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Psychometric evaluation of the Health-Risk Attitude Scale (HRAS-13): assessing the reliability, dimensionality and validity in the general population and a patient population

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ABSTRACT

Objectives: The aim of this study was to assess the reliability, dimensionality and validity of the self-report questionnaire Health-Risk Attitude Scale (HRAS-13) in a sample of the general population and a patient population.

Methods: Sample 1 ($n = 930$) was recruited from the general population aged 18–65 years in the Netherlands. Sample 2 ($n = 486$) was recruited from the population of knee and hip osteoarthritis patients aged 45 and over, also from the Netherlands. Reliability was assessed using Cronbach's alpha, average inter-item correlation and item-total correlations. Dimensionality was examined using confirmatory factor analysis (CFA), principal component analysis (PCA) and bifactor analysis. Validity was assessed by performing known-group analysis using ANOVA tests.

Results: Cronbach's alphas of the HRAS-13 were 0.73 in sample 1 and 0.69 in sample 2. Reliability and dimensionality analyses differed slightly between the samples, and suggest that a short version of the HRAS may capture a general component of health-risk attitude. Validity assessment of known groups showed that the HRAS-13 and a likely HRAS-6 distinguished between subgroups of respondents based on most of the assessed characteristics, but not all.

Discussion: These findings are a preliminary indication that the HRAS-13 is a promising multidimensional instrument for measuring health-risk attitude. However, further research in various samples on decisions where health risks play a role is warranted to confirm the dimensionality of the HRAS-13 and the items to be retained in a full or a shorter version.

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Introduction

People differ in their attitude towards health risks, and such risk attitudes were shown to be associated with different unhealthy behaviours (e.g. smoking), preventive behaviours (e.g. diet, vaccination, safety) and treatment preferences in the clinic (Dieteren et al., 2020; Himmler et al., 2020; Lion & Meertens, 2001; Pearson et al., 1995; Reventlow et al., 2001; Szrek et al., 2012). Therefore, measuring risk attitude in the context of health and health behaviours in a valid and reliable manner is important. Several scales exist that can be used to assess general risk attitude (Lion & Meertens, 2001; Pearson et al., 1995; Zhang et al., 2019), but there is no consensus about whether risk attitude is context dependent (i.e. may differ between life domains), or whether a general risk trait exists (Dohmen et al., 2011; Frey et al., 2017; Mata et al., 2018; Slovic et al., 1980; Weber et al., 2002). Weber et al. (2002) argued that risk attitude is stable across domains, but that people may perceive risk differently depending on the situation or domain. As such, in their Domain-Specific Risk-Taking (DOSPERT) measure, they make a distinction between risk perception and risk-taking behaviour. Zhang et al. (2019) tested the context-dependency of risk attitude by developing a general risk propensity scale and comparing it to the DOSPERT. They developed an instrument that they consider preferable for predicting broad outcomes in multiple domains of life, and that shares many characteristics with personality measures, but also advise that domain-specific measures may be more appropriate when predicting domain-specific risky behaviour. Dohmen et al. (2011) also found that a general measure of risk performs very well in terms of predicting risky behaviour, even across contexts, but that domain-specific items may provide an even stronger measure in that particular context. Soane and Chmiel (2005) observed that people vary in whether their risk preferences are consistent across the domains work, health and finance, and that personality could influence the stability of preferences. The complexity of the topic as well as the lack of consensus highlights the importance of further exploring domain-specific risk attitude scales, with health being an important life domain in this context.

The availability of validated scales to assess *health-related* risk attitude is limited. One potentially useful instrument is the Health-Risk Attitude Scale (HRAS-13), a 13-item scale that aims to measure health-related risk attitude. The HRAS-13 was developed but its reliability, dimensionality and validity so far were tested only in two relatively small convenience samples (van Osch, 2007). Therefore, there is a need to further evaluate the psychometric properties of the Health-Risk Attitude Scale (HRAS-13) in larger samples and diverse populations.

The scale is context-specific to avoid the need to differentiate between risk-taking behaviour and risk perception, as argued by Weber et al. (2002). In addition, the HRAS-13 aims to measure health-risk attitude in a comprehensive manner by including items about the subdomains medical treatment, the importance of health, general attitude towards risk-taking in health and care, and consideration of the future consequences of health behaviours. This distinguishes it from the Health/Safety subscale of the DOSPERT, which focusses on preventive health behaviour (Weber et al., 2002). More information about the motivation for and development and earlier validation of the HRAS-13 can be found in van Osch (2007).

Being able to identify differences in risk attitude between individuals and to predict how a person will resolve risky health decisions may facilitate health research, but also improve health care practice in several ways. Firstly, patients and health care providers can benefit from being able to measure risk attitude in clinical practice as it can explain or predict treatment preferences (Fraenkel et al., 2003; Pearson et al., 1995; Prosser et al., 2002), and it can enhance risk communication and shared decision making (Elwyn et al., 2004). Secondly, being able to distinguish individuals based on their health-risk attitude allows for more tailored policy making in sectors like health insurance (Wagstaff & Lindelow, 2008). Moreover, knowing individuals' health-risk attitude might lead to improved prediction of how society will respond to public health interventions regarding for example vaccination (Brewer et al., 2004) and pandemics such as COVID-19 in which risk perception, attitude and behaviour are crucial for prevention and containment of a virus (Chan et al., 2020; Cori et al., 2020). Also, given the increasing interest in the HRAS (Bansback et al., 2016; Dieteren et al., 2020; Himmler et al., 2020), this paper aims to investigate the reliability, dimensionality and validity of the HRAS-13 in two larger samples, one sample from the general population and one sample from a patient population, both from the Netherlands.

Methods

Data collection

For the purpose of this study, we use available data collected in two separate studies. Respondents in both studies were informed about the purpose of the study and the anonymity of their data, and all respondents included in this study gave informed consent for using their responses for academic purposes. The 13 items of the HRAS-13 (included in Table 5) are rated on a seven-point Likert scale from 'completely disagree' to 'completely agree'. Total scores for the HRAS-13 are obtained by summing the scores to each item, where items 1, 3, 4, 5, 9, 10 and 12 are reverse-scored because of their phrasing. A higher sum-score on the HRAS-13 corresponds to a more positive attitude towards health risks.

Sample 1 concerns a randomly stratified sample from the population aged 18–65 years in the Netherlands according to age, gender and level of education. Respondents were recruited through a survey company and the data were collected online in 2010, in the context of a larger study investigating health state valuations (van Nooten et al., 2015), acceptability of less than perfect health ates (Wouters et al., 2015), and expectations about longevity and quality of life at older age (Rappange et al., 2016). A small sum was donated to a charity of the respondent's choice as reward for participation. Respondents also answered questions about socio-demographic characteristics, their health and happiness levels, and health behaviour. Behavioural variables were categorised into healthy or unhealthy behaviour according to national guidelines, as in Rappange et al. (2016). Smoking behaviour was categorised as no or yes. Nutrition was categorised as eating a variety of foods at least 6 days a week according to the Dutch norms for healthy nutrition or less than the norm. Alcohol consumption was categorised as 'no' if respondents did not drink, moderate if they drank occasionally, or 'heavy/excessive' if alcohol consumption exceeded 21 drinks per week for males or 14 drinks per week for females. Physical exercise was categorised (using Dutch health norms) based on whether respondents exercised at least 30 minutes a day on at least 5 days a week or less than that. Health was measured using a visual analogue scale ranging from 0 (worst imaginable health state) to 100 (best imaginable health state), while happiness was measured using a scale ranging from 0 (completely unhappy) to 100 (completely happy).

Sample 2 consists of knee and hip osteoarthritis patients aged 45 and over, and was recruited by a survey company. Data were collected online in 2019 as part of a study about health preferences of patients with knee or hip osteoarthritis (Arslan et al., 2020). All respondents received a financial compensation for their time investment. Respondents also answered questions about socio-demographic characteristics and their health status, also using a visual analogue scale ranging from 0 (worst imaginable health state) to 100 (best imaginable health state).

Sample and descriptive statistics

A total of 1,223 respondents completed the questionnaire in sample 1. Because it was a lengthy questionnaire and administered online, basic speeding and response pattern analysis were conducted in order to remove potentially poor-quality data. This resulted in exclusion of 156 respondents (12.8%) from the sample on the basis of speeding through the questionnaire (<15 minutes completion time) and another 137 respondents (11.2%) because they had eight or more identical item values on the HRAS-13. The final sample for analysis therefore consisted of 930 observations (76.0%). In sample 2, a total of 648 respondents completed the questionnaire. As in sample 1, speeding (duration <8 minutes) and response pattern analysis (≥8 identical item values on HRAS-13) were performed leading to an exclusion of 85 (13.1%) and 74 respondents (11.4%), respectively. The final sample consisted of 489 respondents (75.5%).

An overview of the descriptive statistics of the HRAS-13 in both samples can be found in Table 1. Sample 1 had a mean HRAS score of 44.5, a standard deviation of 9.9, the median was 44.0 and scores ranged between 15 and 84. In sample 2, the mean and median were slightly higher (48.8 and 49.0, respectively), the standard deviation was lower (5.6) and the range was smaller (29–65). In sample 1, the data are right skewed (0.239) with a kurtosis of 0.234. In sample 2, the HRAS scores were slightly left skewed (−0.277) with a higher kurtosis of 0.500. Figure 1 shows the scoring pattern per item of raw HRAS-13 scores (i.e. before reverse-scoring) in both samples.

Sample characteristics are described in Table 2. In sample 1, 30.1% of respondents were between 16 and 35 years old, 33.7% between 36 and 50 and another 36.2% was older than 50. Gender was almost equally distributed, and most respondents had a partner (64.4%). In terms of education, 14.1% had completed low level education, 53.7% middle level, and 32.3% high level education. In sample 2, respondents were included as of 45 years and older. Hence, 10.0% was in the category between 36 and 50 and the large majority of respondents (90.0%) were between 51 and 90 years old. This sample contained slightly more females (56.4%) and somewhat lower educated

Table 1. Descriptive statistics HRAS-13 in samples 1 and 2

Result	Sample 1	Sample 2
Total *N*	930	489
Mean score	44.5	48.8
SD	9.9	5.6
Median	44	49
Range	15–84	29–65
Skewness	0.239	−0.277
Kurtosis	0.234	0.500

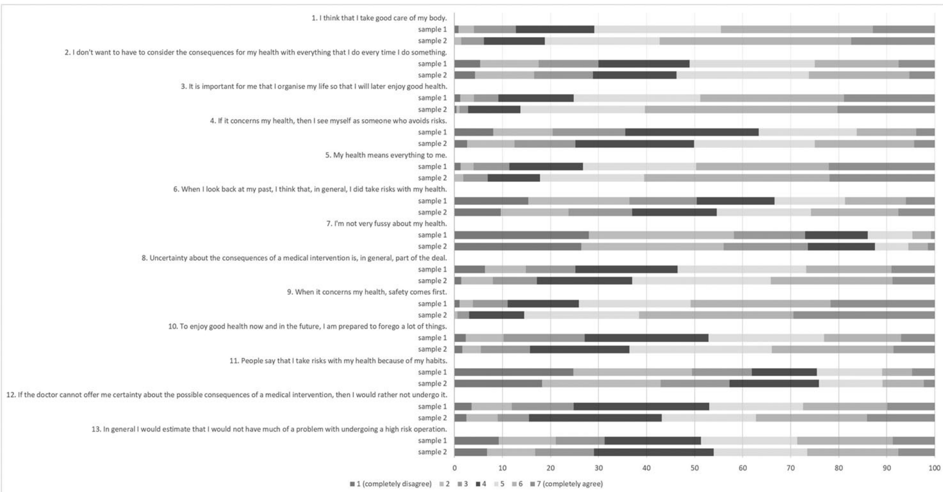

Figure 1. Scoring pattern HRAS-13 scores

respondents (30.7% low, vs. 42.9% middle, 26.0% high and 0.4% other) than the first sample.

Reliability

Reliability of the HRAS-13 was assessed by calculating internal consistency (i.e. Cronbach's alpha), average inter-item correlation and item-total correlations in both samples. We also examined whether removing one of more of the items would lead to an increase of these statistics and hence to a better reliability.

Dimensionality

To assess the dimensionality of the HRAS-13, factor analyses were performed in both samples. To validate the one-factor structure introduced by van Osch (2007), Confirmatory Factor Analysis was performed first. The Confirmatory Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMR) of the one-factor model were compared to their cut-off values to assess model fit (Hu & Bentler, 1999). As the Confirmatory Factor Analysis (CFA) could not confirm the existing factor structure, Principal Component Analysis (CFA) using varimax rotation was performed as in van Osch (2007) to assess the factor

Table 2. Sample characteristics and results ANOVA tests between known groups (validity)

Characteristic		Sample 1 *N* (%)	Sample 1 Mean score HRAS-13	Sample 1 *p*	Sample 2 *N* (%)	Sample 2 Mean score HRAS-13	Sample 2 *p*
Age[a]	16–35 years	280 (30.1)	44.9	n.s.	0 (0.0)	—	n.s.
	36–50 years	313 (33.7)	44.9		49 (10.0)	48.6	
	51–90 years	337 (36.2)	43.6		440 (90.0)	48.8	
Gender	Female	466 (50.1)	42.8	**	276 (56.4)	48.3	*
	Male	464 (49.9)	46.2		213 (43.6)	49.5	
Education level	Low	131 (14.1)	42.7	n.s.	150 (30.7)	48.8	n.s.
	Middle	499 (53.7)	44.8		210 (42.9)	49.3	
	High	300 (32.3)	44.7		127 (26.0)	48.0	
	Other	—	—		2 (0.4)	45.5	
Partner[b]	No	304 (32.7)	45.9	**	—	—	—
	Yes	599 (64.4)	43.7		—	—	—
Smoking	No	576 (61.9)	42.3	**	—	—	—
	Yes	354 (38.1)	48.1		—	—	—
Nutrition	≥ norm	445 (47.8)	42.6	**	—	—	—
	<norm	485 (52.2)	46.2		—	—	—
Alcohol	No	331 (35.6)	43.4	**	—	—	—
	Moderate	492 (52.9)	44.0		—	—	—
	Heavy/excessive	107 (11.5)	49.6		—	—	—
Physical exercise	≥Norm	473 (50.9)	43.4	**	—	—	—
	<Norm	457 (49.1)	45.5		—	—	—
Health[a]	<70	255 (27.4)	46.5	**	206 (42.1)	49.4	n.s.
	70–79	211 (22.7)	45.5		101 (20.7)	48.4	
	80–89	280 (30.1)	43.7		107 (21.9)	48.4	
	≥90	184 (19.8)	41.7		75 (15.3)	48.0	
Happiness[a]	<70	237 (25.5)	46.4	**	—	—	—
	70–79	202 (21.7)	45.8		—	—	—
	80–89	285 (30.6)	43.9		—	—	—
	≥90	206 (22.2)	41.8		—	—	—

Notes: Levels of statistical significance: $^{**}p < .01$; $^{*}p < .05$.
[a]Categories of subgroups for age, health and happiness were established so that each category contained an equal number of respondents in sample 1, cut-off points were rounded off to the nearest multiple of 5.
[b]In sample 1 $n = 903$ (27 missing values; 2.9%).

structure. In addition, bifactor analysis was conducted to assess potential multidimensionality and to test for the existence of a general component and specific sub-factors in health-risk attitude.

Validity

To assess the validity of the HRAS-13, known-group validity was examined. T-tests and ANOVA tests were used to analyse whether groups with different age, gender and marital status as well as groups with varying health behaviours (i.e. smoking, nutrition, alcohol and physical exercise) and general health and happiness showed different HRAS-13 scores. It is hypothesised that there is a negative relationship between the HRAS-13 and age (Dohmen et al., 2011), being female (Dohmen et al., 2011; Weber et al., 2002) and having a partner (Dohmen et al., 2011), hence expecting that these subgroups in the data are more health-risk averse. Based on literature concerning general rather than health-specific risk attitude, individuals with a higher education are expected to be more risk seeking (Donkers et al., 2001; Schurer, 2015). Following

Table 3. Cronbach's alpha analysis (reliability)

Sample 1		Sample 2	
Order of removing items	Cronbach's alpha	Order of removing items	Cronbach's alpha
Starting alpha	0.732	Starting alpha	0.693
HRAS13	0.755	HRAS8	0.725
HRAS8	0.780	HRAS13	0.746
HRAS12	0.801	HRAS12	0.765
HRAS4	0.805	HRAS2	0.778
HRAS2	0.810	HRAS6	0.796
HRAS6	0.823	HRAS11	0.803
HRAS11	0.836	HRAS4	0.808
–		HRAS7	0.817

literature in which health behaviour is associated with risk attitude (Anderson & Mellor, 2008; Beauchamp et al., 2017; Dieteren et al., 2020; Dohmen et al., 2011; Weber et al., 2002), it is expected that HRAS-13 scores are positively associated with unhealthy behaviours (i.e. smoking, poor nutrition, excessive drinking and limited physical exercise) of respondents. Furthermore, based on literature about general risk measures and health and happiness, a negative relationship is expected between the HRAS-13 and health (Courbage et al., 2017; Decker & Schmitz, 2016) and happiness (Guven, 2012; Guven & Hoxha, 2015; Nguyen & Noussair, 2014). As can be seen in Table 3, all these variables were collected in sample 1 but fewer variables were collected in sample 2. Hence, for the second sample we could only test gender, education level and health.

Results

Reliability

As can be seen in Table 3, Cronbach's alpha of the HRAS-13 scale in sample 1 was 0.73, indicating acceptable internal consistency. Cronbach's alpha could be increased up to 0.84 by removing seven items (i.e. 13, 8, 12, 4, 2, 6 and 11). Removing any additional items would no longer lead to an increase in Cronbach's alpha. In sample 2, internal consistency was slightly lower than in sample 1 (Cronbach's alpha 0.69) but could be increased to 0.82 by removing eight items (i.e. 8, 13, 12, 2, 6, 11, 4 and 7). These are largely the same items as identified for removal in sample 1 but removed in a slightly different order. The only other -and additional- item excluded in sample 2 was item 7. In addition, based on average inter-item correlations and item-total correlations and a cut-off correlation for retention of 0.3, items 8, 12 and 13 should potentially be removed (see suppporting information Tables A1 and A2); the reliability of the HRAS-13 could be further improved by removal of additional items. These are largely the same items as based on the Cronbach's alpha.

Dimensionality

Confirmatory Factor Analysis (CFA) was performed to examine the previously determined one-factor structure of the HRAS-13. The results are presented in Table 4. In sample 1, the Comparative Fit Index was 0.78, the Root Mean Square Error of Approximation (RMSEA) was 0.10 and the Standardized Root Mean Square Residual

Table 4. Confirmatory factor analysis and bifactor analysis (dimensionality)

Fit index	Sample 1	Sample 2
Confirmatory factor analysis – one factor		
Comparative fit index	0.778	0.645
Root mean square error of approximation	0.102	0.128
Standardised root mean square residual	0.074	0.091
Bifactor analysis – three factors		
Root mean square error of approximation	0.061	0.089

Table 5. Principal component analysis (dimensionality)

No.	Item	Sample 1			Sample 2		
		PC 1	PC2	PC3	PC 1	PC2	PC3
1	I think that I take good care of my body.*	0.679			0.628		
2	I don't want to have to consider the consequences for my health in everything that I do.		0.549				
3	It is important for me to organise my life in a way that will benefit my health later on.*	0.791			0.740		
4	When it comes to my health, I consider myself a risk avoider.*				0.507		
5	My health means everything to me.*	0.774			0.780		
6	Looking back at my past, I would say that I have generally taken risks with my health.		0.742			0.742	
7	I don't worry too much about my health in what I do.	0.523	0.562			0.704	
8	Uncertainty about the consequences of a medical intervention is, in general, part of the deal.						
9	Safety has priority where my health's concerned.*	0.777			0.774		
10	To ensure good health now and later, I am prepared to forego a lot of things.*	0.648			0.760		
11	People say that I take risks with my health because of my habits.		0.719			0.829	
12	If the doctor can't give me assurances about the possible consequences of a medical intervention, then I'd rather not have it.*			0.504			0.682
13	In general, I would estimate that I would not have much of a problem with undergoing a high risk operation.			0.802			0.771
Cumulative proportion of variance explained		26%	44%	52%	25%	41%	53%

Note: '*' indicates item was reverse-scored in analysis. Only factor loadings >0.50 are presented.

(SRMR) was 0.07. Based on these statistics the model fit is not good, and a one-factor model does therefore not seem accurate. In sample 2, the CFI was 0.65, the RSMEA and the SRMR were 0.13 and 0.09, respectively. Therefore, the one factor model performed worse in sample 2 than in sample 1. We subsequently performed a Principal Component Analysis (PCA) to explore multidimensionality. As can be seen in Figure 2, in sample 1 the first three components had an eigenvalue above one. Hence, a three-factor model was identified with the cumulative proportion of variance explained being 26%, 44% and 52%, respectively. In sample 2, four factors had an eigenvalue

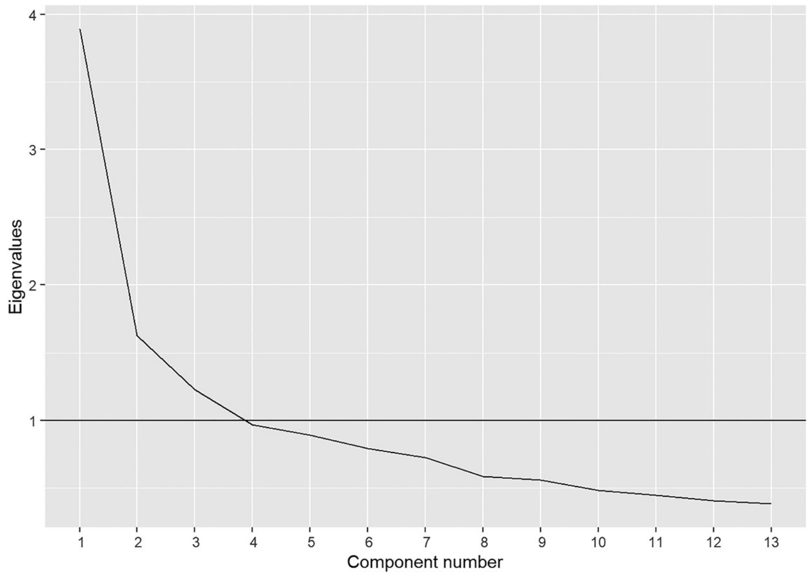

Figure 2. Scree plot sample 1

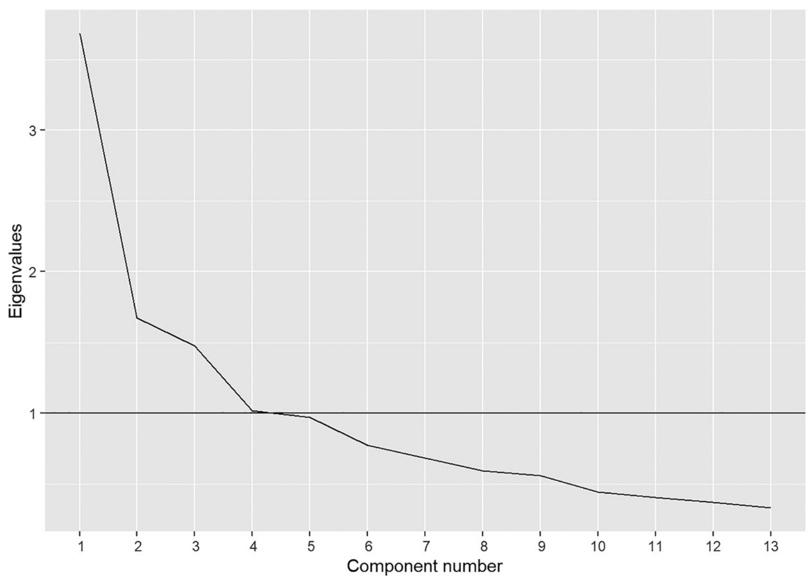

Figure 3. Scree plot sample 2

above one (Figure 3). However, because the eigenvalue of the fourth factor was only marginally above one and for comparability with sample 1, also in this sample a three-factor model was specified. Here, the cumulative proportion of variance explained was 25%, 41% and 53%, respectively. The results of these three-factor models are presented in Table 5. In sample 1, the six items 1, 3, 5, 7, 9 and 10 loaded on the first factor (>0.50). Except for item 7, these items were phrased positively, expressing risk aversion, and were reverse-scored in the analysis. Items 2, 6, 7 and 11 loaded on the second factor (>0.50). These items were all phrased negatively as opposed to most items loading on the first factor. Items 12 and 13 loaded on the third factor (>0.50). Items 4 and 8 had factor loadings lower than 0.5 on all factors. Based on the items that loaded strongly on the first factor, this factor can be described as the degree to which health-risks play an important and active role in peoples' lives. The second factor can be described as health-risks that are perceived to be only implicitly and indirectly related to peoples' lives, i.e. indirect health-risk attitude and unintentional health behaviour. The third factor specifically related to attitude towards risks related to medical treatments. The results of the PCA in the second sample were largely similar (see Table 5). The items generally loaded on the same factors as in sample 1 but there was some variation in the strengths of the loadings. Item 4 now loaded on factor 1, while item 2 no longer loaded on factor 2 and item 7 no longer on factor 1 (<0.5).

Exploratory bifactor models with three factors were estimated in both samples, replicating the number of factors found in the PCA. In both bifactor models we found that the RMSEA statistics were smaller (0.061 and 0.089) than in the one-factor CFA (0.102 and 0.128), indicating a better model fit when accounting for multidimensionality of the HRAS (see Table 4). The models show that there appears to be a general factor, with items 1, 3, 4, 5, 7, 9, 10 and 11 loading on this factor (>0.3) in sample 1, and the same items except for item 4 in sample 2 (see Figures 4 and 5). In addition, in sample 1 there is one and in sample 2 there are two sub-factors consisting of items that do and do not load on the general factor; in both samples there is a third factor consisting of items not loading on the general factor. Some of the items do not load on the general factor nor on any of the sub-factors. A concurrent finding from the different reliability and dimensionality analyses in these two samples is that a short version of the HRAS, in any case including the items 1, 3, 5, 7, 9 and 10, may capture a general component of health-risk attitude.

Validity

Despite the fact that the aforementioned analyses indicate that the HRAS-13 likely is not unidimensional and that some of the current 13 items may be redundant, the analyses did not point towards an unambiguous break-down of the measure into dimensions or reduction in the number of items. Hence, in this first validation study of the HRAS-13, we here present results for the validity of the 13-item measure as originally proposed (van Osch, 2007) and previously used in the literature (Bansback et al., 2016; Dieteren et al., 2020; Himmler et al., 2020). Results (only tables) for the validity of a likely 6-item short version consisting of the items 1, 3, 5, 7, 9 and 10 are presented in the suppporting information (see appendix, Tables A3 and A4).

Female respondents on average had a statistically significant lower HRAS-13 score than males in both samples (see Table 2). Only sample 1 contained information about whether respondents had a partner; respondents with a partner were found to have lower HRAS-13 scores. In neither of the samples a statistically significant relationship was found with age or education level. On average, respondents engaged in unhealthy behaviours had higher HRAS-13 scores (in sample 1). Smokers had a substantially higher HRAS-13 score than non-smokers. Respondents who did not meet the

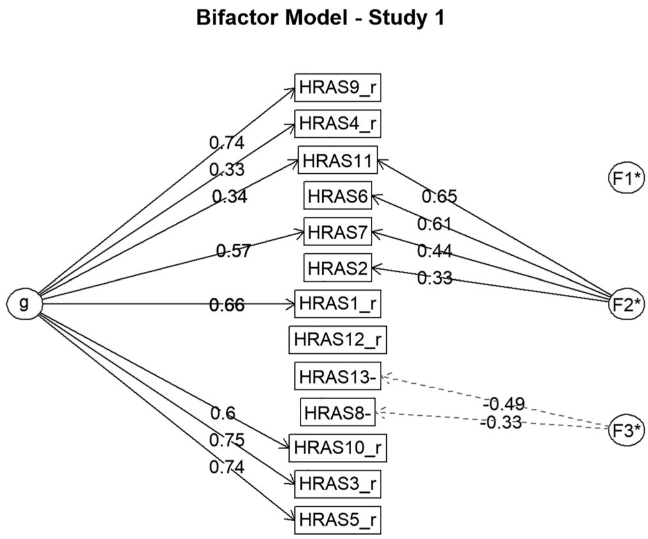

Figure 4. Bifactor model sample 1

norm for eating healthily had a significantly higher HRAS-13 score than those who did. Heavy drinkers had a higher HRAS-13 score than those who drank moderately or not at all. Respondents who exercised regularly had a lower HRAS-13 score than those who did not. HRAS-13 scores were negatively associated with health and happiness scores in sample 1. In sample 2, health-risk attitude was similarly associated with gender, but not significantly associated with health (the other variables were not available for this sample). The results of the mean HRAS-13 scores of different subgroups are summarised in Table 2.

Discussion

The aim of this paper was to assess the psychometric properties of the HRAS-13 in terms of reliability, dimensionality and validity in a sample from the general population and a sample from a patient population. Respondents in the patient sample ($n = 489$) had a higher mean HRAS-13 score than respondents in the general population sample ($n = 930$), indicating that the patient sample generally had a more positive attitude towards health risks, or was more health-risk seeking. HRAS-13 scores were also less widespread in the rather homogeneous patient sample.

Reliability—examined using the Cronbach's alpha as a measure for internal consistency—was higher in the general population sample (sample 1) than in the patient sample (sample 2). In the first sample, Cronbach's alpha could be increased from 0.73 to 0.84 by removing seven of the thirteen items, leaving a scale of six items consisting of 1, 3, 5, 7, 9 and 10. In the second sample, internal consistency (Cronbach's alpha of 0.69 in HRAS-13) could be increased by removing eight items, that is, the same seven items as in sample 1 (Cronbach's alpha of 0.81) and item 7 (Cronbach's alpha of 0.82). In addition, based on average inter-item correlations and item-total correlations items 8, 12 and 13 should potentially be removed. The reliability of the HRAS-13 could be

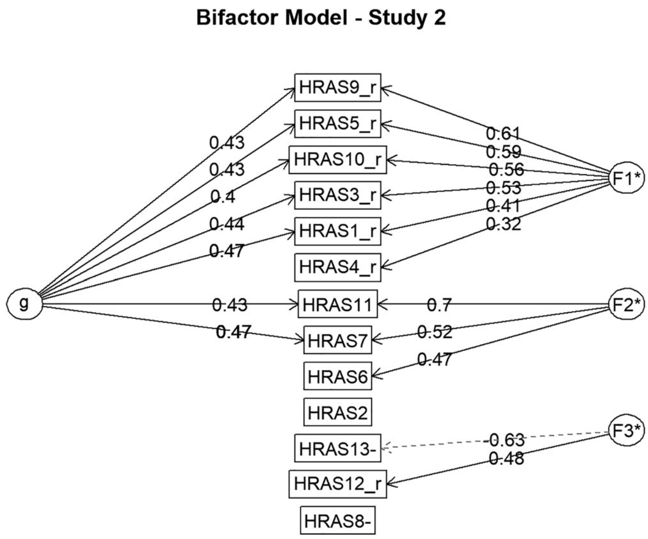

Figure 5. Bifactor model sample 2

further improved by removal of additional items in largely the same order as shown in the Cronbach's alpha analysis. These results indicate that the reliability of the scale could be improved if items are removed from the scale, which would also reduce respondent burden.

The one-factor model found by van Osch (2007) was not confirmed in these samples (CFA). Instead, using Principal Component Analysis a three-factor structure was specified for both samples, with the items loading similarly on the three factors in each sample. The factor loadings indicated that the first factor can be described as the degree to which health-risks and attitude towards it play an important role in peoples' lives. The second factor was characterised by items that described indirect health-risk attitude and unintentional health behaviour. The third factor specifically related to attitude towards risks involved in medical treatment. These dimensionality results indicate that health-risk attitude as measured by the HRAS-13 in these two samples likely is a multidimensional concept. The bifactor analyses in both samples confirmed the multidimensionality of the HRAS-13 and the potential redundancy of some of its items. The items loading on the first factor in the PCA and the general factor in the bifactor analysis largely corresponded to those that were retained in the reliability analysis, while the items loading on the second and third factor corresponded to those that were removed in order to increase Cronbach's alpha. Considering that the results of the reliability and dimensionality analyses differed between the two samples, one of which is a general public sample and the other a specific patient sample, we see these results as a preliminary indication that the HRAS-13 is a multidimensional scale, with some of the current 13 items possibly contributing to a general factor, some only to a specific sub-factor, and some items perhaps being redundant. A concurrent finding from the different analyses in both samples is that a short version of the HRAS including (at least) the items 1, 3, 5, 7, 9 and 10 may capture a general component of health-risk attitude. However, further studies are required to confirm the dimensionality of the HRAS-13 and the items to be retained in a full or a shorter version. Moreover, although here risk attitude was only measured in the domain of health, the factor structures observed support the multidimensionality of risk attitude also within this domain, and is a preliminary indication that domain-specific variance may exist, in addition to a general risk attitude component (Frey et al., 2017; Weber et al., 2002). To provide more conclusive evidence on the relative importance of general and domain-specific risk attitude, in future studies the HRAS-13 should also be compared to a measure of general risk attitude.

In the assessment of known-groups validity we found that the HRAS-13 was associated in the expected direction with various sample characteristics. In general, females (both samples) and people with a partner (only measured in sample 1) reported a significantly lower HRAS-13 score than their counterparts. Contrary to our expectation, no relationship was found with age nor education. Looking at the mean HRAS-13 scores per age group in sample 1, there might be a non-linear relationship between the variables that is not identified by ANOVA tests. The expectation that education was related to risk attitude was based on the literature about general risk-attitude rather than health-specific. As measured in sample 1, respondents engaged in unhealthy behaviours (i.e. smoking, poor nutrition, excessive drinking and limited physical exercise) generally reported higher HRAS-13 scores. These findings are much in line with our expectations based on previous literature. The results for sample 1 also show that healthier and happier respondents had lower HRAS-13 scores. No association was found between health-risk attitude and health in sample 2. Overall, these correlations show that the HRAS-13 can distinguish between subgroups of respondents based on the observable characteristics gender, having a partner, health behaviour and health and happiness in a sample from the general population. In the patient sample, HRAS-13 scores differed by gender but not by health. The latter could be because people in the patient population were generally in poorer health. Analysis of known-group validity of the HRAS-6 showed some additional statistically significant associations. Older people were found to have lower HRAS-6 scores in both samples, the same holds for healthier people in sample 2. However, females no longer had statistically significant different HRAS-scores from those of males in sample 2. Other associations were similar to HRAS-13 scores.

Studying the performance of the HRAS-13 in samples from the general population and a specific patient population in relation to several outcome measures and behaviours is a strength of this research. The scale was originally developed based on information from patients and experts, and now its reliability, dimensionality and validity in two large samples from the general and a patient population were assessed. Results of reliability and dimensionality were largely similar in both samples. Regarding validity, some differences were found. These similarities and differences in results across samples also warrant caution in interpreting results. Firstly, this study contained one sample of the general population and one relatively homogenous patient population. Although we found quite similar results in both samples, it should be investigated further whether elements of risk attitude of the general public (e.g. in relation to prevention and health behaviour) are sufficiently captured in the HRAS-13, and whether results are also similar in other patient samples. Secondly, the HRAS involves stated preferences which might not always be a good predictor of revealed preferences and behaviour, and vice versa (Bradley & Daly, 1997; Charness et al., 2020; Frey et al., 2017; King & Bruner, 2000; List & Gallet, 2001; Mata et al., 2018; Murphy et al., 2005). As such, it is recommended to study the performance of the HRAS-13 in a context where data about revealed health behaviour (e.g. treatment choices, adherence to guidelines) is available. Furthermore, both studies were conducted in the Netherlands, which potentially limits the generalisability of the findings. Within a Canadian sample, Bansback et al. (2016) reported that women were more risk averse than men, which is similar to our findings. However, they also reported an association between HRAS-13 scores and age, which was not observed in our studies. For a broader applicability of the HRAS-13 and understanding of the results in different settings, future research of the reliability and validity of the HRAS-13 in samples of the general population as well as a variety of patient populations and in multiple countries is encouraged. In addition, the relatively newer DOSPERT + M, an additional subscale of the DOSPERT that focuses on risk related to healthcare activities, was not included here as it was not included in the data available for this study (Butler et al., 2012; Rosman et al., 2013; Schwartz et al., 2013). It would be interesting for future research to compare the HRAS-13 with the DOSPERT + M (and the health/safety subscale) in the context of preventive health behaviours and treatment decisions. Lastly, to remove possibly poor-quality data, about a quarter of respondents were excluded based on speeding and response pattern analysis in both samples. Excluded respondents were mostly male and younger than the remainder of the samples, they were of similar education level and had higher HRAS-13 scores than the included respondents. When performing the reliability, dimensionality, and validity analyses with the full sample, results remained largely the same. In terms of reliability, Cronbach's alpha would have been lower if the full samples were used. Regarding dimensionality, a one-factor structure would again not be confirmed in the full samples, and a three-factor model was identified instead. The expected relationship between HRAS-13 scores and age between would have been statistically significant in the full sample 1. This could be explained by the fact that exclusion was slightly selective in terms of gender and age.

In conclusion, this psychometric evaluation has shown that further study is necessary into the reliability, dimensionality and validity of the HRAS-13 as a measure of risk attitude in the health domain. The results showed that internal consistency of the scale would be higher if some items are excluded. However, based on the dimensionality results, this would also mean excluding indirect health-risk attitude and behavior and attitude towards medical treatment risks. Depending on the context in which the instrument is used, studying the validity of a shorter version of the HRAS representing a general component of health-risk attitude could be relevant, both in terms of its psychometric properties as in reducing respondent burden. Certain dimensions (or sub-factors), as for example the one determined by the items 8, 12 and 13 relating to the risks associated with medical treatments, may be more relevant in specific populations or contexts. Nonetheless, the ability of the HRAS-13 and the HRAS-6 to discriminate between a number of different subgroups based on socio-demographics and health behaviours, makes that, awaiting further validation, these versions of the measure can already be used in a descriptive and predictive manner for individuals as well as for groups of individuals. Hence, the HRAS-13 can inform patients and health care providers about treatment preferences, and the HRAS-6 can inform members of the public, public health practitioners and policy makers about the general attitude of people towards risk taking in the health domain. More studies, both in large representative samples of the general public as in a variety of patient samples and healthcare contexts are required before these versions of the HRAS can be applied to inform policy decisions such as healthcare priority setting and health insurance, and decisions about public health in terms of for example prevention of diseases, promotion of a healthier lifestyle, or adherence to treatment guidelines and precautionary health safety measures in times of a pandemic. Next steps are to adopt and test the scale in varying health-risk contexts in medical decision making, and to further research the usefulness of the HRAS-13 in research and practice.

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Data availability

The data that support the findings of this study are available from the corresponding author, upon reasonable request, with the permission of the third parties involved in data collection.

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