Journal of Fundamentals of Mental Health

Mashhad University of Medical Sciences

Psychiatry and Behavioral Sciences Research Center

Original Article **Open Access**

Factor structure of Perceived Vulnerability to Disease Questionnaire (PVDQ): Exploratory and confirmatory methods

Balal Izanloo[1]; *Negar Sadeghi[2]; Samaneh Dehghan Nezhad[3]; Reihaneh Dargahian[4]; Zahra Madanipoor[3]

[1]*Assistant professor, Department of Educational Research, Faculty of Psychology and Education, Kharazmi University, Tehran, Iran.*
[2]*Postdoc researcher, Department of Psychology, Faculty of Psychology and Education, Shiraz University, Shiraz, Iran.*
[3]*Counselor in Ministry of Education, Tehran University, Tehran, Iran.*
[4]*Psychotherapist in private clinic, Mashhad, Iran.*

Abstract

Introduction: The present study aimed to investigate the psychometric features of the Perceived Vulnerability to Disease Questionnaire (PVDQ).

Materials and Methods: A sample of 370 adults from Karaj City, Iran, was selected using convenience sampling and completed PVDQ. Research data were collected over three months between March and June 2020. Half of the data was collected through an online questionnaire, and the other half was collected through a paper-pencil questionnaire. To investigate the factor analysis, the Exploratory Structural Equation Model and Confirmatory Factor Analysis were used. Data were analyzed using R and some packages, including psych, lavaan, and Mplus.

Results: The results showed that, unlike the original two-factor structure, which removed items 3 and 14, the three-factor structure for PVDQ has the maximum fitness and justified interpretation. The alpha of the three factors was 0.83, 0.76, and 0.70, and their AVE index was 0.52, 0.51, and 0.49, respectively.

Conclusion: Although the factor structure in the original version is two factors (including germ aversion and perceived infectability subscales), the results of the present study have shown three-factor structures that consist of germ aversion, personal infectability, and interpersonal infectability. Indeed, it shows differences in respondents' perceptions of transmission in the present study, including personal vulnerability to infection and feelings of vulnerability from social relationships to infection.

Keywords: Disease susceptibility, Factor analysis, Infection

Please cite this paper as:
Izanloo B, Sadeghi N, Dehghan Nezhad S, Dargahian R, Madanipoor Z. Factor structure of Perceived Vulnerability to Disease Questionnaire (PVDQ): Exploratory and confirmatory methods. Journal of Fundamentals of Mental Health 2025 Mar-Apr; 27(2): 119-130. DOI: 10.22038/JFMH.2024.80050.3131

***Corresponding Author:**
Department of Psychology, Faculty of Psychology and Education, Shiraz University, Shiraz, Iran.
negar.sa.35@gmail.com
Received: May. 20, 2024
Accepted: Oct. 17, 2024

Introduction

Humans have encountered many infectious diseases over the years. These diseases, from the plunge to flu, AIDS, and COVID-19, have affected the lives of humans worldwide. Although individuals have different biological immune systems against infectious diseases, there are personal differences called Behavioral Immune Systems (BIS). The behavioral immune system is a psychological adaptation that decreases the risk of infection (1).

This means that individual differences in perceived vulnerability can lead to behaviors that prevent transmission, and individuals who feel vulnerable to infection probably adhere to more preventive behaviors. Preventive behaviors must be fundamental for controlling diseases, especially in epidemic and pandemic situations. The World Health Organization (WHO) highlighted that behavior is the first defense against infectious diseases (2). Therefore, the perception of susceptibility to infectious disease is important, especially in terms of transmission. Based on BIS, the behavioral immune system evolved two facets including germ aversion and perceived infectability. Recent research reveals that higher BIS was associated with protective behaviors.

For example, Karlsson et al. (1) investigated the behavioral immune system and vaccination intentions during the coronavirus pandemic. The results showed that individuals who perceived themselves as more susceptible to disease were slightly more willing to accept vaccination.

Makhonava and Shepherd (3) showed that perceived vulnerability to disease was linked with responses to COVID-19 and preventative behaviors such as social distancing behaviors. Shook et al. (4) found that the behavioral immune system is associated with concern and preventative health behaviors. Lee et al. (5) showed that individuals with high perceived infection sensitivity to the MERS outbreak tended to have more preventive behaviors. Other research also supports that risk perception can influence human reactions against infectious disease (6-17). Therefore, assessing vulnerability to diseases and determining how perceived risk is linked to engagement in protective behaviors is important.

One of the scales that measure risk perception of disease based on BIS is the Perceived Vulnerability to Disease Questionnaire (PVDQ), which was designed by Duncan, Schaller, and Park to assess the perceived risk of diseases. Duncan et al. suggest that the emerging implication is that different psychological phenomena may be uniquely predicted by individuals' differences in perceived vulnerability to infectious diseases (18). They criticize self-report instruments that assess perceived vulnerability to diseases and believes that disgust sensitivity measures assess reactions to a broad range of stimuli, only a subset of which are directly relevant to disease transmission.

Also, they believe these measures are designed to assess affective responses and are suitable for emotion-laden beliefs. From their point of view, other measures are designed to assess hypochondria and other health-relevant anxieties and focus on a broad range of potential health problems rather than infectious diseases in particular. Consequently, they designed PVDQ to assess vulnerability to diseases without mentioned defects. Duncan et al. obtained the validity of the scale equal to 0.82 using Cronbach's alpha method. This scale has been used in some studies, and its validity has been reported as favorable (19-21).

Although PVDQ is one of the most widely used measures of vulnerability to infectious diseases, there were some questions about factor structure and scores in different studies. Diaz et al. (21) said, "The use of the PVDQ in different studies in the last years has produced three different scale options: the scoring for the subscales, perceived infectability, and germ aversion.

Only three studies -Duncan et al., Murray et al., and Makhanova et al. have used the two PVDQ subscales, perceived infectability and germ aversion, showing adequate internal consistency in both subscales, whilst the germ aversion subscale failed to get adequate reliability in several studies, with Cronbach's alphas from 0.55 to 0.61" (22). Duncan et al. believe that a limitation of the scale is that researchers should use the overall PVDQ score in their studies with adequate internal consistency."

As these studies have shown, not only was the internal consistency of PVDQ in various types of research different but the factor structure of this scale was also reconsidered inadequately. The present study aims to investigate the factor structure of PVD in an Iranian sample.

Materials and Methods

Using convenience sampling, participants were 370 adults selected from the public population of Karaj City, Iran. Kim's approach was used to determine the sample size. That is, according to 15 items of the instrument, the degree of freedom 89 (which was calculated based on the 2-factor model with 15 indicators in original form), the significance level 0.05, the power 0.80, and McDonald's centrality goodness of fit index 0.95 the sample size was 377. In practice, 370 questionnaires were collected (23). Inclusion and exclusion criteria were determined based on the age of the participants.

The age range was from 18 to 60 years old, with 69% in the age range of 18 to 40 years old and 31% in the age range of 41 to 60. We eliminated participants who were not in this age range. Approximately two-thirds of the sample were women (N= 224; 60.4%), and one-third were men (N= 146; 39. 6%). Participants were selected from different ages and occupational spectrums. Research data were collected in three months between March and June 2020. Half of the data were completed through an online questionnaire, and the other half were collected through a paper-pencil questionnaire. The average time for answering questions was 20 minutes.

Research instrument

A) Perceived Vulnerability to Disease Questionnaire (PVDQ): designed by Duncan, Schaller, and Park (2009) was used to assess vulnerability to diseases. This scale has 15 questions on a scale of one to seven, and participants rate their agreement or disagreement with each option on this scale. The questionnaire has two subscales, the first measuring perceived infectability and the second showing germ aversion.

B) Duncan et al. obtained a scale validity of 0.82 using Cronbach's alpha (18). Various studies have studied this scale, and its validity has been reported as favorable (19-25). In Iran, this questionnaire has been used, and its validity has been reported between the range of 0.70 to 0.81 through retesting and internal consistency (19).

Results

Data were analyzed using R and some packages, including psych, EGAnet, lavaan, and Mplus (26-31). Before data analysis, items 3, 5, 11, 12, 13, and 14 were scored reversely. Then, factor structure was investigated by exploratory methods such as Parallel analysis, Exploratory Graph Analysis (EGA), Exploratory Structural Equation Model (ESEM), and Exploratory Factor analysis (EFA). Finally, Confirmatory Factor Analysis (CFA) confirmed the identified factor structure.

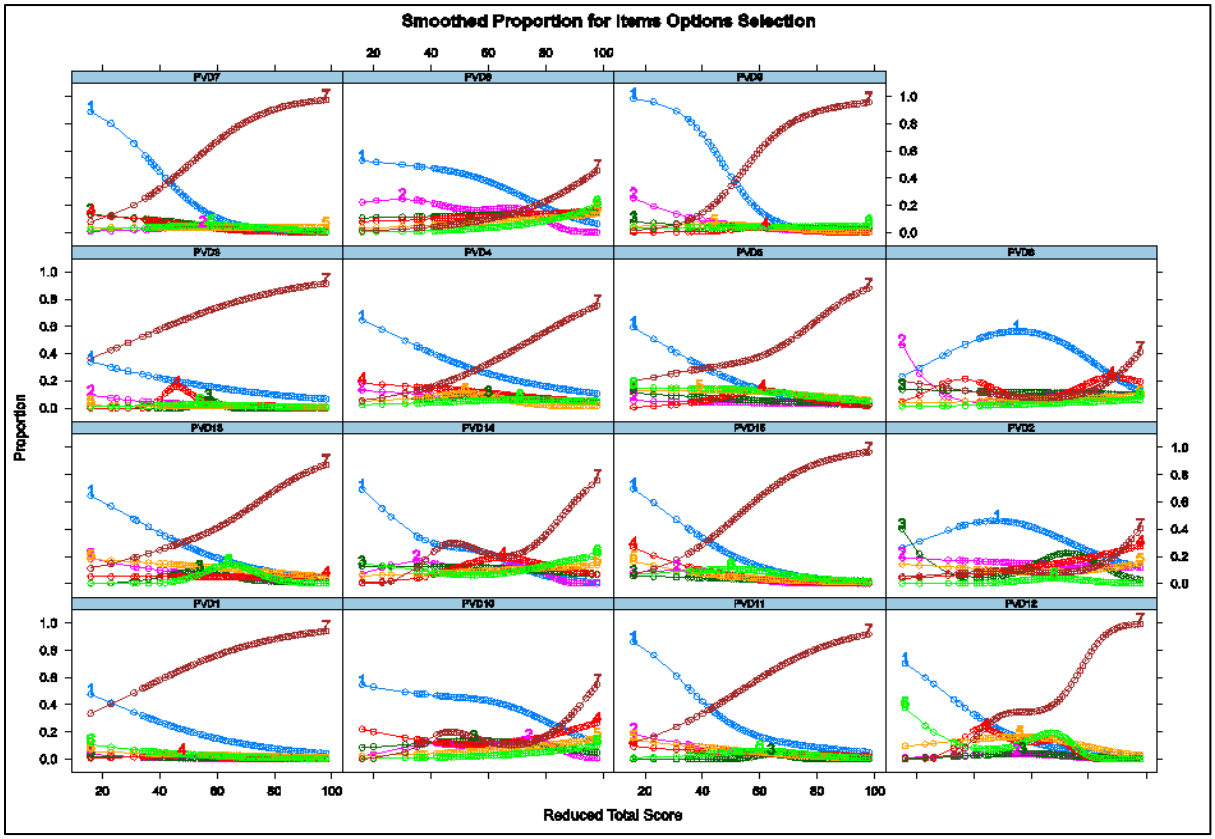
Items statistics

As seen in Table 1 and Plot 1, not all item options discriminate between traits measured by items. One problem in the PVDQ test is using a 7-point Likert scale in its scoring. Results from the present study showed that using the wide range is undesirable in some respects. First, the sample size needs to be increased to estimate accurately. Second, the person's preference for selecting items is concentrated on the marginal options (i.e., options 1 and 7). Other options are not to discriminate against persons well or receive much attention (Plot 1). The appropriate points for these items appear to be three or maximally 5 points Li5-point, not 7 points. As shown in Table 1, items 1, 2, 5, 6, and 10 had a low correlation with the total row score, and their mean was lower than other items.

Table 1. Descriptive statistics of items and their options

Item	raw.r*	r.cor	r.drop*	mean	sd	1	2	3	4	5	6	7
PVD1	0.37	0.27	0.21	6.0	2.1	0.13	0.00	0.01	0.01	0.03	0.02	0.80
PVD2	0.34	0.25	0.19	3.1	2.0	0.32	0.14	0.15	0.16	0.09	0.02	0.11
PVD4	0.48	0.37	0.30	4.6	2.5	0.22	0.07	0.08	0.09	0.06	0.06	0.43
PVD5	0.36	0.27	0.20	5.3	2.1	0.12	0.04	0.05	0.09	0.11	0.11	0.49
PVD6	0.37	0.31	0.21	2.9	2.1	0.44	0.10	0.11	0.13	0.07	0.04	0.11
PVD7	0.57	0.56	0.45	6.0	2.0	0.10	0.03	0.03	0.02	0.04	0.04	0.74
PVD8	0.49	0.47	0.34	3.5	2.2	0.28	0.14	0.13	0.13	0.09	0.06	0.17
PVD9	0.64	0.64	0.52	5.7	2.2	0.14	0.03	0.04	0.02	0.04	0.04	0.69
PVD10	0.38	0.32	0.21	3.3	2.2	0.35	0.11	0.11	0.14	0.08	0.04	0.16
PVD11	0.43	0.34	0.27	5.6	2.3	0.15	0.04	0.01	0.04	0.04	0.05	0.67
PVD12	0.45	0.38	0.31	5.4	2.0	0.11	0.02	0.03	0.10	0.13	0.11	0.49
PVD13	0.44	0.34	0.27	5.2	2.3	0.16	0.05	0.05	0.05	0.10	0.08	0.52
PVD15	0.52	0.47	0.39	5.9	2.0	0.11	0.02	0.03	0.03	0.03	0.07	0.71

*raw.r: The correlation of each item with the total score, not corrected for item overlap. r.cor: Item whole correlation corrected for item overlap and scale reliability. r.drop: Item whole correlation for this item against the scale without this item.



Plot 1. Smoothed proportion for selection of items options in the sample

Parallel analysis with related statistics

Parallel analysis based on polychoric correlation matric by psych package (26) showed four factors and three components. The Velicer's MAP test for the first four factors equals 0.053, 0.045, 0.029, and 0.037, confirming the factor structure. Results from the SRMR index for the first four factors are 0.177, 0.111, 0.046, and 0.036, which shows that the three fare enough to explain the items correlation. Finally, the minimum BIC (-89.42) and SABIC (73.39) statistics confirmed the structure of the 3 and 4 factors, respectively.

Exploratory graph analysis (EGA)

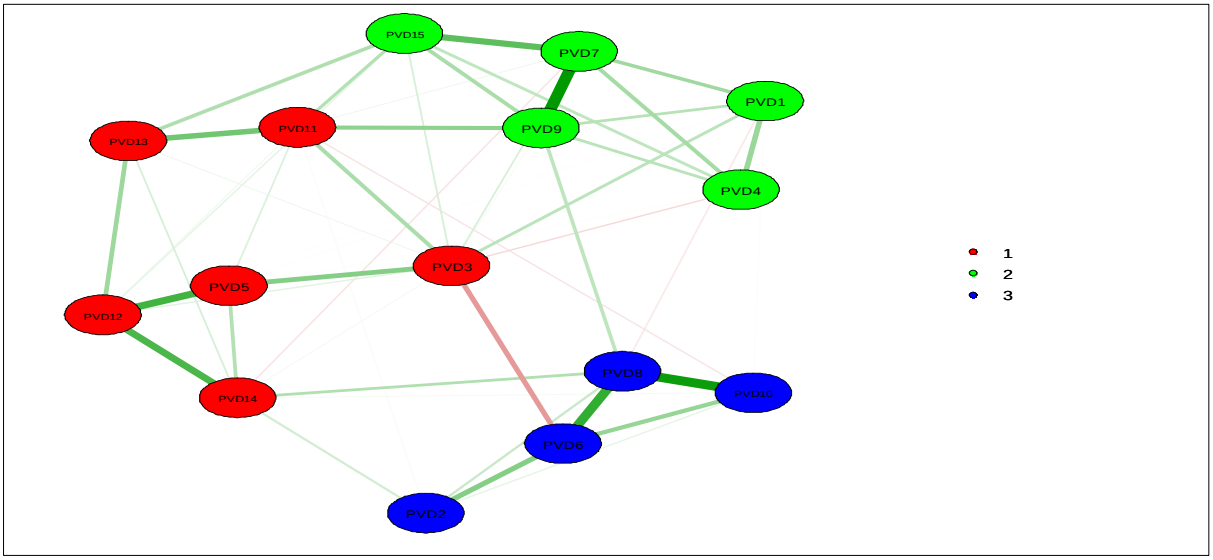
In graph theory, the relation between variables in a data set and their clustering is done by partial correlation (a type of correlation between two variables that eliminates the effects of other variables in a data set from both variables). The estimated partial correlations can be used as a graph in a weighted network structure. In such a graph, each node represents one variable, and each nonzero edge (i.e., the partial correlation or weight) shows that two variables are not independent after controlling the effects of other variables in a data set. When the partial correlation of two variables is zero, no edge is drawn between two nodes (variables), which shows that after controlling the effect of other variables, the two variables in question are independent (32).

Results from EGA by EGAnet package (29) showed that the 3-factor structure is dominant. To check its stability, a parametric bootstrap (based on the observed correlation matrix and with the assumption of multivariate normality of the same number of cases and variables, 1000 samples are generated, and their partial correlation matrix is analyzed) and a nonparametric one (1000 samples are selected from empirical data and analyzed) used. As can be seen (Table 2), approximately in 80 percent of cases, the 3-factor structure was achieved in both methods, which indicated the dominance of the three-factor structure in the data. The four-factor structure was achieved in 21 (parametric) and 17 (nonparametric) percent of cases, indicating low stability of these factor structures. The two and 5-factor structures have a very low percentage of the time so that we can ignore them (Table 1). The patterns of items for 3 clusters (factors) for all EGA methods are shown in Plot 2. Items 3, 5, 11, 12, 13, and 14 were assigned to Cluster One; items 1, 4, 7, 9, and 15 to Cluster Two; and items 2, 6, 8, and 10 to Cluster Three.

Table 2. Percentage of cases in 2 to 5-factor structures are replicated by parametric and nonparametric methods in exploratory graph analysis

Number of factors	Parametric Percent of frequency	Nonparametric Percent of frequency
2	-	0.3
3	79.2	80.8
4	20.7	17.1
5	0.1	1.8

Based on the bootstrap result from the parametric method, the only negative partial correlation is between 3 and 6 items. However, the result from the nonparametric bootstrap shows a negative partial correlation for items 3 with 4, 6, 10 with 11, and 7 with 14. Of course, the biggest negative relation is for item 3 with 4 and 6 items.



Plot 2. Exploratory graph analysis for PVD test data

Exploratory Structural Equation Model (ESEM)

In the ESEM method, which combines EFA and CFA methods, all items are loaded in all factors, and the model fit is evaluated. The ESEM method is appropriate when cross-factor loadings are non-ignorable. The WLSMV estimation method, which is appropriate for ordinal data, was used to implement this method in Mplus. Results from the Chi-square difference test DIFFTEST function in Mplus shows show that the three factors structure has an acceptable goodness of fit to the data (Table 3). Of course, we must note that the structure is complex rather than simple. The CFA section also presents the fit of the 2 and 3 factors structure in Table 2.

Table 3. The goodness of fit indices for a single factor to five factors based on ESEM method

Factor	χ^2	df	P	^{2}(df), p$\chi\Delta$	RMSEA (CI 90%)	CFI	TLI	SRMR
1	1118.564	90	.0001	-	0.176(0.166-0.185)	0.471	0.383	0.152
2	433.618	76	.0001	421.296(14), .0001	0.113(0.102-0.123)	0.816	0.746	0.077
3	101.747	63	.0014	201.854(13), .0001	0.041(0.025-0.055)	0.980	0.967	0.032
4	70.511	51	.0365	29.855(12), .0029	0.032(0.009-0.049)	0.990	0.979	0.025
5	45.674	40	.2481	22.762(11), .0190	0.020(0.001-0.042)	0.997	0.992	0.018

Results of 2 and 3 exploratory factor analyses in Mplus with the WLSMV estimation method for ordinal data are presented in Table 4. The factor rotation was done by the GEOMIN method with an oblique rotation, which is the default in Mplus. The correlation of factors is -0.007. In 2-factor structure and 3-factor structures, the correlation of factor 1 with 2, 1 with 3, and 2 with three are -0.008 ،0.309, and 0.032, respectively, which show low overlaying of factors in both 2 and 3 factors structure. The factor loading of items for two and 3-factor structures are shown in Table 3. In this table, the largest loading of items on factors is bold.

As can be seen, the two and 3-factor structures are not simple. So, besides having a high significant load on one factor, some items also have a low significant load on one or two other factors. In 2-factor structure, items 1, 2, 4, 5, 13, and 14 have a commonality of less than 0.3, and items 1, 3, 12, and 14 have significant loads on two factors. In the 3-factor structure, items 3, 11, and 14 have a significantly lower load on three factors, and items 6, 9, and 13 have a significantly lower load on two factors. Item 2 has the lowest commonality. The only difference between the EGA and EFA methods results is in item 11. While the EGA method puts item 11 on the first cluster (corresponding with the first factor), the EFA method puts this item on the first factor (corresponding with the second cluster). Note that the first cluster corresponds to the 3rd factor, the second cluster to the 1st factor, and the third cluster to the 2nd factor. While based on the maximum factor loading of items on three factors resulting from the EFA method, item grouping of other items is similar for EGA and EFA methods. The fit of the 2 and 3 factors structure to data with the CFA method is instigated in the nest section.

Table 4. Rotated factor loadings with GEOMIN (Oblique) method in 2 and 3-factor structure along with R2 values

Item	2 factors solution			3 factors solution			
	1	2	R^2	1	2	3	R^2
1	0.509*	-0.145*	0.281	0.538*	-0.141*	0.027	0.320
2	0.006	0.486*	0.237	-0.016	0.482*	0.061	0.238
3	0.531*	-0.183*	0.317	0.232*	-0.266*	0.469*	0.405
4	0.449*	0.036	0.203	0.584*	0.071	-0.105	0.318
5	0.494*	0.120	0.258	0.011	-0.011	0.659*	0.439
6	-0.119	0.718*	0.531	0.014	0.742*	-0.128*	0.559
7	0.796*	-0.017	0.634	0.906*	0.011	-0.090	0.778
8	0.038	0.853*	0.729	0.081	0.853*	0.025	0.737
9	0.774*	0.121	0.613	0.835*	0.153*	0.002	0.720
10	-0.074	0.726*	0.534	-0.006	0.735*	-0.040	0.540
11	0.625*	-0.088	0.398	0.454*	-0.135*	0.335*	0.429
12	0.558*	0.261*	0.377	0.019	0.121	0.752*	0.595
13	0.494*	0.078	0.250	0.234*	0.009	0.424*	0.296
14	0.292*	0.402*	0.245	-0.222*	0.326*	0.665*	0.521
15	0.694*	-0.004	0.482	0.693*	-0.006	0.099	0.532

Target rotation is one method of investigating conformity between the researcher's expected factors loading pattern and rotated factor loadings matrix. In this method, the researcher applies his/her knowledge about factor loading patterns to rotate factors. That is, based on theoretical results from the EFA method; the pattern loading matrix rotated such that the loading of items on unrelated factors or factors that the item loading is low but significant tends to zero. Accordingly, items factor loading on factors guides the rotation of the factor loading matrix. The target rotation, which can be done orthogonally or obliquely, has been done for the original factor structure (18), and the two and 3-factor structure results from the EFA method. Hear, with the aim of factor structure simplification, the target rotation with orthogonal type was used. However, there was not much difference in the results of target rotation with oblique and orthogonal types have not much difference. As shown in Table 5, the expected structure is not achieved in any of the cases, and approximately the same structures of Table 3 have been holed. For example, in the original two-factor structure, items 3, 5, 6, 9, 10, 12, and 14 still load significantly on two factors, and items 5 and 15, instead of the first factor, load on the 2nd factor.

Also, in 2 and 3-factor structures from the EFA method, target rotation does not lead to zero low loadings on factors. In what follows, although the fitting tethering of results from different exploratory methods is investigated with CFA, based on results from exploratory methods, the PVDQ test is composed of three factors with a complex structure.

Table 5. Results from target rotation (orthogonal) for original two factors and 2 and 3 factors structure from EFA

Item	2 original factors		2 EFA factors		3 EFA factors		
	1	2	1	2	1	2	3
1	-0.112	0.518*	0.507*	-0.155*	0.542*	-0.142*	0.077
2	0.486*	-0.028	0.012	0.486*	-0.012	0.478*	0.096*
3	-0.149*	0.543*	0.528*	-0.194*	0.328*	-0.285*	0.465*
4	0.064	0.446*	0.450*	0.027	0.558*	0.075	-0.031
5	0.152*	0.484*	0.496*	0.110*	0.142*	-0.039	0.646*
6	0.709*	-0.170*	-0.109*	0.721*	-0.024	0.745*	-0.065
7	0.034	0.796*	0.796*	-0.033	0.882*	0.014	0.017
8	0.853*	-0.022	0.049	0.852*	0.071	0.850*	0.102*
9	0.171*	0.764*	0.776*	0.106*	0.828*	0.152*	0.110*
10	0.720*	-0.126*	-0.065	0.728*	-0.026	0.734*	0.019
11	-0.047	0.629*	0.623*	-0.100	0.520*	-0.149*	0.370*
12	0.296*	0.538*	0.561*	0.249*	0.166*	0.088*	0.748*
13	0.110	0.487*	0.495*	0.068	0.317*	-0.009	0.443*
14	0.419*	0.263*	0.297*	0.396*	-0.094	0.296*	0.651*
15	0.040	0.693*	0.694*	-0.018	0.708*	-0.010	0.176*

Confirmatory Factor Analysis (CFA)

The CFA method fits different exploratory models (Table 5). As can be seen, although the original 2-factor structure (Row named 2OF in Table 5) did not have a good fit to the data, its bi-factor model with two specific factors (named 2OF.Bifactor correspond to the two original factors) had a good fit to the data compared to the second order model (named 2OF.SOF in Table 6). The fitting bi-factor counterpart of different exploratory models (i.e., 2 and 3 factors from EFA and 3 clusters from EGA (named 2EFA and 3EFA and 3EGA in Table 5, respectively) also had a better fit to the data (named 2EFA.Bifactor) compared to the 2 and 3 factors from EFA that formed based on the largest loadings. The last three rows in Table 5 indicated the fitting of the two original factors and 2 and 3 factors from the ESEM method in Target (Orthogonal) rotation (as expected, their fitting values were the same as the results from ESEM in Table 2). Also, fitting the two original factor structures (named ESEM (2OF.TR)) and two factors from EFA (ESEM (2EFA.TR)) based on Target (Orthogonal) rotation were not acceptable. However, the fit of three exploratory factors with Target (Orthogonal) rotation was very good. This showed that appropriate fitting was achieved for three factors with complex structures (cross-factor loading). As can be seen, the fit of the bi-factor model for two original factors (named 2OF.Bifactor in Table 5) and two factors from EFA (named 2EFA.Bifactor) was acceptable, but for both models, their construct reliability (Composite reliability) for general factor in very low (bellow 0.5), which indicate that total score form bi-factor model was not stable enough and cannot be reliable. In addition, only some items had significant positive and negative loads in this factor, while other items' loadings in the genres factor were insignificant. Accordingly, despite the good fit of these two models to the data, their results cannot be interpreted. In addition to the good fit of the model to the data, other aspects of models, such as construct reliability and discrimination validity (AVE indices in Table 5), should be considered. In this research, the reliability of factors in different models was evaluated by omega (33) in addition to the alpha.

Suppose we assume the sum of individual scores of items scale or subscale each weighted one. In that case, omega quantifies part of the variance of these scores, which is explained by a general factor (assessed by all items in the scale) or each of the specific factors (measured by some scale items). Omega values equal to or greater than 0.5 are acceptable, and values equal to 0.7 or 0.75 are good (34-35). Factors with omega less than 0.5 are problematic and should be revised. Omega is a model-based reliability that can be considered an estimation of validity, especially discriminant validity since omega determines the interpretability of the general factor and specific factors and the degree of emphasis on them. Omega does not have problems related to the internal

consistency indices such as alpha, split-half, and KR20. If the alpha assumption is established, it is a kind of omega (36). Evaluation of second level factor reliability was done by Level 1 omega coefficient (show the ratio of total variance of observed scores explained by the second factor), Level 2 omega coefficient (indicate the ratio of total variance of first level factors explained by the second factor) and partial omega coefficient in Level 1 (indicate the ratio of total variance of observed scores explained by the second factor after removing the unique effect of first-order factors) were used (Table 7).

Table 6. Fitting of different exploratory models by CFA and ESEM methods

Model*	χ_r^2	df	CFI	TLI	RMSEA (CI 90%)	SRMR
1F	1385.135	90	0.332	0.221	0.197(0.188-0.206)	0.198
2OF	605.889	89	0.733	0.686	0.125(0.116-0.135)	0.141
2OF.Bifactor	151.217	75	0.961	0.945	0.052(0.040-0.064)	0.066
2OF.SOF	605.437	89	0.733	0.686	0.125(0.116-0.135)	0.141
2EFA	512.109	89	0.782	0.743	0.113(0.104-0.123)	0.118
2EFA.Bifactor	146.450	75	0.963	0.948	0.051(0.038-0.063)	0.069
3EFA and 3EGA	347.620	87	0.866	0.838	0.090(0.080-0.100)	0.105
ESEM(2OF.TR)	433.618	76	0.816	0.746	0.113(0.102-0.123)	0.077
ESEM(2EFA.TR)	433.618	76	0.816	0.746	0.113(0.102-0.123)	0.077
ESEM(3EFA.TR)	101.747	63	0.980	0.967	0.041(0.025-0.055)	0.032
3EFA(items 3 and 14 deleted)	170.429	62	0.94	0.92	0.069(0.057-0.081)	0.076

*analysis was done with MPLUS. 1F: one factor model, 2OF: two original factors, 2OF.Bifactor: bi-factor model for two original factor, 2OF.SOF: second order model for two original factor, 2EFA: two factors explanatory factor analysis, 3EFA and 3EGA: three factors explanatory factor analysis& three factors exploratory graph analysis, ESEM (2OF.TR): exploratory structural equation modeling for two original factors with target rotation, ESEM (2EFA.TR): exploratory structural equation modeling for two factors from exploratory factor analysis with target rotation, ESEM (3EFA.TR): exploratory structural equation modeling for three factors from exploratory factor analysis with target rotation. 3EFA (items 3 and 14 are deleted): three factors from EFA without item 3 and item 14.

Table 7. Omega reliability along with alpha and AVE for the first and second level factors

Models	First level factors				Second level factor			Alpha	AVE
	1th factor	2th factor	3th factor or g	total	1th level	2th level	Partial omega in the first level		
1F	0.391	-	-	-	-	-	-	0.772T	0.249
2OF	0.729	0.553	-	0.607	-	-	-	0.717-0.823-0.772T	0.339-0.404-0.374T
2OF.Bifactor	0.635	0.498	0.218g	0.628	-	-	-	0.717-0.823-0.772BT	0.485T
2OF.SOF	0.729	0.553	-	0.827	0.201	0.245	0.537	0.717-0.823-0.772T	0.339-0.404-0.374T
2EFA	0.590	0.743	-	0.618	-	-	-	0.826-0.756-0.772T	0.362-0.431-0.385T
2EFA.Bifactor	0.559	0.709	0.116g	0.634	-	-	-	0.826-0.756-0.772BT	0.483T
3EFA and 3EGA	0.523	0.768	0.673	0.629	-	-	-	0.831-0.789-0.730-0.772T	0.481-0.509-0.384-0.456T
3EFA (items 3 and 14 are deleted)	0.516	0.768	0.637	0.636				0.831-0.789-0.698-0.756T	0.519-0.509-0.397-0.478T

g: general factor in bi-factor analysis. T: total. 1F: one factor model, 2OF: two original factors, 2OF.Bifactor: bi-factor model for two original factor, 2OF.SOF: second order model for two original factor, 2EFA: two factors explanatory factor analysis, 3EFA and 3EGA: three factors explanatory factor analysis& three factors exploratory graph analysis, ESEM (2OF.TR): exploratory structural equation modeling for two original factors with target rotation, ESEM (2EFA.TR): exploratory structural equation modeling for two factors from exploratory factor analysis with target rotation, ESEM (3EFA.TR): exploratory structural equation modeling for three factors from exploratory factor analysis with target rotation. 3EFA (No 3 and 14): three factors from EFA without items 3 and 14.

Due to the accepted results from the 3-factor model from the ESEM method in terms of fitting, construct reliability (omega), and discriminant validity (AVE), we can conclude that the factor structure of the PVDQ test in the present sample is three factors with complex structure. As we can see from factor loadings of the three factors structure in Table 2, items 3,

11, and 14 have a relation with three factors simultaneously, and items 6, 9, and 13 have a relation to the two factors simultaneously. The fitting of the complex three facts, or significant fitted, a simultaneous load of items 3, 11, and 1a four on three factors is not very desirable. So, items 3 and 14 were deleted, and then the model was fitted to the data investigated by three factors with a simple structure. As the results in Tables 5 (row named 3EFA (items 3 and 14 are deleted) and 6 (named 3EFA (items 3 and 14 are deleted)) show the deletion of items 3 and 14, both the fit of the three-factor model with a simple structure is acceptable. The structure reliability and discover, imminent v, validity (AVE index) were acceptable. Of course, the construct reliability and its discriminant validity were borders.

So, the interpretation of its sores should be done with care. Table 8 shows items of standardized factor loadings on three factors based on the CFA method. The correlation of factor 1 with 2 and 3 and factor 2 with 3 are 0.065, 0.56, and 0.015, respectively. The only significant one was the correlation factor 1 and 3.

Table 8. Factor loadings of 13 remaining items on three factors with their standard errors and Z values from CFA

Item	factor	loading	SE	Z	R^2
PVD1	1	0.538	0.067	8.062	0.289
PVD4	1	0.552	0.049	11.196	0.305
PVD7	1	0.856	0.035	24.162	0.733
PVD9	1	0.847	0.034	25.099	0.717
PVD15	1	0.741	0.044	16.674	0.549
PVD2	2	0.475	0.044	10.706	0.226
PVD6	2	0.731	0.036	20.596	0.535
PVD8	2	0.860	0.026	32.520	0.740
PVD10	2	0.732	0.033	22.488	0.536
PVD5	3	0.549	0.055	9.903	0.302
PVD11	3	0.743	0.055	13.567	0.552
PVD12	3	0.630	0.053	11.933	0.397
PVD13	3	0.580	0.056	10.411	0.336

Discussion

The present study aims to investigate the factor structure of the PVDQ. There was different research about the factor structure of the scale. For example, in a Portuguese sample, Ferreira et al. (24) reported a two-factor analysis comprised of perceived infectability and germ aversion factors with acceptable goodness-of-fit indices. In other Portuguese samples, Martin et al. (37) reported a three-factor structure for PVD. They found that based on Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA), a slight superiority of a three-factor model over the existing two-factor models of the 15-item original PVD.

Also, in four studies, Do Bú et al. (38) adapted and validated the PVD scale for the Brazilian context (PVD-br). Their results confirmed the bifactorial structure. Chiesi et al. (39) investigated the Italian version of PVD. In this research, exploratory factor analysis of the scale supported the two-factor structure of the I-PVDQ and factor loadings loaded appropriately onto Perceived Infectability (PI) and Germ Aversion (GA). Conversely, ÜhandÖzlem and Gökler (40) reported four sub-dimensions: infect, ion perception, reverse-scored, germ avoidance, and reverse-scored in The Turkish version of PVD. Therefore, factor analysis of scale can be different across cultures.

The present study found that the scale has three factors analysis. The first factor includes items 1,4,7,9,11, and 15, called germ aversion, consistent with the original version. The second factor, including items 2, 6, 8, and 10, is termed personal infectability, and the third factor, including items 3, 5, and 12, is called interpersonal infectability. Indeed, in this research, perceived infectability is divided into two components, which include personal and interpersonal infectability. In other words, participants responded to questions based on feelings of personal vulnerability to infection and feelings of vulnerability from social relationships to infection. Although germ aversion and infectability factors are consistent

with the literature, a third factor shows the difference in respondents' perceptions of the importance of transmission in the present study.

Unfortunately, the original version of the scale lacks the fit indices of the factors structure, and only exploratory factor analysis is used for construct validity. As shown before, these two factors do not fit well with the present data. The present study shows that some items have factor loadings on two or three factors simultaneously. Good fitness, reliability, and discernment validity are achieved when items 3 and 14 are eliminated in a simpler factor structure. As shown before, items 3, 11, and 14 load on three factors simultaneously, and items 6, 9, and 13 relate to the two factors simultaneously. In this relation, Díaz, Soriano, and Beleña (21) have also found that the germ aversion factor only achieved enough fitness and reliability if items 11 and 13 were eliminated and the mean of women is more than the mean of men in the perceived infectability factor. Also, Karakulak et al. (41) revealed significant differences across countries in PVD exist.

They found that these differences may stem from genuine variations in PVD or cultural and contextual influences on item interpretation (e.g., "My hands do not feel dirty after touching money": different norms for behaviors may exist across different cultural and temporal contexts) and associated practices. Therefore, it seems that the perception of sustainability, especially in various cultures, can be different in personal and social situations and should be attended to it. The first limitation of this research is data collection during quarantine. Half of the data were completed online, and the other half were collected through a paper-pencil questionnaire. Therefore, people who completed the questionnaires online could not use the questioner's guidance like others. Also, the ratio of women to men in this study was higher in age; most people were under forty. Finally, another limitation of the present study is related to generalizability. Because the data of this study were collected only from 18 to 65-year-old residents of Karaj City, the data obtained from this community cannot be generalized to all age and ethnic groups, and the results should be generalized carefully. Especially considering that there is a lot of ethnic and racial diversity in Iran. To reach more valid and practical results, limitations based on generalizability should be minimized, and research in this area should be done in wider areas and with samples from different and larger communities to ensure the sustainability of the results.

Conclusion

In the present study, we investigated the factor structure of the Perceived Vulnerability to Disease Questionnaire (PVDQ). The results have shown that the three-factor structure for PVDQ has the maximum fitness and justified interpretation. However, more research about gender and cultural differences is needed. This explains that this scale is culture and gender-dependent, and is necessary to pay attention to cultural and gender differences. In addition, the response spectrum needs to be revised because respondents mostly select extreme options rather than middle options.

Although internal consistency, construct reliability, and discrimination validity are acceptable, future research should use greater samples if we want reliable and valid results.

Acknowledgements

Thanks to the participants for their contribution to this study.

Conflict of Interests

The authors declare that they have no conflict of interest to declare.

Funding

The study was done with the personal support of the corresponding author.

Ethical Considerations

The research meets all applicable standards about the ethics of survey research throughout the processes of data collection, data analysis, and reporting. Informed consent was obtained from all participants in the research.

Authors' Contributions

All authors involved in design, data gathering, data analysis, writing and revising the manuscript. The first author more involved in study design and supervising the research process and the corresponding author more contributed in writing and revising the manuscript.

References

1. Karlsson LC, Soveri A, Lewandowsky S, Karlsson L, Karlsson H, Nolvi S, et al. The behavioral immune system and vaccination intentions during the coronavirus pandemic. Pers Individ Dif 2022; 185: 111295.
2. Commodari E. The role of sociodemographic and psychological variables on risk perception of the flu. Sage Open 2017; 7(3): 2158244017718890.
3. Makhanova A, Shepherd MA. Behavioral immune system linked to responses to the threat of COVID-19. Pers Individ Dif 2020; 167: 110221.
4. Shook NJ, Sevi B, Lee J, Oosterhoff B, Fitzgerald HN. Disease avoidance in the time of COVID-19: The behavioral immune system is associated with concern and preventative health behaviors. PLoS ONE 2020; 15(8): e0238015.
5. Lee SY, Yang HJ, Kim G, Cheong HK, Choi BY. Preventive behaviors by the level of perceived infection sensitivity during the Korea outbreak of Middle East Respiratory Syndrome in 2015. Epidemiol Health 2016; 38: e2016051.
6. Brewer NT, Chapman GB, Gibbons FX, Gerrard M, McCaul KD, Weinstein ND. Meta-analysis of the relationship between risk perception and health behavior: the example of vaccination. Health Psychol 2007; 26(2): 136.
7. Wise T, Zbozinek TD, Michelini, G, Hagan CC. Changes in risk perception and protective behavior during the first week of the COVID-19 pandemic in the United States. R Soc Open Sci 2020; 7(9): 200742.
8. Brug J, Aro AR, Oenema A, De Zwart O, Richardus JH, Bishop GD. SARS risk perception, knowledge, precautions, and information sources, the Netherlands. Emerg Infect Dis 2004; 10(8): 1486.
9. Poletti P, Ajelli M, Merler S. Risk perception and effectiveness of uncoordinated behavioral responses in an emerging epidemic. Math Biosci 2012 Aug 1; 238(2): 80-89
10. Cava MA, Fay KE, Beanlands HJ, McCay EA, Wignall R. Risk perception and compliance with quarantine during the SARS outbreak. J Nurs Scholarsh 2005; 37(4): 343-7.
11. Barr M, Raphael B, Taylor M, Stevens G, Jorm L, Giffin M, et al. Pandemic influenza in Australia: Using telephone surveys to measure perceptions of threat and willingness to comply. BMC Infect Dis 2008; 8(1): 1-4.
12. Bults M, Beaujean DJ, de Zwart O, Kok G, van Empelen P, van Steenbergen JE, et al. Perceived risk, anxiety, and behavioural responses of the general public during the early phase of the Influenza A (H1N1) pandemic in the Netherlands: results of three consecutive online surveys. BMC Public Health 2011; 11(1): 1-3.
13. Taglioni F, Cartoux M, Dellagi K, Dalban C, Fianu A, Carrat F, et al. The influenza A (H1N1) pandemic in Reunion Island: Knowledge, perceived risk and precautionary behaviour. BMC Infect Dis 2013; 13(1): 1-2.
14. Zuckerman JN, Hoet B. Hepatitis B immunization in travelers: Poor risk perception and inadequate protection. Travel Med Infect Dis 2008; 6(5): 315-20.
15. Yang XY, Gong RN, Sassine S, Morsa M, Tchogna AS, Drouin O, et al. Risk perception of COVID-19 infection and adherence to preventive measures among adolescents and young adults. Children 2020; 7(12): 311.
16. Hromatko I, Grus A, Kolđeraj G. Do islanders have a more reactive behavioral immune system? Social cognitions and preferred interpersonal distances during the COVID-19 pandemic. Front Psychol 2021; 12: 647586.
17. Aerts C, Revilla M, Duval L, Paaijmans K, Chandrabose J, Cox H, Sicuri E. Understanding the role of disease knowledge and risk perception in shaping preventive behavior for selected vector-borne diseases in Guyana. PLoS Negl Trop Dis 2020; 14(4): e0008149.
18. Duncan LA, Schaller M, Park JH. Perceived vulnerability to disease: Development and validation of a 15-item self-report instrument. Pers Individ Dif 2009; 47(6): 541-6.
19. Ahmadzadeh M, Ghamarani A, Samadi M, Shamsi A, Azizollah A. The investigation of validity and reliability of a scale of perceived vulnerability to disease in Iran. British journal of social sciences 2013; 1(4): 43-51.
20. Fukukawa Y, Oda R, Usami H, Kawahito J. [Development of a Japanese version of the Perceived Vulnerability to Disease Scale]. Shinrigaku Kenkyu 2014; 85(2): 188-95. (Japanese)
21. Díaz A, Soriano JF, Beleña Á. Perceived vulnerability to disease questionnaire: Factor structure, psychometric properties and gender differences. Pers Individ Dif 2016; 101: 42-9.
22. Moradi Motlagh M, Nainian MR, Fata L, Gholami Fesharaki M, Ghaedi G. Investigation of the moderating role of perceived vulnerability to infectious diseases regarding the relationship between disgust and fear of contamination. Avicenna journal of clinical medicine 2019; 26(1): 34-43.
23. Kim KH. The relation among fit indexes, power, and sample size in structural equation modeling. Struct Equ Modeling 2005; 12(3): 368-90.
24. Ferreira J, Magalhães AC, Bem-Haja P, Alho L, Silva CF, Soares SC. Perceived vulnerability to disease questionnaire: Psychometric validation with a Portuguese sample. BMC Psychol 2022; 10(1): 130.
25. Chiesi F, Marunic G, Tagliaferro C, Lau C. The psychometric properties and gender invariance of the Italian version of the Perceived Vulnerability to Disease Questionnaire (I-PVDQ) during the COVID-19 pandemic. BMC Psychol 2022; 10(1): 321.

26. Revelle W. Psych: Procedures for personality and psychological research. Version 1.9. 12. Evanston, Illinois, USA: Northwestern University, 2020.
27. R Core Team. A language and environment for statistical computing (Version 3.5. 2, R Foundation for Statistical Computing, Vienna, Austria, 2018). 2019. Available from: https://www.R-project.org/
28. Reise SP, Bonifay WE, Haviland MG. Scoring and modeling psychological measures in the presence of multidimensionality. J Pers Assess 2013; 95(2): 129-40.
29. Golino H, Christensen AP. EGAnet: Exploratory Graph Analysis: A framework for estimating the number of dimensions in multivariate data using network psychometrics. R Package Version 0.8. 0. 2019. Available from: https://cran.r-project.org/web/packages/EGAnet/EGAnet.pdf
30. Lavaan RY. An R package for structural equation modeling and more. Version 0.5–12 (BETA). J Stat Softw 2012; 48(2): 1-36.
31. Muthén LK, Muthén BO. 1998-2011. Mplus User's Guide. Los Angeles (CA): Muthén and Muthén; 1998.
32. Golino HF, Epskamp S. Exploratory graph analysis: A new approach for estimating the number of dimensions in psychological research. PLoS ONE 2017; 12(6): e0174035.
33. McDonald RP. Test theory: A unified treatment. London: Psychology press; 2013.
34. Hair JF, Black WC, Babin BJ, Anderson RE, Tatham R. Multivariate data analysis. Uppersaddle River.2006.
35. Reise SP. The rediscovery of bifactor measurement models. Multivariate Behav Res 2012; 47(5): 667-96.
36. Watkins MW. The reliability of multidimensional neuropsychological measures: From alpha to omega. Clin Neuropsychol 2017; 31(6-7): 1113-26.
37. Martins AP, Vega-Hernández MC, Soares FR, Afonso RM. Perceived Vulnerability to Disease Scale: Factorial structure, reliability, and validity in times of Portugal's COVID-19 pandemic lockdown. arXiv preprint arXiv 2024: 03108.
38. Do Bú EA, de Alexandre ME, Rezende AT, Bezerra VA. Perceived vulnerability to disease: Adaptation and validation of the PVD-br. Curr Psychol 2023; 42(14): 11745-58.
39. Chiesi F, Marunic G, Tagliaferro C, Lau C. The psychometric properties and gender invariance of the Italian version of the Perceived Vulnerability to Disease Questionnaire (I-PVDQ) during the COVID-19 pandemic. BMC Psychol 2022; 10(1): 321.
40.Ünal E, Özlem A, Gökler ME. Evaluation of the validity and reliability of the Turkish version of the perceived vulnerability to disease scale. Osmangazi Tıp Dergisi 2023; 45(2): 188-97.
41. Karakulak A, Stogianni M, Alonso-Arbiol I, Shukla S, Bender M, Yeung VW, et al. The perceived vulnerability to disease scale: Cross-cultural measurement invariance and associations with fear of COVID-19 across 16 countries. Soc Personal Psychol Compass 2023; 17(11): e1287.