

Perceived Happiness and General Health: An IRT Investigation

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Abstract Background: Measuring latent outcomes such as patient satisfaction, health-related quality of life, and depression has been a common procedure in medical and epidemiological research. However, assessing the latent construct of perceived happiness has been less prevalent. Moreover, recent pilot data suggest that perceived happiness may serve as a useful outcome in epidemiological studies. Therefore, the aim of this study was to evaluate an existing measure of perceived happiness using advanced psychometric analyses. **Methods:** Participants in this study were $N = 302$ adults, 18+ years of age, who completed an electronic health and fitness survey. Happiness was assessed using the Subjective Happiness Scale (SHS). The SHS is a four-item scale with seven response categories measuring general happiness from intrinsic and relative perspectives. A graded response item-response theory (IRT) model was used to psychometrically evaluate the SHS. Additionally, a single item general health measure was used to further validate the SHS. SAS procedures including PROC IRT were applied. **Results:** The IRT analysis indicated that all four items fit a unidimensional construct with large item slopes (1.71 to 4.98) and varied item thresholds (-3.13 to 1.12). Factor analysis of the SHS polychoric correlation matrix retained a single factor explaining 77.8% variance. Additionally, internal consistency reliability ($\alpha = 0.88$) indicated a reliable SHS. Finally, SHS scores examined between known groups showed that those reporting good general health had significantly ($p < .001$) greater perceived happiness than those reporting poor general health. **Conclusion:** Results from this study show that a brief four-item perceived happiness scale may have value in epidemiological research.

Keywords: happiness, health, Epidemiology, Surveillance

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1. Introduction

Patient-reported outcomes are commonly used in medical oriented research and can include measures of pain, functioning, satisfaction, and health-related quality of life (HRQOL) [1,2]. Certain research questions addressed in public health and medical research rely on the use of psychosocial measures for outcome, predictor, and even moderator and mediator variables [3]. Common psychosocial measures used in epidemiologic research include depression, perceived stress, anxiety, resilience, and posttraumatic stress [4,5]. Many of these complex measures are developed and assessed as latent constructs (i.e., unobservable traits) and require a scale consisting of multiple items targeting construct characteristics [6,7].

Numerous measures related to personal fulfillment have been studied in health and longevity research such as life satisfaction and measures of quality of life. However, perceived happiness, a measure of joy, remains elusive in the medical literature. Moreover, a person's happiness is anecdotally associated with many important health

outcomes, yet published data are scant. Recent pilot data, though, suggest that one's perceived happiness may serve as a useful outcome in epidemiological studies [8]. To that point, given that many population-based researchers select the most efficient scales, to economize survey administration, an advanced psychometric investigation of a happiness scale and its items is prudent [9]. Therefore, the purpose of this measurement study was to provide a report on the evaluation of an existing measure of perceived happiness using item response theory (IRT).

2. Methods

Study design

Data for this research came from the Health, Fitness, and Spirituality (HFS) Measurement Study where participants are continually recruited for a measurement assessment of psychosocial constructs useful for epidemiologic research. The primary constructs of interest in this project were spirituality, religiosity, and happiness with secondary interests in short physical activity, health, and fitness scales. Details regarding these scales and

related procedures have been published elsewhere [8]. Briefly, participants have been recruited by electronic mail from random university/academic institution directories. If agreeing to participate, respondents followed a link provided which took them to a *Google Forms* questionnaire [10]. A total of 19 items were included in the questionnaire and comprised measures of self-assessed general health (health) (1 item), self-assessed fitness (fitness) (1 item), physical activity (PA) (3 items), body mass index (BMI) (2 items), religiosity (5 items), happiness (4 items), and age, race, sex covariates (3 items). For this study, 302 adult respondents 18+ years of age with complete data were included.

Assessment of Health and Fitness

Health was assessed using a single item from NHANES asking participants what they thought about their health in general [11]. Available responses included “Excellent”, “Very good”, “Good”, “Fair”, or “Poor”. For this study, a health score was created ranging from 1 to 5, where a higher score indicated better self-assessed health. The same general health item has been used extensively in population-based research and has acceptable psychometric properties [12]. Fitness was also assessed using a single item known to be valid in estimating maximal oxygen consumption [13,14]. The fitness item asked participants to rate their own physical fitness. Responses included “Very good”, “Good”, “Fair”, “Poor”, or “Very poor”. For this study, a fitness score was created ranging from 1 to 5, where a higher score indicated better self-assessed fitness.

Assessment of Physical Activity (PA)

PA was assessed with a three-item scale modified from the NHANES PA questionnaire module [15]. The first question asked about vigorous-intensity PA, for at least 10 minutes continuously. The second question asked about moderate-intensity PA, for at least 10 minutes continuously. The third question asked about muscle-strengthening activity (MSA), such as push-ups, sit-ups, yoga or weight lifting. Those participating in one of the PA items received an item score of ‘1’ and those not received a ‘0’. The sum of the three items served as the PA score for this study, ranging from 0 to 3. From this PA scale, a measure of physical inactivity was also created. Those with a total PA score of ‘0’ received a physically inactive (PIA) score of ‘1’ and otherwise ‘0’.

Assessment of Happiness

Happiness was the primary variable being evaluated and assessed using the Subjective Happiness Scale (SHS), a four-item scale measuring general happiness from intrinsic and relative perspectives [16]. Table 1 contains the SHS as administered to participants in this study. A single happiness score was created by summing, with item 4 reverse scored first. The SHS has shown to be valid and reliable across several different populations [8,16,17].

Assessment of BMI and covariates

BMI (kg/m^2) was assessed using self-reported height (in) and weight (lb). The English conversion formula of $\text{BMI} = \text{weight (lb)} / \text{height (in)}^2 \times 703$ was used to convert BMI to kg/m^2 [18]. To foster trust and honesty of survey respondents, age was collected using grouped categories

of “18 to 24”, “25 to 34”, “35 to 44”, “45 to 54”, “55 to 64”, “65 to 74”, and “75+” years. For descriptive purposes, however, a numeric measure of age was computed using category midpoints. Finally, participant sex and race were assessed using conventional survey questions.

Table 1. Subjective Happiness Scale (SHS) as used in the Health, Fitness, and Spirituality (HFS) Measurement Study

Item and Response options						
1. In general, I consider myself:						
1	2	3	4	5	6	7
not a very happy person					a very happy person	
2. Compared to most of my peers, I consider myself:						
1	2	3	4	5	6	7
less happy					more happy	
3. Some people are generally very happy. They enjoy life regardless of what is going on, getting the most out of everything. To what extent does this characterization describe you?						
1	2	3	4	5	6	7
not at all					a great deal	
4. Some people are generally not very happy. Although they are not depressed, they never seem as happy as they might be. To what extent does this characterization describe you?						
1	2	3	4	5	6	7
not at all					a great deal	

Note. The numeric values above were used for the scoring procedure with item 4 reverse scored first.

Statistical analyses

Descriptive statistics with means and standard deviations were examined along with comparisons by sex. Scale reliability procedures included Cronbach alpha (α) and alpha with item deleted [19,20]. Corrected item correlations with scale scores (r_{score}) and inter-item correlations (r) were also computed. To support the assumption of a unidimensional happiness construct, a factor analysis was conducted. Since the SHS consists of ordinal-level items, the factor analysis used the item’s polychoric correlation matrix. Additionally, the number of extracted factors followed the Kaiser rule of eigenvalues greater than 1.0 [21].

The IRT model used was the graded response model (GRM). The GRM is a generalization of the two-parameter logistic model (2PLM) and is used for polytomous response items [22,23]. The GRM was selected over other polytomous IRT models because 1) it is suggested when all items have the same ordinal response options and 2) it estimates both item difficulty thresholds (b values) and item discrimination (a values) parameters. Item discrimination was of interest in this study because of its ability to identify how strongly each item is associated with the latent happiness trait [24]. Item difficulty values relate to the level of the latent trait required where the respondent has a 50% chance of endorsing the current or higher response categories versus all lower categories [25]. Evaluating the extent to which difficulty parameters within and between items cover the latent happiness trait range is important in determining how well the scale items function. Therefore, both item parameters estimated by the GRM were considered useful to properly assess the SHS functioning.

To further assess the SHS, item response category characteristic curve (CCC) graphs and a test information curve were generated. CCC graphs examine the latent trait values at which the probability of selecting an item category or higher is 50% (i.e., difficulty parameters). Each CCC was evaluated for proper item functioning across the latent trait (theta, θ). Test information tells us how certain we are about a person's location (theta, θ) on the latent trait continuum and provides a way to quantify how well a scale discriminates across the latent trait. Both CCC graphs and test information were inspected to ensure a wide coverage across the latent happiness continuum.

Finally, difference in mean happiness scale score was examined between different levels of general health to provide construct validity evidence by evaluating known groups discrimination [26]. Due to the ordinal nature of some variables, analogous nonparametric tests were also run. In all cases, results were the same, and so the parametric statistics and p-values were reported. Additionally, all tests of differences used the pooled variance statistics, since variances were equal, less PIA where non-pooled p-value is reported. All analyses were performed using SAS version 9.4 [27]. Significance was defined as $p < .05$.

3. Results

Table 2 contains descriptive statistics to better characterize study participants, overall and by sex. Overall, the current sample age ($Mean \approx 48.4$ yr, $Median \approx 49.5$ yr) approximates the U.S. age ($Mean \approx 48.1$ yr, $Median \approx$

46.8 yr) of adults 18+ years as calculated from NHIS 2022 data. Males, compared to females, were older, of greater percentage white, less obese, more physically active, and of greater reported fitness (all $p < .05$). Table 3 begins the psychometric assessment of the SHS with internal consistency statistics. Overall, scale reliability was satisfactory with acceptable alpha $\alpha_{Overall} = .875$, acceptable item-score correlations, and acceptable inter-item correlations. The lowest reliability correlation values were for SHS4, with alpha deleted of $\alpha_{Deleted} = .900$, item-score correlation of $r_{Score} = .576$ and inter-item correlations of $r = .572$, $r = .590$, and $r = .612$.

Table 4 contains results from the exploratory factor analysis of the SHS. The analysis of the polychoric correlation matrix retained a single factor (Eigenvalue = 3.11) and explained 77.8% of common variance. Table 5 contains the statistical results from the IRT GRM analysis of the SHS. Scale calibration indicated that all four items fit a unidimensional construct with large item slopes ranging from $a = 1.71$ to $a = 4.98$ and varied item thresholds ranging from $b = -3.13$ to $b = 1.12$. Figure 1 displays the CCC graph for each item and provides a visual aid in inspecting item category coverage across theta (θ). It can be seen that most item categories have their own area on the theta (θ) scale where their probability of endorsement is greater than any other category, indicating adequate item category functioning. The minor exception is for categories 3 and 5 in SHS4. Additionally, Figure 1 also visually indicates the same difficulty location parameters displayed in Table 5, as the intersection of each CCC. Thus, it is apparent that the difficulty locations are ordered for SHS4.

Table 2. Descriptive statistics for Health, Fitness, and Spirituality (HFS) Measurement Study variables

Variable	Overall (N = 302)		Male (N = 132)		Female (N = 170)		Sex Diff
	Mean	SD	Mean	SD	Mean	SD	p
Age (yr)	48.4	14.70	52.7	14.45	45.0	14.03	<.0001
White race (1 = yes, 0 = no)	0.69	0.47	0.77	0.43	0.62	0.49	.009
BMI (kg/m ²)	27.4	8.18	27.0	7.49	27.8	8.69	.423
Obese (1 = yes, 0 = no)	0.26	0.44	0.20	0.40	0.31	0.46	.032
Health (1 thru 5)	3.5	0.92	3.5	0.91	3.4	0.93	.409
PA (0 thru 3)	1.7	1.10	1.9	1.06	1.6	1.13	.026
PIA (1 = yes, 0 = no)	0.17	0.38	0.13	0.34	0.20	0.40	.095
Fitness (1 thru 5)	3.7	0.94	3.8	0.89	3.5	0.96	.003

Note. A numeric variable for Age was created by assigning midpoints from reported age groups. BMI is body mass index. Fitness is self-rated fitness by single-item. PA is a measure of physical activity from three NHANES items indicating participation in moderate-intensity PA, vigorous-intensity PA, and muscle strengthening activity. Health is a self-rated general health item from NHANES. Both independent t test and Wilcoxon two-sample test were employed with same results and so t test p-values are reported. No variances were significantly different (F statistic $ps > .05$), less PIA where non-pooled t test p-value is reported.

Table 3. Scale reliability statistics for the Subjective Happiness Scale (SHS)

Item	Mean	SD	r_{Score}	SHS1	SHS2	SHS3	SHS4
SHS1	5.57	1.22	.797	1.000	.837	.814	.612
SHS2	5.36	1.29	.770	.837	1.000	.769	.572
SHS3	5.04	1.45	.759	.814	.769	1.000	.590
SHS4	5.23	1.68	.576	.612	.572	.590	1.000
$\alpha_{Overall}$	.875		$\alpha_{Deleted}$	.810	.820	.825	.900

Note. $N = 302$. r_{Score} is adjusted item correlation with the scale score. $\alpha_{Overall}$ is internal consistency reliability. $\alpha_{Deleted}$ is α with respective item deleted. SHS1 thru SHS4 are Subjective Happiness Scale items. SHS4 is reversed scored. SHS item correlations are polychoric.

Table 4. Factor analysis of the Subjective Happiness Scale (SHS)

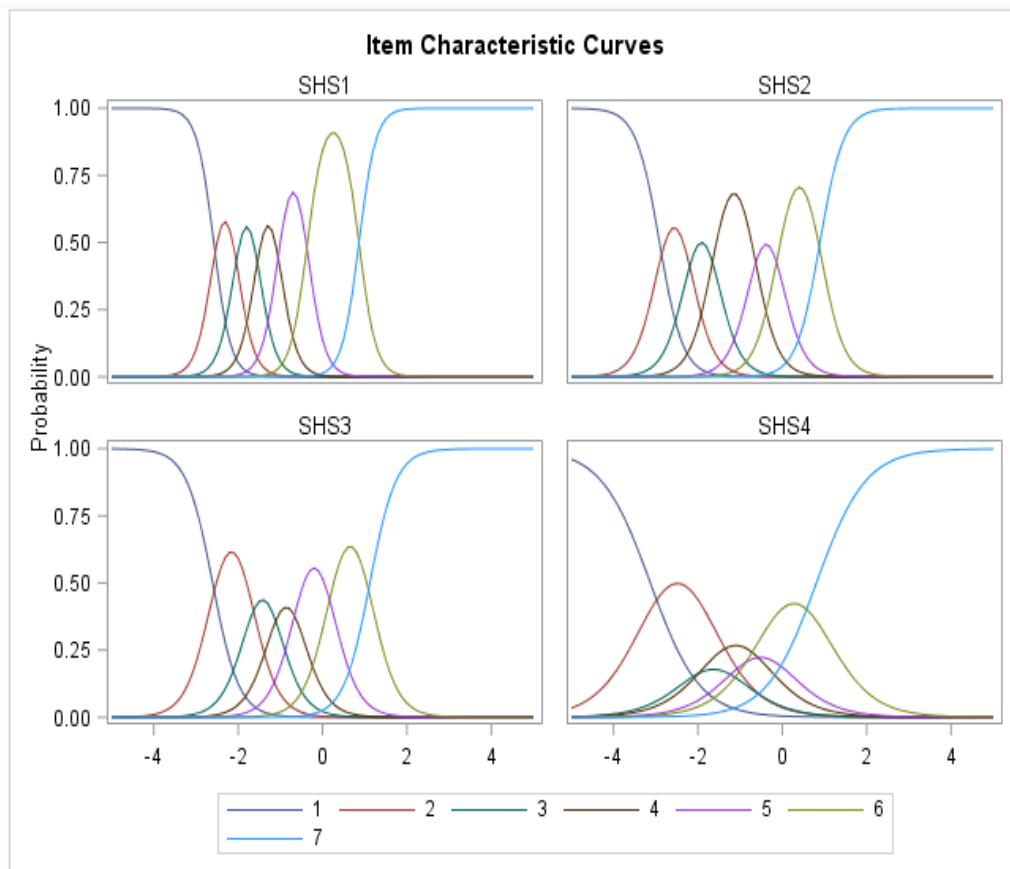
Factor	Eigenvalue	Difference	Proportion	Cumulative
1	3.111	2.607	0.778	0.778
2	0.504	0.272	0.126	0.904
3	0.232	0.079	0.058	0.962
4	0.153		0.038	1.000

Note. N = 302. Analysis used item polychoric correlation matrix.

Table 5. Graded response model (GRM) item parameter estimates for the Subjective Happiness Scale (SHS)

Item	Parameter	Estimate	SE	Item	Parameter	Estimate	SE
SHS1	b_1	-2.579	0.252	SHS3	b_1	-2.605	0.254
	b_2	-2.050	0.163		b_2	-1.713	0.141
	b_3	-1.544	0.120		b_3	-1.131	0.104
	b_4	-1.033	0.092		b_4	-0.590	0.086
	b_5	-0.358	0.076		b_5	0.188	0.080
	b_6	0.863	0.089		b_6	1.122	0.108
	a	4.985	0.708		a	3.222	0.322
SHS2	b_1	-2.910	0.315	SHS4	b_1	-3.127	0.365
	b_2	-2.216	0.189		b_2	-1.846	0.183
	b_3	-1.607	0.128		b_3	-1.424	0.147
	b_4	-0.683	0.087		b_4	-0.783	0.113
	b_5	-0.083	0.077		b_5	-0.252	0.100
	b_6	0.892	0.096		b_6	0.806	0.122
	a	3.607	0.383		a	1.709	0.180

Note. N = 302. a values are the GRM item discrimination parameters. b values are the GRM item threshold (difficulty) parameters. SE is standard error. All parameter estimates are significant from zero ($p < .001$) less SHS2 b_5 ($p = .139$).

**Figure 1.** Item category characteristic curve (CCC) graphs for each Subjective Happiness Scale (SHS) item

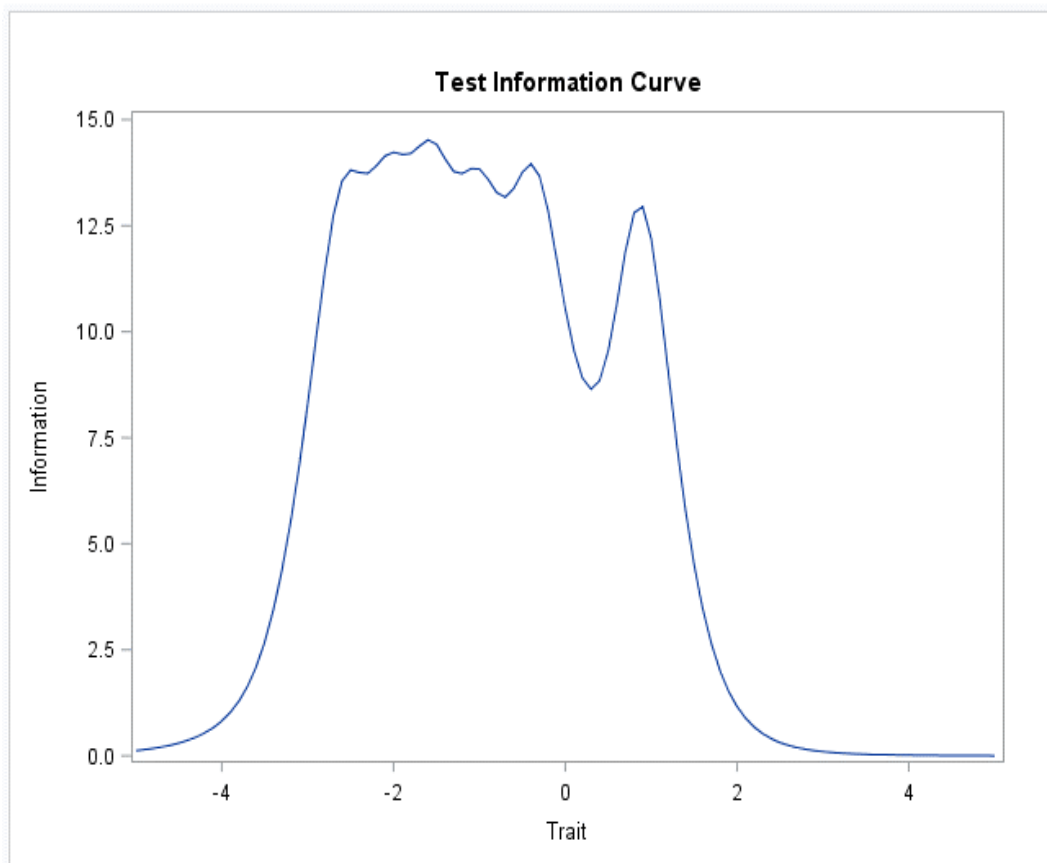


Figure 2. Test information graph for the Subjective Happiness Scale (SHS)

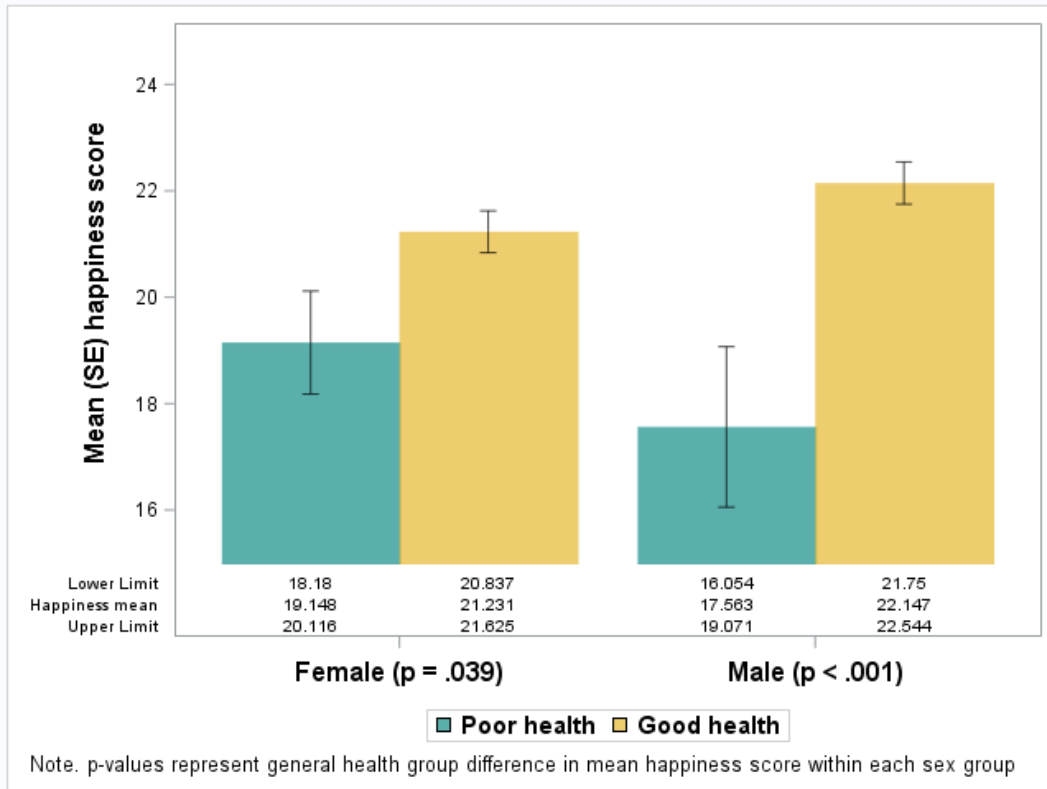


Figure 3. Subjective Happiness Scale (SHS) sum scores by general health and sex

Figure 2 displays the test information curve for the SHS. This curve indicates where on the theta (θ) scale the SHS information is greatest. That is, measurement precision is greatest between the approximate theta (θ) values of -4.0 and 2.0. Table 6 contains the IRT GRM person happiness trait estimates (theta, θ) by general health status for validating via known group differences. Firstly, Pearson correlations between the IRT theta (θ) scores and SHS scores strongly converge overall ($r = .960$) and within good ($r = .955$) and poor ($r = .973$) general health groups. Secondly, significant differences were noted between general health groups for both the IRT theta (θ) scores ($p < .0001$) and the SHS scores ($p < .0001$). Finally, Figure 3 extends the known group validity comparison via stratifying by sex. The graph clearly exhibits visually the practical and significant difference in SHS scores between general health groups for both males ($p < .001$) and females ($p = .039$).

Table 6. IRT person latent happiness trait estimates (theta, θ) by general health status for Subjective Happiness Scale (SHS)

	Mean	SD	Min	Max	<i>r</i>
Overall					
IRT theta (θ)	-0.02	0.92	-2.82	1.54	.960
Scale score	21.2	4.8	5.0	28.0	
Good health					
IRT theta (θ)	0.06	0.88	-2.82	1.54	.955
Scale score	21.6	4.5	7.0	28.0	
Poor health					
IRT theta (θ)	-0.53	0.98	-2.82	1.54	.973
Scale score	18.6	5.4	5.0	28.0	
Good - Poor	Difference				
IRT theta (θ)	0.59	0.90	<i>p</i>	<.0001	
Scale score	3.08	4.67	<i>p</i>	<.0001	

Note. *r* is Pearson correlation coefficient between SHS scores and IRT GRM theta (θ) estimates. *p*-values for independent *t* statistics comparing good versus poor health happiness. Scale score is the sum of SHS items.

4. Discussion

The purpose of this study was to evaluate an existing measure of perceived happiness, called the Subjective Happiness Scale (SHS), by means of an advanced psychometrics procedure, specifically the item response theory (IRT) graded response model (GRM), using data from the Health, Fitness, and Spirituality (HFS) Measurement Study. Internal consistency analysis indicated that the SHS is a reliable tool in a survey research scenario. Factor analysis of the SHS confirmed its unidimensionality by retaining a single factor and explaining a large percentage of the common variance. Additionally, the IRT analysis indicated that all four items fit a unidimensional construct with adequate discriminatory power (i.e., slope parameters) and adequate item coverage (i.e., item difficulty parameters) across the happiness trait continuum. These findings support a previous report on the SHS that found the scale to have adequate psychometric properties using classical test theory methods [8]. Additionally, a recent validity and reliability study of the SHS found the scale reliable ($\alpha > .82$) in two separate samples of Saudi working women [28]. Lastly, a larger study evaluating the psychometric properties of the SHS found the

Chinese version of the scale adequate in its internal consistency reliability ($\alpha = .82$) of Hong Kong adults [29]. Therefore, in combination, these findings support the acceptable psychometric properties of the SHS for population-based research.

The current study also found that SHS scores were able to discriminate between groups that would likely show differences in perceived happiness. Specifically, SHS scores showed that those reporting good general health had significantly greater perceived happiness than those reporting poor general health. The same happiness and general health trends were found in separate male and female populations. This ability to discriminate between known groups provides construct validity evidence for the SHS [30]. These findings have less support in the current body of literature for generally healthy adults. The SHS has been shown, however, to discriminate in Brazilian adolescent populations, where youth with poor oral health and poor oral health-related quality of life (OHRQoL) had lower levels of happiness [31]. In sum, the evidence supports the acceptable functioning of the SHS as a tool to measure perceived happiness and discriminate across groups in population-based research.

The results from this study should not be interpreted without considering its limitations [8]. One limitation of this study is its use of a convenience sample as recruited from random university/academic institutions. Consequently, the sample may suffer from certain selection bias as well as biases associated with higher socioeconomic status and greater health status. Thus, future studies examining the SHS should draw samples from more diverse subpopulations and possibly employ random sampling techniques. A second limitation of this study is its use of complete case analysis. Some bias, therefore, may have been introduced if data are not missing completely at random (MCAR). A final limitation of this study is the fact that the IRT-derived theta coverage did not extend to extreme positive values of happiness. This was evidenced by item thresholds and test information curve analyses. Therefore, the SHS may not necessarily provide high functioning estimates for extreme happiness trait. Further research may be warranted and should include participants with high happiness trait in the sample to determine if items can target those levels of theta.

The strengths associated with this study and its findings relate to its use of IRT. Namely, the IRT analysis in this study was able to 1) examine how well each item functioned in measuring the latent happiness trait, 2) provide a measure of reliability (i.e., information) with an added advantage of measuring how that information varied across the latent trait, and 3) provide a person happiness score, called theta (θ), to use in validating the SHS sum score. These strengths help support the evidence for the SHS as an acceptable tool to measure perceived happiness in adults.

5. Conclusions

The findings from this study indicate that the four-item Subjective Happiness Scale (SHS) is a well functioning instrument that provides a valid measure of perceived happiness. The SHS items are reliable and provide scores

that can discriminate between different subpopulations. The economic nature of the SHS makes it particularly useful for population-level epidemiological research.

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