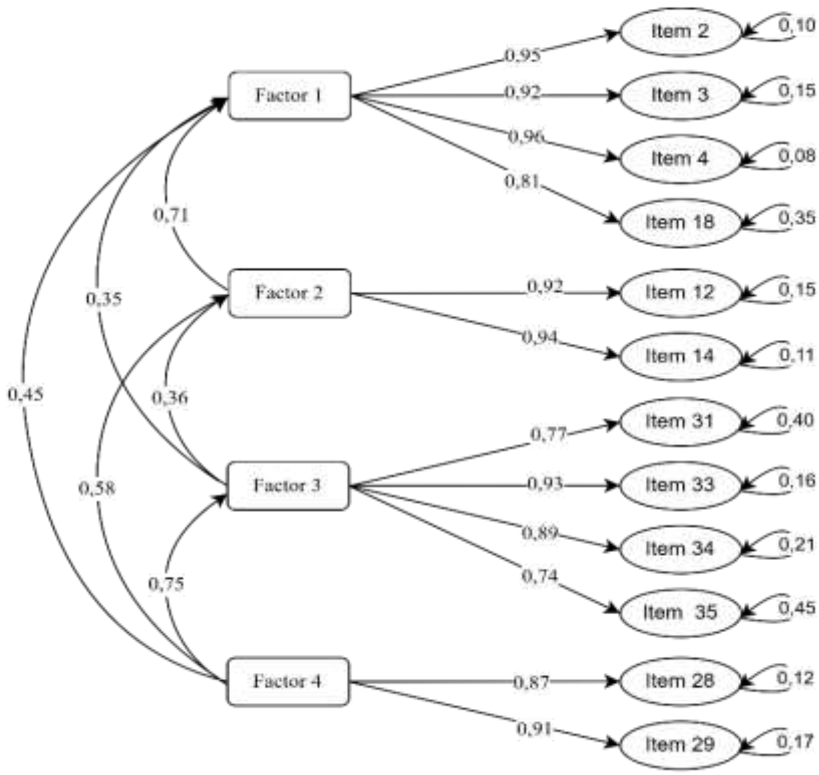

Figure 1. CFA Model

The 4-factor, 12-item model demonstrated strong psychometric properties, with high standardized factor loading ranging from 0.74 to 0.96, confirming robust convergent validity. Model fit assessment, however, yielded mixed results. The comparative fit index (CFI) indicated an excellent fit (CFI = 0.959), showing that the hypothesized model substantially outperformed the null model. In contrast, the absolute fit indices suggested only marginal fit (RMSEA = 0.090 and SRMR = 0.104). Such discrepancies are commonly reported in SF-36 validation studies and highlight persistent structural challenges in replicating certain inter-item correlations. Overall, the model's validity and reliability affirm that the four domains effectively capture core aspects of HRQoL within the pooled sample.

The derived four-factor HRQoL structure aligns with several existing SF-36 validation studies in Indonesia and Southeast Asia, which often compress the original eight dimensions into four to six factors. For instance, Arovah & Heesch (2020) similarly identified distinct, yet interrelated, physical and mental dimensions within the Indonesian adult population. This structural alignment reinforces the instrument's convergent validity in the local context. At the same time, the marginal overall fit mirrors previous findings, underscoring the need for ongoing model refinement and localized adaptation.

Measurement Invariance (MI) testing was conducted to assess whether the latent HRQoL construct was interpreted equivalently across Generations X, Y, and Z. The initial requirement for valid cross-group comparison, the Configuration Invariance test, was decisively not satisfied (CFI = 0.609; RMSEA = 0.159). This failure to achieve Configuration Invariance has profound substantive implications. It suggests that the latent dimensions of HRQoL are not structurally organized or understood in the same manner by the different generations. This interpretation is consistent with literature linking socio-economic and technological shifts between generations to varying health profiles, which may alter how cohorts perceive and respond to the questionnaire items. This structural lack of equivalence means that direct comparisons of latent HRQoL mean scores across generations are statistically invalid.

D. CONCLUSION AND SUGGESTIONS

This study successfully identified and validated a robust four-factor structure for the Health-Related Quality of Life (HRQoL) instrument (Physical Functioning, Role Limitations Due to Physical Condition, Emotional Well-being, and Role Limitations Due to Emotional Condition) demonstrating strong convergent validity and reliability in the combined sample. Thus, the objective of identifying the HRQoL factor structure was achieved. However, in contrast to the successful model validation, the objective of testing measurement equivalence decisively failed as the instrument did not satisfy the Configuration Invariance prerequisite necessary for valid cross-group comparison.

This finding makes an important scientific contribution by empirically demonstrating the limitations of applying generic HRQoL instruments to intergenerational populations, implying that the latent HRQoL factor structure is not equivalent across Generations X, Y, and Z. Theoretically, this supports the view that generational differences in social pressures and economic contexts shape how cohorts interpret health constructs. Practically, it means that HRQoL data cannot be used for valid latent mean comparisons across generations, as doing so risks biased conclusions in clinical research and public policy. To address this measurement equivalence deficit and provide methodological guidance, future research is recommended to take several operational steps: first, conduct separate Confirmatory Factor Analysis (CFA) tests for each generation group (X, Y, and Z) to verify model stability at the individual group level.

Subsequently, apply Partial Invariance techniques to specifically identify the items (particularly within factors like Emotional Well-being) that are the primary sources of non-invariance, and free the constraints on these items to achieve the Partial Scalar Invariance required for valid latent mean comparisons. Finally, integrating qualitative methods, such as cognitive interviewing, is strongly advised to deeply understand the reasons why these items are perceived differently by each generation.

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