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# Joint factor analysis and approximate equipercentile linking of common trait health anxiety measures: a cross-sectional study of the 14-, 18- and 64-item health anxiety inventory, the illness attitude scale, and the 14-item Whiteley Index

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## Abstract

**Background** Research on health anxiety has bloomed in recent years, but summaries of the literature are complicated by the use of dissimilar self-report questionnaires. Furthermore, these instruments have rarely been administered in parallel, and especially not in clinical samples. In this study, we aimed to investigate the relationship between five widespread health anxiety measures, and to draft guidelines for the conversion of different sum scores.

**Methods** Clinical trial participants with principal pathological health anxiety ( $n = 335$ ) and a sample of healthy volunteers ( $n = 88$ ) completed the 14-item Whiteley Index (WI-14), the Illness Attitude Scale (IAS), and the 14-, 18-, and 64-item Health Anxiety Inventory (the HAI-64, HAI-18, and HAI-14). Cross-sectional data from all participants were pooled ( $N = 423$ ) and we conducted a joint factor analysis and approximate equipercentile linking of the WI-14, IAS, HAI-64, HAI-18, and HAI-14.

**Results** Inter-scale correlations were high ( $r_s \geq 0.90$  and  $\geq 0.88$  in adjusted analyses), and the scree plot of the joint factor analysis spoke for a unifactorial solution where 89/105 items (85%) had loadings  $\geq 0.40$ . Most items at the core of this broad trait health anxiety factor pertained to the worry about health, the fear of having or developing a serious disease, and to some extent bodily preoccupation. We present a cross-walk table of observed equipercentile linked sum scores.

**Conclusions** This study speaks clearly in favor of the WI-14, IAS, HAI-64, HAI-18, and HAI-14 all tapping into the same trait health anxiety construct, the core of which appears to concern the worry about health, the fear of having or developing a serious disease, and to some extent bodily preoccupation. Based on recently reported cut-offs for the

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HAI-14, a reasonable cutoff for pathological health anxiety in a psychiatric setting probably lies around 7–8 on the WI-14, 52–53 on the IAS, 82–83 on the HAI-64, and 26–27 on the HAI-18.

**Trial registration** ClinicalTrials.gov NCT01966705, NCT02314065.

**Keywords** Health anxiety, Hypochondriasis, Illness anxiety disorder, Linking, Somatic symptom disorder

## Introduction

Health anxiety is a multifaceted psychological trait that is primarily characterized by a fear of, or preoccupation with, having or developing a serious health condition such as terminal cancer, a severe cardiovascular disease, or a progressive neurological disorder [1]. Higher levels of trait health anxiety commonly imply increased anxiety sensitivity and intolerance of uncertainty [2], increased bodily preoccupation [3], increased frequency and intensity of behaviors aimed at reducing health anxiety in the short term [4], and a more pronounced fear of death [5]. In the general population, trait health anxiety varies on a continuum, from benign levels of concern about health, to pathological health anxiety that is both recurrent and excessive [6–9]. Based on its clinical characteristics, pathological health anxiety can be considered a *de facto* anxiety or perhaps obsessive-compulsive spectrum disorder [2, 10–14].

Over the past decades, research focusing on health anxiety has been growing rapidly for several reasons; one being the relative success of the cognitive-behavioral framework in guiding treatment efforts and promoting interest in experimental work [11, 15]. Other factors sparking an interest in health anxiety include a rise in work focusing on the role of information technology in exacerbating health concerns [16], emergent discrepancies in widespread diagnostic taxonomies [14, 17], and an increased interest in the role of psychological factors in somatic disease including covid-19 [18, 19]. However, an obstacle to the interpretation of this increasingly diverse research field is that a large number of different trait health anxiety measures are in circulation, and that these are not easily compared. Thus, it is often difficult to determine whether participants of different studies suffer from similar levels of trait health anxiety, and if so, whether these levels are indicative of pathological health anxiety.

Self-report measures of trait health anxiety have existed since the mid-1960s. The 14-item Whiteley Index with dichotomous (“yes”/“no”) items (WI-14) was developed based on hospital staff definitions of “hypochondriasis” [20]. Its psychometric properties are usually found to be acceptable but not ideal, and revised versions with Likert-type items are now more common [21]. The Illness Attitude Scale (IAS; and sometimes referred to in the plural) was probably the most widely used measure of trait health anxiety from about the late

1980s to the early 2000s [22], and was developed on the basis of statements by patients who exhibited abnormal illness behavior or believed they had an undiagnosed disease [23]. Its psychometric properties are usually found to be good, though the factor structure is disputed [24]. The Health Anxiety Inventory [1] is perhaps the most widely used self-report measure of trait health anxiety today, and exists in many forms, the three most common probably being the 64-, 18-, and 14-item versions (HAI-64, HAI-18, and HAI-14). This questionnaire was developed to capture the cognitive and emotional components of DSM-IV hypochondriasis which was the prototypical pathological health anxiety diagnosis up until 2013. Common versions of the Health Anxiety Inventory are all widely believed to possess good to excellent psychometric properties [1, 25]. In a recent study, a cutoff of 22 on the HAI-14 was found to be appropriate for identifying patients with pathological health anxiety in the psychiatric setting [26]. When the respondent is known to suffer from pathological health anxiety, a score of 28 or higher is indicative of moderate symptoms, and 33 of substantial symptoms [26]. In summary, the WI-14, IAS, HAI-64, HAI-18 and HAI-14 are all examples of widespread measures of trait health anxiety, but knowledge about how scores can be converted from one measure to another is lacking.

In this study, we aimed to investigate the relationship between the WI-14, IAS, HAI-64, HAI-18, and HAI-14 using a composite dataset derived from two clinical trials for pathological health anxiety and a sample of healthy volunteers. In a joint factor analysis, we aimed to test our hypothesis that the scales would be highly correlated and tap into the same latent trait health anxiety construct. Should such a broad latent trait health anxiety factor be present, we aimed to determine what cognitive, emotional, and behavioral characteristics that lie at the core of this factor. Furthermore, we intended to relate the sum scores of the WI-14, IAS, HAI-64, HAI-18, and HAI-14 by means of equipercenile linking. Using the resulting linking table, we intended to make use of recently developed guidelines for interpreting the HAI-14 [26] so as to draw conclusions about approximate cut-offs and guidelines for interpreting severity in terms of the WI-14, IAS, HAI-64, and HAI-18.

## Methods

### Design

This was a psychometric study based on cross-sectional data from a composite adult sample (pooled  $N=423$ ) of 335 adult participants of two clinical trials of cognitive behavior therapy for pathological health anxiety [27, 28] and 88 healthy volunteers recruited via newspaper advertisements [29]. Notably, the two clinical trials included 336 participants but 1 was dropped from the present study due to missing WI-14 data. This study was a collaboration between Gustavsberg Primary Care Clinic and Karolinska Institutet, Stockholm, Sweden. All procedures were approved by the regional ethics review board of Stockholm (2013/375–31/5, 2014/1530–31/2), all participants gave informed consent to participate in research, and both clinical trials were preregistered at ClinicalTrials.gov (NCT01966705, NCT02314065).

### Procedure

All participants in the clinical trials exhibited a fear of, or preoccupation with, severe illness and met full criteria for a principal diagnosis of DSM-5 somatic symptom disorder or illness anxiety disorder as determined by a clinical psychologist aided by the Health Preoccupation Diagnostic Interview [HPDI; 30] and the Mini-International Neuropsychiatric Interview [MINI; 31]. The main exclusion criteria were a serious somatic condition, a substance use disorder, a psychotic disorder, a bipolar disorder, severe depression, and recurrent suicidal ideation. The healthy volunteers were assessed using the MINI and included only if found to be healthy. Prior to the eligibility interview, all 423 participants (both the clinical trial participants and the healthy volunteers), completed the self-report trait health anxiety measures as listed below.

### Outcomes

We administered the HAI-64, IAS, and WI-14 online in Swedish, using previously evaluated translations [1, 20, 23, 29]. Participants completed the questionnaires via their web browser, with black text on white background and radio buttons to mark responses. On the HAI-64, each of the 64 items renders a score of 0–3 and the respondent is encouraged to select one of four statements that best corresponds to their level of trait health anxiety (e.g., from “*I do not worry about my health*” to “*I spend most of my time worrying about my health*”). In this study, the HAI-64 had a theoretical range of 0–192 and was also rescored as the HAI-18 with a range of 0–54, and the HAI-14 with a range of 0–42, so as to enable approximate linking. The main difference, besides the number of items, between the HAI-14 on the one hand and the HAI-64 and HAI-18 on the other, is that the latter versions include a “negative consequences” subscale, which measures the perceived negative consequences of

developing a serious disease. In this study, internal consistency was excellent for the sum scales of all versions of the Health Anxiety Inventory, i.e., the HAI-64 ( $\alpha=0.99$ ), HAI-18 ( $\alpha=0.97$ ), and HAI-14 ( $\alpha=0.97$ ). On the IAS, 27 items are each scored 0–4, and responses indicate the frequency of various experiences pertaining to “worry about illness”, “concerns about pain”, “health habits”, “hypochondriacal beliefs”, “tanatophobia”, “disease phobia”, “bodily preoccupations”, “treatment experience”, and “effects of symptoms”, giving the sum score a theoretical range of 0–108. The internal consistency of the IAS in this study was excellent ( $\alpha=0.97$ ). On the WI-14, each item is scored 0 (“no”) or 1 (“yes”), resulting in a theoretical range of 0–14. The internal consistency of the WI-14 in this study was excellent ( $\alpha=0.94$ ).

### Statistical analysis

We conducted all statistical analyses in Stata 15.1. First, we validated that the trait health anxiety scales measured the latent construct, and were suitable for equipercentile linking. We calculated Pearson correlations and conducted a joint factor analysis of all ( $64+27+14=105$ ) items, based on principal axis factoring with promax rotation. Considering that we expected factor loadings to be strong, factors to be few, and there to be many items per factor, we regarded the sample size of 423 as sufficient for this purpose [32, 33]. Because the HAI-64 is considerably longer than the IAS and WI-14, as a sensitivity analysis, we also conducted a secondary factor analysis that only included the items of the HAI-14, IAS, and WI-14. When we had established that all questionnaires tapped into the same latent trait health anxiety construct, we proceeded to equipercentile linking of the WI-14, IAS, HAI-64, HAI-18, and HAI-14. Equipercentile linking is a procedure whereby scores on scales measuring the same thing are linked by means of percentiles, so that scores on two scales are assumed to be equivalent if they correspond to the same percentile of each respective scale distribution. As is commonly done for discrete scales [34], we defined the percentile of each score as the percentage of participants scoring below that score, plus the percentage of participants having exactly that score divided by two. We linked sum scores in the ranges that were observed (represented in the sample), and based on presmoothed frequency distributions that allowed us to model all sum scores (including those not directly observed) within each such range. As a sensitivity analysis, we also report linked sum scores based on observed (non-smoothed) frequency distributions as supplementary material.

**Table 1** Sample trait health anxiety sum scores

		Pathological health anxiety (n = 335)	Healthy volunteers (n = 88)	Total (N = 423)
HAI-14	M (SD), range	29.3 (4.7), 16–41	6.4 (3.8), 0–21	24.5 (10.3), 0–41
	Median (IQR)	29 (32–27)	5 (8–4)	28 (31–21)
HAI-18	M (SD), range	35.5 (6.2), 19–53	8.1 (4.5), 0–28	29.8 (12.6), 0–53
	Median (IQR)	36 (40–31)	7 (11–5)	34 (39–26)
HAI-64	M (SD), range	111.8 (20.4), 54–174	30.4 (13.3), 9–88	94.9 (38.2), 9–174
	Median (IQR)	112 (126–98)	28.5 (37.5–21.5)	104 (121–80)
IAS	M (SD), range	70.8 (12.3), 41–103	21.0 (8.6), 5–55	60.5 (23.3), 5–103
	Median (IQR)	71 (79–63)	20 (26.5–15)	67 (76–52)
WI-14	M (SD), range	10.7 (2.0), 5–14	1.1 (1.2), 0–7	8.7 (4.3), 0–14
	Median (IQR)	11 (12–9)	1 (2–0)	10 (12–7)

Note. "Range" refers to observed values as opposed to theoretical ranges. HAI=Health Anxiety Inventory (14, 18, and 64-item version as indicated); IAS=Illness Attitude Scale; IQR=interquartile range; WI-14=14-item Whiteley Index with dichotomous ("yes"/"no") items

**Table 2** Pearson correlation matrix of trait health anxiety measures

	HAI-14	HAI-18	HAI-64	IAS	WI-14
HAI-14	-				
HAI-18	0.99	-			
HAI-64	0.97	0.99	-		
IAS	0.94	0.93	0.94	-	
WI-14	0.92	0.91	0.90	0.92	-
HAI-64 minus HAI-14	0.95	0.97	1.00	0.92	0.88
HAI-64 minus HAI-18	0.96	0.97	1.00	0.93	0.89

Note. All values are significant ( $P < 0.0001$ ), though note that because the HAI-64 was rescored as the HAI-18 and HAI-14, item scores were often identical per definition and the correlations between these three measures are therefore inflated. Adjusted correlations with the HAI-64 minus the HAI-18 and HAI-14 are therefore included. HAI=Health Anxiety Inventory (14, 18, and 64-item version as indicated); IAS=Illness Attitude Scale; WI-14=14-item Whiteley Index with dichotomous ("yes"/"no") items

## Results

### Sample characteristics

The pathological health anxiety participants completed their questionnaires between December 4th 2013 and March 22nd 2014 ( $n=131$ ), and December 10th 2014 and March 15th 2017 ( $n=204$ ), in each respective clinical trial, and the healthy volunteers completed their questionnaires between March 19th 2014 and June 3rd 2014 ( $n=88$ ). A typical pathological health anxiety participant was a 38 years old ( $SD=12$ ) female (240/335, 72%) with a tertiary education (259/335, 77%) who scored in the moderate pathological range of trait health anxiety (Table 1). In this subsample, 64/335 (19%) had comorbid depression and 207/335 (62%) met full criteria for at least one comorbid anxiety disorder, post-traumatic stress disorder, or obsessive-compulsive disorder. A typical healthy

volunteer was a 49 years old ( $SD=18$ ) female (59/88, 67%) with a tertiary education (80/88, 91%) who scored low on trait health anxiety (Table 1). None of the healthy volunteers was found to meet criteria for a psychiatric disorder. In the pooled sample ( $N=423$ ), the distribution of trait health anxiety scores covered most but not all theoretically possible sum scores (the WI-14 being the exception where all scores, 0–14, were observed; see the supplementary material for details).

### Joint factor analysis and feasibility of equipercenile linking

In the pooled sample, Pearson correlations between the trait health anxiety measures were all high ( $\geq 0.90$  and  $\geq 0.88$  in adjusted analyses; Table 2) and the Kaiser-Meyer-Olkin (KMO) statistic was indicative of adequate sampling (0.98). Joint factor analysis of the HAI-64, IAS, and WI-14 pointed to one factor being clearly dominant, as is illustrated in the scree plot in Figure S1. All three scales contributed with items that received factor loadings in at least the high 0.80s. The common theme of these core items appeared to be worry about health and the fear of having or developing a serious disease, notable examples being HAI-64 #8 (i.e., HAI-14 and HAI-18 #5: "I am [...] afraid that I have a serious illness"), IAS #1 ("Do you worry about your health?"), and WI-14 #1 and #4 ("Do you often worry about the possibility that you have got a serious illness?", "Do you worry a lot about your health?"). Weak items were primarily found in the HAI-64 Negative Consequences (NC) subset (i.e., #48 onwards), and were primarily items that concerned social interaction in the case of serious illness (Tables S1 and S2). When two factors were retained in the analysis, most of the 17 NC items mapped onto a relatively weak second

factor (Tables S3 and S4). Overall, however, this factor analysis indicated that the WI-14, IAS, HAI-64, HAI-18, and HAI-14 tap into one and the same strong trait health anxiety factor as their primary source of variance, and results were similar when the factor analysis included the items of the WI-14, IAS, and HAI-14 only (Figure S2, Tables S5 and S6).

#### Equipercenile linking of trait health anxiety sum scores

Because all trait health anxiety scales appeared to be closely associated, we proceeded to equipercenile linking of their sum scores. Table 3 can be used for approximate linking of sum scores on the WI-14, IAS, HAI-64, HAI-18, and HAI-14. With the help of Table 3, each trait health anxiety score that was observed in the present study can be linked to its percenile, which in turn can be linked to a score on another trait health anxiety scale. Thus, for example, a score of 22 on the HAI-14 corresponds to approximately 26–27 on the HAI-18. Linking based on non-presmoothed frequency distributions resulted in relatively similar outcomes.

#### Discussion

This study was an unusual attempt at a joint analysis of five common trait health anxiety self-report questionnaires. We found that the WI-14, IAS, HAI-64, HAI-18, and HAI-14 all loaded heavily on the same broad latent trait health anxiety factor, as illustrated by the fact that out of 105 items in total, 35 had loadings  $\geq 0.80$  and 89 had loadings  $\geq 0.40$ . A strength of the present study is that all non-healthy participants had pathological health anxiety as opposed to other primary psychopathologies, so that a clear gradient in trait health anxiety, without substantial interference of partially overlapping constructs such as somatic disease and panic disorder symptoms, could be modelled for the purpose of factor analysis and the linking of sum scores. The strong unifactorial solution seen in this study speaks in favor of the linking of sum scores derived from the WI-14, IAS, HAI-64, HAI-18, and HAI-14.

Based on estimates derived from the cross-walk table (Table 3), an HAI-14 cutoff of 22 to screen for pathological health anxiety in the psychiatric setting [26] corresponds to a score of ca. 26–27 on the HAI-18, 82–83 on the HAI-64, 52–53 on the IAS, and 7–8 on the WI-14. These tentative cutoffs are slightly higher than those previously reported [35], most probably because the present estimates are derived from an analysis where consecutive psychiatric patients constituted the reference group [26] whereas previous estimates were derived from a study that employed a more pragmatic reference group [35]. In respondents with confirmed pathological health anxiety, based on the recent suggestion that scores below 28 on the HAI-14 are indicative of mild symptoms [26],

the same could be said of scores below ca. 33–34 on the HAI-18, 105–106 on the HAI-64, 67–68 on the IAS, and 10–11 on the WI-14. Similar to scores of at least 33 on the HAI-14 [26], symptoms are probably to be regarded substantial even within the clinical range if the respondent scores at least ca. 40–41 on the HAI-18, 128–129 on the HAI-64, 80–81 on the IAS, or 12–13 on the WI-14. These approximate conversions and rule of thumb guidelines for the interpretation of scores derived from common trait health anxiety scales could be of use both in research and the clinic.

In this study, items that pertained to worrying about health and fearing the prospect of having or developing a serious disease were at the heart of the trait health anxiety construct. One implication of this finding is that, should a minimal set of questions be used for the purpose of identifying individuals with pathological health anxiety, for example by the general practitioner or as part of a screening procedure, these questions should ideally focus on worrying about health and the fear of having or developing a serious disease. Thus, for example, it would probably be more fruitful to ask “*Would you say that you worry a lot about your health, and the possibility of having a serious disease?*” than to ask about repeated doctor shopping or other aspects of the trait health anxiety construct. Importantly, this view of health worries and the fear of disease as the core of the trait health anxiety construct contrasts with certain widespread conceptualizations of pathological health anxiety, such as the ICD-11 hypochondriasis diagnosis, which focuses more on the presence of excessive health-related behaviors. Results for bodily preoccupation were mixed, and our impression is that items tapping into worry such as IAS #20 (“*When you notice a sensation in your body, do you find it difficult to think of something else?*”, 0.90–0.94) had substantial factor loadings whereas items that conceived of bodily preoccupation in terms of perceptual changes or “being aware” of the body only had slightly weaker or even modest loadings (e.g., HAI-64 #3: “*I am constantly aware of bodily sensations or changes*”, 0.74–0.75; WI-14 #3: “*Do you find that you are often aware of various things happening in your body?*”, 0.53–0.58). Items pertaining to the fear of death (IAS #13–14) showed mixed results in the 0.59–0.78 range, thus only partly corroborating the common view that the fear of death is an integral component of pathological health anxiety [5, 36]. Interestingly, not responding to medical reassurance (IAS #11, WI-14 #10), which used to be a criterion for hypochondriasis during the DSM-IV era, had relatively weak loadings (0.50–0.59). One possible explanation for this is that these medical reassurance items were phrased in a manner that led participants to reply based on whether they usually feel reassured in the very short term, as opposed to whether this reduction tends to persist for a longer period of time

**Table 3** Cross-walk table of equipercntile linked scores on trait health anxiety measures

Percentile	HAI-14	HAI-18	HAI-64	IAS	WI-14	Percentile	HAI-14	HAI-18	HAI-64	IAS	WI-14
0.045			0			29.339					55
0.060					5	30.119				87	
0.119			9			30.664					56
0.133	0				6	30.665		28			
0.212						30.986				88	
0.291		1		10		31.592		24			
0.364					7	31.897				89	
0.441						32.085					57
0.602	1					32.502					8
0.630			11			32.851			90		
0.754					8	33.333		29			
0.916		2				33.611					58
0.924				12		33.850			91		
1.142					9	34.772		25			
1.251			13			34.890				92	
1.597					10	35.243					59
1.614			14			35.968				93	
1.622	2					36.343		30			60
1.967		3				36.971					
2.014				15		37.080				94	
2.116					11	38.220				95	
2.449			16			38.781					61
2.710					12	39.097		26			
2.917			17			39.386				96	
3.385				4		39.719		31			
3.389						40.255					9
3.396					13	40.572					
3.412	3					40.657				97	
3.553						41.777					62
3.931				18	0	42.594				98	
4.156			19			43.000					63
4.471					14	43.472				99	
5.006			20			44.240		32			
5.028					15	44.594				100	
5.095			21			44.648					64
5.601		5				45.498		27			
5.803				22		46.667				101	
5.926	4					46.776					65
6.187			23			47.601		33			

**Table 3** (continued)

Percentile	HAI-14	HAI-18	HAI-64	IAS	WI-14	Percentile	HAI-14	HAI-18	HAI-64	IAS	WI-14
6.784			24			48.076			103		
6.895				17		48.819				66	
6.989		6				49.400			104		
7.390			25			49.498					10
7.884				18		50.751			105		
8.003			26			51.055				67	
8.437	5					51.110	28				
8.619			27			52.103		34			
8.874				19		52.128			106		
8.908		7				53.364				68	
9.236			28			53.528			107		
9.850			29			54.949			108		
9.853				20		55.734				69	
10.455			30			56.386			109		
10.465					1	56.905		35			
10.712						57.834			110		
10.810				21		58.135	29				
10.879	6					58.151				70	
11.050			31			59.287			111		
11.629			32			60.599				71	
11.733				22		60.739			112		11
12.190			33			61.750					
12.348						61.853		36			
12.614				23		62.188			113		
12.728			34			63.059				72	
12.919	7					63.633			114		
13.244			35			65.075			115		
13.443				24		65.209	30				
13.735			36			65.516				73	
13.817						66.512			116		
14.203		10				66.784		37			
14.208				25		67.942			117		
14.629	8					67.959				74	
14.650			38			69.363			118		
14.905				26		70.372				75	
15.075			39			70.769			119		
15.109		11				71.581		38			
15.481			40			71.782	31				
15.537				27		72.155			120		

**Table 3** (continued)

Percentile	HAI-14	HAI-18	HAI-64	IAS	WI-14	Percentile	HAI-14	HAI-18	HAI-64	IAS	WI-14
15.868				41		72.737					76
16.082					2	73.516				121	
16.113				28		74.848				122	
16.124	9					75.041					77
16.222			12			76.132		39			
16.235				42		76.146				123	
16.584				43		76.974					12
16.641				44	29	77.274					
16.913				44		77.406				124	
17.131				30		77.543		32			
17.175			13			78.628				125	
17.223				45		79.420					79
17.329	10					79.808				126	
17.515				46		80.299		40			
17.590				47	31	80.947				127	
17.790				47		81.456					80
17.984			14		32	82.041				128	
18.019						82.519		33			
18.047				48		83.092				129	
18.187	11			49		83.364			41		81
18.286						84.008					
18.413				50	33	84.098				130	
18.509						85.064				131	
18.642			15			85.131					82
18.716				51		85.993				132	
18.764					34	86.754				133	
18.790						86.886					
18.909	12			52		86.920					
19.075					35	87.275		42			
19.089				53		87.748				134	
19.144			16			88.233					84
19.223						88.578				135	
19.259	13			54		89.375				136	
19.321					3	89.576					85
19.348						90.120		43			
19.421				55	36	90.139				137	
19.524			17			90.776					
19.576				56		90.790		35			86
19.583	14					90.870				138	



**Table 3** (continued)

Percentile	HAI-14	HAI-18	HAI-64	IAS	WI-14	Percentile	HAI-14	HAI-18	HAI-64	IAS	WI-14
19.590					37	91.181					13
19.726				57		91.568			139		
19.810					38	91.881					87
19.838		18				92.233			140		
19.872				58		92.526		44			
19.947	15			59		92.860					88
20.012					39	92.865			141		
20.024						93.463			142		
20.147		19		60		93.745					89
20.148					40	93.866		36			
20.246				61		94.026			143		
20.278						94.499		45			
20.327	16			62		94.551					90
20.405					41	94.555			144		
20.486				63		95.047			145		
20.502		20				95.281					91
20.530				64	4	95.505			146		
20.634						95.930			147		
20.656				65		95.939					92
20.753					42	96.026		37			
20.759	17			66		96.083		46			
20.786						96.323			148		
20.924				67		96.532					93
20.947			21			96.686			149		
21.049					43	97.020			150		
21.074				68		97.068					94
21.240						97.319		47			
21.311	18			69		97.328			151		
21.335					44	97.428		38			
21.377				70	5	97.428					95
21.424						97.552			152		
21.520		22		71		97.609			153		
21.628					45	97.866					96
21.735				72		97.990			154		
21.854	19					98.099		48			
22.091				73		98.212					97
22.103					46	98.308			155		
22.129				74		98.389					
22.275		23				98.412		39			
				75		98.494			156		

**Table 3** (continued)

Percentile	HAI-14	HAI-18	HAI-64	IAS	WI-14	Percentile	HAI-14	HAI-18	HAI-64	IAS	WI-14
22.377			73			98.652					14
22.566				47		98.657			157		
22.678			74			98.750				98	
22.719					6	98.799			158		
23.008			75			98.800		49			
23.060				48		98.921			159		
23.260	20					99.027			160		
23.283		24				99.066				99	
23.370			76			99.118			161		
23.628				49		99.169	40				
23.769			77			99.171		50			
24.205			78			99.198			162		
24.291				50		99.268			163		
24.608		25				99.331			164		100
24.683			79			99.332			165		
24.916	21			51		99.391		51			
25.067						99.414			166		
25.204			80			99.448			167		
25.772			81			99.503			167		
25.964				52		99.547			168		101
26.288		26				99.558			169		
26.308					7	99.613			170		
26.388			82			99.620		52			
26.904	22					99.668			171		
26.981			83		53	99.727			171		
27.051						99.729			172		102
27.758			84			99.749	41				
28.109				54		99.791			172		
28.317		27				99.862		53			
28.506			85			99.865			173		
29.082	23					99.907			174		103
29.293			86			99.952					

Note: Linking was based on presmoothed frequency distributions. Using this table, each trait health anxiety score can be linked to a percentile, which in turn can be linked to a score on another trait health anxiety scale. Thus, for example, a score of 22 on the HAI-14 corresponds to about 26–27 on the HAI-18. HAI=Health Anxiety Inventory (14, 18, and 64-item version as indicated); IAS=Illness Attitude Scale; WI-14=14-item Whiteley Index with dichotomous (“yes/“no”) items

("When your doctor tells you that you have no physical disease to account for your symptoms, do you refuse to believe him?", "Is it hard for you to believe the doctor when he tells you there is nothing for you to worry about?"). The focus on this short time frame is unfortunate, considering that the cognitive-behavioral view of pathological health anxiety would contend that it is not so much the lack of a short-term reduction in anxiety that is characteristic of this clinical problem, but rather the reduced likelihood of a reduction in health anxiety being maintained over time [e.g., 37, 38]. Generally speaking, many items pertaining to overt behaviors such as symptom checking, reassurance seeking, and various avoidance behaviors were also in the lower range, highlighting that whereas high levels of trait health anxiety always imply an increased fear of or preoccupation with having or developing a serious disease, different individuals engage in different behaviors in the hope of reducing or managing this problem in the short term [4]. For example, an individual worrying about skin cancer may be more inclined to "examine [his or her] body for disease" (IAS #9), than an individual worrying about a severe congenital heart defect or pancreatic cancer. Interestingly, both being afraid of seeking health care (HAI-64 #22) and the inclination to seek healthcare (IAS #23 and #24) loaded on the same latent trait health anxiety trait which corroborates the previous finding that both patterns are common, and may even be found in the same individual and fluctuate over time [39]. Abnormal health behaviors are probably important for trait health anxiety, but measuring these using specific examples results in clear psychometric challenges.

We are aware of one previous study where more than one health anxiety scale was included in the same factor analysis [40]. In that study, 503 undergraduate students completed the HAI-18 and the Multidimensional Inventory of Hypochondriacal Traits [MIHT; 41]. When a second-order health anxiety factor was added, the MIHT Affective/Worry subfactor which focuses on worry about health and the fear about serious illness had the strongest factor loading (0.96), followed by a factor representing the first 14 items of the HAI-18 (i.e., the HAI-14; 0.83). Similar to the present study, the MIHT Behavioral/Reassurance subfactor had a modest factor loading of 0.55, and the Negative Consequences (NC) items of the HAI-18 did worse (0.51). Thus, on the whole, the outcome of the previous study was similar to the present one in the sense that the worry about health and the fear of serious illness was at the core of the trait health anxiety construct [40], which speaks for the validity of our findings. The fact that many of the HAI-64 NC items had relatively weak factor loadings on the broad trait health anxiety factor in both studies also has clinical implications in that this speaks for further use of the HAI-14 rather than the HAI-64 or HAI-18 if construct validity in the field as a

whole is to be promoted. Simply put, the HAI-14 appears to focus on the core aspects of trait health anxiety.

This study had notable strengths. Several trait health anxiety questionnaires were administered in parallel which is unusual, especially in clinical samples. Furthermore, data could be derived from a combination of healthy volunteers and patients with pathological health anxiety which means that the full range of trait health anxiety scores were available for analysis. This study also had limitations. Participants were primarily self-referred, reported high average educational attainment, and were primarily female. This implies a threat that results may not generalize as well to populations that are not actively seeking treatment, that are less educated, and that are primarily male. Notably, relatively little is known about measurement invariance with regard to psychometric measures of health anxiety (for one of few noteworthy investigations, see MacSwain et al., 2009 [42]). This means that it is not clear to what degree the WI-14, IAS, HAI-64, HAI-18, and HAI-14 behave differently in psychometric terms for example as a function of demographic characteristics. Another limitation is that the HAI-14 and HAI-18 were scored from the corresponding items of the HAI-64 as opposed to administered separately, which may have affected the outcome due to intermediate items giving rise to framing and ordering effects [e.g., 43]. Because the HAI-64, IAS, and WI-14 were not administered in weighted or random order, ordering effects could also have affected the study overall, which highlights the preliminary nature of these findings. A limitation of this study is also that the full theoretical ranges of sum scores were not observed. Specifically, none of the participants had a score of 42 on the HAI-14, 54 on the HAI-18, 0–8 or 175–192 on the HAI-64, or 0–4 or 104–108 on the IAS. These sum score ranges were therefore not modelled. Last, we wish to highlight that several common trait health anxiety questionnaires were not included in the present study. For example, based on a decision taken around 2010 [44], in the research program from which these data were derived, we administered a dichotomous ("yes"/"no") item version of the WI-14 as opposed to a Likert-version which is more common nowadays [21].

## Conclusion

This study indicates that the WI-14, IAS, HAI-64, HAI-18, and HAI-14 are all valid measures of the same trait health anxiety construct, the core of which appears to be the worry about health, the fear of having or developing a serious disease, and to some extent bodily preoccupation. Approximate linking guidelines enable clinicians and researchers to convert sum scores between questionnaires, and to determine how trait health anxiety levels compare over published studies. For the clinician, a take

home message from this study could also be that it is probably more fruitful to identify patients with pathological health anxiety by asking them about health worries and the fear of serious disease (which appears to lie at the core of health anxiety) than to ask about specific behavioral patterns such as healthcare consumption or reassurance seeking which differ considerably between patients, and commonly change for the same patient over time.

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12888-023-05151-7>.

Supplementary Material 1: Key output from joint factor analyses

Supplementary Material 2: Trait health anxiety sum score distributions

Supplementary Material 3: Sensitivity analysis: alternative linking based on non-smoothed frequency distributions

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## Authors' contributions

EA had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. Conception and design: EA. Acquisition of data: EA and EHL. Statistical analysis: EA. Drafting of the manuscript: EA. Interpretation, critical revision for intellectual content, approved the final manuscript: EA, SÖ, and EHL.

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## Data Availability

The data analyzed during the current study are not publicly available due to the relevant Swedish and European Union data protection and privacy legislation, but are available from the corresponding author on reasonable request. Such requests will be considered on a case-by-case basis, so as to ensure that data and materials are stored, managed, and shared in accordance with the local policies of the sponsor and the relevant Swedish and European Union data protection and privacy legislation.

## Declarations

### Competing interests

EA and EHL have authored a self-help book and several book chapters on the topic of health anxiety, available in the public marketplace. EHL is also a shareholder of DahliaQomit AB, a company specializing in online psychiatric symptom assessment. SÖ declares no conflict of interest.

### Ethics approval and consent to participate

This research was approved by the regional ethics review board of Stockholm (2013/375–31/5, 2014/1530-31/2) and conducted in accordance with the relevant guidelines and regulations. All study participants gave informed consent to participate in research.

### Consent for publication

Not applicable.

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