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Brief Communication

Translating measurement into practice with PHQ-9 calculator: an open tool to assess depression levels in the Brazilian population

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Translating measurement into practice with PHQ-9 calculator: an open tool to assess depression levels in the Brazilian population]

Short Title: PHQ-9 Calculator for Assessing Depression

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Abstract

Objective: We aim to create a web-based calculator for assessing depressive symptoms with the Patient Health Questionnaire 9 (PHQ-9), utilizing IRT-based standardized scores, to improve measurement precision, standardization, and practical application in clinical practice.

Methods: This study developed a web-based calculator using a graded response IRT model for assessing depressive symptoms with the PHQ-9, using data from the Brazilian National Health Survey 2019 (n = 90,846, aged 15 to 107 years old, 52.8% female). The tool calculates latent depressive symptoms and converts them into T-scores, with stratification by sex and age groups. The application respects patient confidentiality by deleting sensitive information postcalculation.

Results: Estimated models resulted in a mean sample size of 3244.5 participants in each group (SD: 1066). The calculator can be accessed at <https://mheg.shinyapps.io/phq9-score>.

Discussion: The development of an IRT-based web calculator for the PHQ-9 represents an advancement in depressive symptoms' assessment, offering precision and potential clinical utility. By standardizing scores into a common metric, this tool facilitates the interpretation of depressive symptoms and comparison across different instruments. The study's scope is limited to the Brazilian population and external validity for other contexts is warranted. Future studies should evaluate the clinical validity and the threshold of the tool for predicting real life problems.

Keywords: Common metrics, T-score, item response theory, Pesquisa Nacional de Saúde.

Introduction

Depression is a prevalent mental health condition and a leading cause of disability¹. The Patient Health Questionnaire 9-item version (PHQ-9) was developed with the purpose of screening and following up people with depression in primary care settings². It is a Likert-type scale with items that reflect the nine symptoms of depression according to the Diagnostic and Statistical Manual of Mental Disorders³, inquiring about the frequency of each symptom in the past two weeks⁴. Practitioners have been using sum scores to assess the latent trait, according to Classical Test Theory (CTT), which posits that each item has the same weight to capture the targeted

construct. For instance, suicidal ideation is an item within the PHQ-9 that represents a critical symptom and indicates that a given subject is at a high level of psychological distress. Therefore, the complex nature of mental disorders calls for more nuanced measurement techniques. Furthermore, using sum scores makes it difficult to compare PHQ-9 with other measures of depressive symptoms, which yields the need to translate test results into common metrics, such as using T-scores⁵. Considering that scenario, the Item Response Theory (IRT) emerges as a more suitable assessment approach.

The IRT comprehends a set of models that analyze responses to observed items in order to measure a latent trait or construct⁶. Unlike CTT, which uses sum scores to quantify different levels of the latent trait, IRT focuses on how the probability of responding to individual items distinguishes between individuals with varying trait levels⁷. The trait level can be estimated by using two item properties: thresholds and discrimination. Threshold is related to the probability of an individual to agree with a particular response category. Higher categories (e.g., higher scores on a likert scale) require having a higher level of the latent trait for endorsement. Discrimination, on the other hand, reflects how well an item distinguishes between individuals with different levels of the construct being assessed^{6,7}.

In educational exams, such as ENEM (Exame Nacional do Ensino Médio) in Brazil and SAT (Scholastic Aptitude Test) in USA, IRT is used to ensure fairness and comparability across different test versions. By estimating latent scores, which is a standardized score, those evaluation tools enable scores to be compared across exams, even if they contain different items. This methodology reflects the call for using common metrics in psychiatry and psychology, improving measurement precision and comparability⁵. The use of various instruments with distinct metrics complicates the interpretation of test results, the comparison of disease severity across instruments, and the communication of scores to patients. Converting raw scores (e.g., summed scores) into a common metric, such as the T-score, is a solution to the above-mentioned issues. This solution is particularly useful for assessing non-physical entities, such as those found in mental health assessments, which do not have established forms of measurement⁵. Furthermore, the estimated factor scores can be converted into T-scores, which have been proposed as a common metric for psychological constructs⁵. For instance, a T-score of 70 could be easily interpreted

as two standard deviations above the mean, which corresponds to being at the top 97.5% of the population.

There is a pressing need for automated and reliable tools within healthcare systems to estimate depressive symptoms for both screening and follow-up purposes. An IRT-based scoring approach, which accounts for the relative importance of each depressive symptom, can enhance the accuracy of these assessments. Standardizing these scores with T-scores provides clinicians with a clear understanding of the severity of a patient's symptoms, relative to the general population. This report details the development of an accessible web-based calculator that employs IRT-based standardized scores for the PHQ-9. This tool, designed for use on any internet-enabled device, serves both professionals and the general population by allowing users to compare their depressive symptom levels with data from over 80,000 Brazilians⁸, categorized by age and biological sex.

Therefore, the aim of the current study is to translate theoretical measurement advances into practical, standardized clinical tools and to offer a model for developing similar mental health assessment tools across different contexts, facilitated by making the code open access. While the psychometric properties of the PHQ-9 in the Brazilian population were previously validated in another study⁸, this research focuses on testing IRT-based models stratified by sex and age groups and providing a tool for estimating them. Our hypothesis is that these models will demonstrate good fit across all demographic groups and that it will be a useful asset in clinical practice.

Methods

We used data and analysis described in Damiano et. al. (2023)⁸. The data set comprised the National Health Survey (*Pesquisa Nacional de Saúde – 2019*, PNS-2019), a large representative Brazilian survey (90,846 participants with complete PHQ-9 data, aged 15 to 107 years old, 52.8% female) co-designed with the Brazilian Institute of Geography and Statistics (IBGE, a governmental agency). Confidentiality of personal data was maintained throughout the original study and informed consent was obtained for all participants. The PNS-2019 project was reviewed and approved by the National Research Ethics Committee/National Health Council, under Opinion No. 3.529.376⁹. For more details on sampling and data description, see Stopa et. al. (2020)⁹ and for psychometric analysis see Damiano et. al. (2023)⁸.

The PHQ-9 is a widely used, validated questionnaire designed to assess depressive severity. It comprises nine items reflecting core symptoms of depression, with respondents indicating the frequency of each symptom over the past two weeks. Examples of items include "Little interest or pleasure in doing things" and "Feeling down, depressed, or hopeless" ². Previous works validated the questionnaire in the Brazilian population¹⁰, as well as tested its reliability, score distribution and sex and age scalar invariance ⁸.

Although PHQ-9 scores are generally comparable across sex and age groups ⁸, research indicates that the expression and severity of depressive symptoms can vary across the lifespan¹¹ and sex ¹². Therefore, to better capture these nuances and provide more precise estimates, we opted to stratify the analysis by sex and age groups (15-19; 20-24; 25-29; 30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60-64; 65-69; 70-74; 75-79; 80+). First, we conducted confirmatory factor analysis (CFA) to evaluate and ensure a good fit across all demographic groups. Second, IRT models (using the expected a-posteriori method) were estimated for each group, from which discrimination and threshold parameters were used to estimate individual latent scores without the need to access the original data. IRT parameters were estimated using the 'mirt' package¹³. After estimating the parameters, we used the `generate.mirt_object()` function from the 'mirtCAT' package ¹⁴ to create models able to estimate latent scores using only IRT parameters with the 'mirt' function `fscores()`, without requiring sensitive data.

After estimating the 28 models and extracting their parameters, we developed an user-friendly web application made with the R package 'shiny' ¹⁵, designed to make the IRT-based assessment accessible to clinicians. This web-app inputs user responses and, using the above-mentioned IRT model parameters, calculates an individualized latent depression score. Latent scores are then converted to T-scores to facilitate interpretation, providing clinicians with an immediate and accurate measure of patient depressive symptoms. To uphold user confidentiality, we incorporated an algorithm that automatically deletes user information (name, age, sex, e-mail, etc.) after score calculation. This ensures that sensitive information is only accessible to the recipients intended by the patient. App and analysis code can be found at https://osf.io/xfmjh/?view_only=347d5b72bdf346af962fa53b565764cd.

All analyses and scoring methods were conducted with R version 4.3.1. We utilized the 'mirt'¹³ and 'mirtCAT'¹⁴ packages for IRT analysis, and the 'shiny'¹⁵ package was employed for developing the web application.

Results

The 28 estimated models (14 age groups for each sex) resulted in a mean sample size of 3244.5 participants in each group (SD: 1066). Tables S1-S28 describe the IRT parameters and model structure for the 28 models used in the calculator. All models fitted the data well (Table S29).

Based on these parameters, we constructed the application that can be accessed at <https://mhcg.shinyapps.io/phq9-score> (Fig 1).

PHQ-9

Depression Level Calculator Based on the Brazilian Standards of 2019

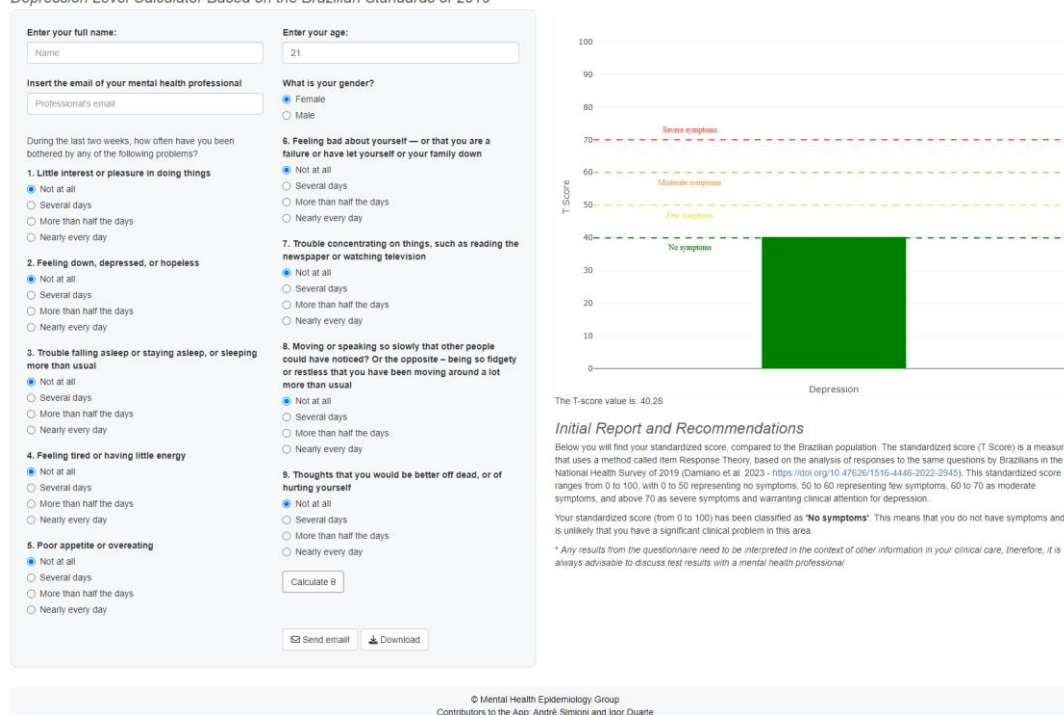


Fig 1. PHQ-9 shiny application screenshot.

Discussion

In this communication, we addressed three key challenges in current mental health care settings: we 1) enhanced the precision of depression measurement by employing IRT, 2) applied a common metric (T-score) to a widely used scale for assessing depressive symptoms (PHQ-9) and 3) developed a free, user-friendly tool

that eliminates the need for complex calculations to generate precise measurements of depressive symptomatology.

The development of this IRT-based tool represents an important step for mental health assessment. It is easy to use and quantifies depressive symptoms at the latent trait level using a standardized metric that reflects the population distribution. This makes it a valuable resource for clinicians, who can ask patients to complete the questionnaire and receive the results in any pointed email. The results are based on the distribution of the depression latent trait in the Brazilian population, but external validity for other contexts remains to be explored. Nevertheless, the open-access code enables replication of this calculator in other settings, provided that IRT parameters specific to the PHQ-9 items are incorporated.

Our tool allows for the calculation of T-scores from PHQ-9 responses, situating individuals on the population distribution of depressive symptom severity. Based on prior work by Damiano et al. (2023), a PHQ-9 summed score of 10 corresponds approximately to a T-score of 63.78, which is commonly used as a cutoff for moderate depressive symptoms and depression screening ². Similarly, a PHQ-9 score of 16, corresponding to a T-score of 70.88, aligns with the 98th percentile of the population and represents severe depressive symptoms in the PROMIS framework ¹⁶. These thresholds can serve as reference points for identifying potential concern levels in depressive symptom severity.

An important limitation to consider is that the T-score metric is not a fixed measure. It relies on the reference population used, whose depression levels may fluctuate over time. Therefore, as the measurement properties of the PHQ-9 evolve due to changes in symptom prevalence or other population-level factors, recalibration of T-score norms will be necessary. Another limitation is that, even though the use of standardized metrics like the T-score is desirable for improving comparability and interpretability ^{5,16}, it does not resolve all measurement issues. For instance, T-scores from different instruments may not be directly comparable if they measure different symptoms, even within the same construct.

Although our findings are promising and the developed technology can be used in different contexts, it is important to note that the calculator itself is not a validated diagnostic screening tool for predicting specific outcomes, such as suicide or hospitalization. Rather, it offers insights into where an individual falls within the

population distribution of depressive symptoms. Future research should focus on validating cutoffs such as those proposed by PROMIS¹⁶ against structured interviews or other clinical outcomes to establish predictive validity. Additionally, studies could assess the tool's performance in multidimensional models that evaluate comorbid conditions, such as anxiety and externalizing spectrum disorders. Nonetheless, this free tool can be used in the Brazilian context, offering a standardized method to determine an individual's level of depressive symptoms using a widely recommended scale¹⁷. Furthermore, the tool's open-access design ensures that it can be updated and adapted for specific populations, as the IRT parameters for the PHQ-9 are readily available.

Data sharing statements

Data is accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>. Application source code can be found at https://osf.io/xfmjh/?view_only=347d5b72bdf346af962fa53b565764cd. Study design and ethical details can be found elsewhere⁸.

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Supplementary Materials

Table S1 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 15-19 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	2.260	0.844	1.938	2.443
Feeling down, depressed, or hopeless	2.864	1.159	1.949	2.447
Trouble falling or staying asleep, or sleeping too much	1.696	1.324	2.182	2.598
Feeling tired or having little energy	2.068	0.887	1.915	2.360
Poor appetite or overeating	1.544	1.479	2.413	2.975
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.649	1.310	2.047	2.485
Trouble concentrating on things, such as reading the newspaper or watching television	2.147	1.025	1.922	2.452
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	1.719	1.606	2.482	3.114
Thoughts that you would be better off dead, or of hurting yourself	2.069	2.394	2.871	3.305

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S2 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 15-19 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	2.412	0.340	1.286	1.736
Feeling down, depressed, or hopeless	3.293	0.506	1.257	1.788
Trouble falling or staying asleep, or sleeping too much	1.752	0.711	1.536	2.004
Feeling tired or having little energy	1.990	0.319	1.335	1.914
Poor appetite or overeating	1.819	0.652	1.386	1.978
Feeling bad about yourself or that you are a failure or have let yourself or your family down	3.244	0.720	1.279	1.820
Trouble concentrating on things, such as reading the newspaper or watching television	2.172	0.598	1.461	2.036
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.161	1.039	1.698	2.268
Thoughts that you would be better off dead, or of hurting yourself	2.463	1.498	2.073	2.527

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S3 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 20-24 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	2.567	0.844	1.849	2.246
Feeling down, depressed, or hopeless	2.951	1.075	1.935	2.335
Trouble falling or staying asleep, or sleeping too much	1.816	1.032	1.870	2.271
Feeling tired or having little energy	2.068	0.727	1.745	2.293
Poor appetite or overeating	1.564	1.355	2.230	2.769
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.670	1.300	2.045	2.386
Trouble concentrating on things, such as reading the newspaper or watching television	2.383	1.029	1.904	2.383
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.027	1.487	2.237	2.743
Thoughts that you would be better off dead, or of hurting yourself	2.073	2.463	3.010	3.415

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S4 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 20-24 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	2.328	0.442	1.431	1.848
Feeling down, depressed, or hopeless	2.980	0.518	1.353	1.803
Trouble falling or staying asleep, or sleeping too much	1.743	0.634	1.528	1.909
Feeling tired or having little energy	2.092	0.236	1.247	1.677
Poor appetite or overeating	1.743	0.692	1.535	2.024
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.668	0.821	1.496	1.925
Trouble concentrating on things, such as reading the newspaper or watching television	2.325	0.780	1.587	2.101
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	1.762	1.204	2.035	2.609
Thoughts that you would be better off dead, or of hurting yourself	2.302	1.736	2.336	2.763

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S5 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 25-29 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	2.710	0.916	1.926	2.376
Feeling down, depressed, or hopeless	3.355	1.086	1.881	2.330
Trouble falling or staying asleep, or sleeping too much	1.616	1.097	1.914	2.301
Feeling tired or having little energy	2.003	0.706	1.784	2.236
Poor appetite or overeating	1.857	1.393	2.149	2.702
Feeling bad about yourself or that you are a failure or have let yourself or your family down	3.265	1.321	2.023	2.440
Trouble concentrating on things, such as reading the newspaper or watching television	2.413	1.177	2.068	2.575
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	1.897	1.617	2.417	2.910
Thoughts that you would be better off dead, or of hurting yourself	2.558	2.261	2.885	3.265

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S6 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 25-29 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	2.781	0.432	1.364	1.773
Feeling down, depressed, or hopeless	2.902	0.568	1.412	1.857
Trouble falling or staying asleep, or sleeping too much	1.766	0.569	1.365	1.746
Feeling tired or having little energy	2.179	0.234	1.178	1.617
Poor appetite or overeating	1.927	0.756	1.478	2.021
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.627	0.928	1.622	2.044
Trouble concentrating on things, such as reading the newspaper or watching television	2.533	0.774	1.585	2.065
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.173	1.042	1.745	2.217
Thoughts that you would be better off dead, or of hurting yourself	2.065	1.977	2.577	2.991

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S7 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 30-34 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.022	0.933	1.856	2.237
Feeling down, depressed, or hopeless	2.707	1.124	1.976	2.425
Trouble falling or staying asleep, or sleeping too much	1.700	0.957	1.838	2.267
Feeling tired or having little energy	2.154	0.647	1.698	2.114
Poor appetite or overeating	1.756	1.438	2.292	2.847
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.630	1.448	2.174	2.563
Trouble concentrating on things, such as reading the newspaper or watching television	2.748	1.154	1.964	2.372
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.043	1.540	2.342	2.823
Thoughts that you would be better off dead, or of hurting yourself	2.290	2.455	3.053	3.427

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S8 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 30-34 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	2.762	0.459	1.410	1.799
Feeling down, depressed, or hopeless	3.057	0.543	1.355	1.814
Trouble falling or staying asleep, or sleeping too much	1.738	0.503	1.348	1.722
Feeling tired or having little energy	2.161	0.182	1.140	1.576
Poor appetite or overeating	1.915	0.805	1.537	2.072
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.718	0.951	1.651	2.084
Trouble concentrating on things, such as reading the newspaper or watching television	2.576	0.791	1.601	2.070
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.118	1.046	1.723	2.263
Thoughts that you would be better off dead, or of hurting yourself	2.242	2.016	2.580	3.008

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S9 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 35-39 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.055	0.985	1.943	2.390
Feeling down, depressed, or hopeless	2.946	1.093	1.942	2.481
Trouble falling or staying asleep, or sleeping too much	1.725	0.915	1.788	2.151
Feeling tired or having little energy	2.053	0.722	1.779	2.235
Poor appetite or overeating	2.014	1.496	2.248	2.691
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.817	1.461	2.127	2.560
Trouble concentrating on things, such as reading the newspaper or watching television	2.675	1.188	2.053	2.518
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.180	1.550	2.306	2.767
Thoughts that you would be better off dead, or of hurting yourself	2.212	2.532	3.237	3.899

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S10 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 35-39 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	2.949	0.433	1.331	1.781
Feeling down, depressed, or hopeless	2.925	0.475	1.330	1.765
Trouble falling or staying asleep, or sleeping too much	1.670	0.453	1.267	1.654
Feeling tired or having little energy	2.210	0.158	1.116	1.517
Poor appetite or overeating	1.922	0.829	1.597	2.096
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.773	0.912	1.574	1.993
Trouble concentrating on things, such as reading the newspaper or watching television	2.616	0.769	1.583	2.037
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.354	0.932	1.604	2.069
Thoughts that you would be better off dead, or of hurting yourself	2.040	1.969	2.553	2.988

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S11 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 40-44 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.175	0.945	1.796	2.206
Feeling down, depressed, or hopeless	3.121	1.019	1.803	2.198
Trouble falling or staying asleep, or sleeping too much	1.822	0.771	1.539	1.905
Feeling tired or having little energy	2.080	0.662	1.674	2.146
Poor appetite or overeating	1.950	1.482	2.202	2.614
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.876	1.334	2.021	2.463
Trouble concentrating on things, such as reading the newspaper or watching television	2.895	1.171	1.933	2.313
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.392	1.385	2.058	2.455
Thoughts that you would be better off dead, or of hurting yourself	2.351	2.374	2.972	3.496

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S12 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 40-44 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	2.789	0.395	1.311	1.749
Feeling down, depressed, or hopeless	2.984	0.427	1.263	1.709
Trouble falling or staying asleep, or sleeping too much	1.603	0.320	1.155	1.586
Feeling tired or having little energy	2.167	0.084	1.069	1.516
Poor appetite or overeating	1.859	0.852	1.559	2.094
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.756	0.889	1.556	1.983
Trouble concentrating on things, such as reading the newspaper or watching television	2.578	0.727	1.522	1.959
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.142	0.883	1.627	2.145
Thoughts that you would be better off dead, or of hurting yourself	2.071	1.978	2.571	2.918

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S13 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 45-49 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.227	0.969	1.768	2.172
Feeling down, depressed, or hopeless	2.854	1.042	1.833	2.233
Trouble falling or staying asleep, or sleeping too much	1.732	0.735	1.593	1.973
Feeling tired or having little energy	2.166	0.677	1.685	2.102
Poor appetite or overeating	2.017	1.429	2.132	2.611
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.598	1.435	2.152	2.603
Trouble concentrating on things, such as reading the newspaper or watching television	3.143	1.167	1.927	2.332
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.251	1.393	2.134	2.564
Thoughts that you would be better off dead, or of hurting yourself	2.277	2.341	2.917	3.351

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S14 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 45-49 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	2.831	0.399	1.307	1.718
Feeling down, depressed, or hopeless	2.901	0.373	1.184	1.637
Trouble falling or staying asleep, or sleeping too much	1.589	0.234	1.063	1.451
Feeling tired or having little energy	2.271	0.066	1.004	1.470
Poor appetite or overeating	1.937	0.811	1.550	2.102
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.843	0.869	1.516	1.924
Trouble concentrating on things, such as reading the newspaper or watching television	2.579	0.751	1.541	2.006
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.327	0.858	1.565	2.026
Thoughts that you would be better off dead, or of hurting yourself	2.160	1.834	2.477	2.869

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, Cadernos de Saúde Pública, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from "Pesquisa Nacional de Saúde - 2019", accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S15 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 50-54 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.154	0.894	1.721	2.135
Feeling down, depressed, or hopeless	2.888	0.939	1.826	2.277
Trouble falling or staying asleep, or sleeping too much	1.732	0.735	1.511	1.897
Feeling tired or having little energy	2.291	0.620	1.558	2.095
Poor appetite or overeating	1.976	1.446	2.222	2.688
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.764	1.360	2.082	2.433
Trouble concentrating on things, such as reading the newspaper or watching television	3.051	1.149	1.901	2.314
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.543	1.282	2.024	2.407
Thoughts that you would be better off dead, or of hurting yourself	2.516	2.248	2.738	3.033

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S16 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 50-54 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.085	0.401	1.247	1.621
Feeling down, depressed, or hopeless	2.894	0.417	1.220	1.659
Trouble falling or staying asleep, or sleeping too much	1.661	0.110	0.882	1.293
Feeling tired or having little energy	2.255	0.075	1.031	1.466
Poor appetite or overeating	1.712	0.892	1.649	2.231
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.541	0.962	1.626	2.105
Trouble concentrating on things, such as reading the newspaper or watching television	2.645	0.745	1.467	1.890
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.217	0.881	1.597	2.127
Thoughts that you would be better off dead, or of hurting yourself	2.161	1.940	2.428	2.907

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S17 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 55-59 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.065	0.959	1.807	2.172
Feeling down, depressed, or hopeless	3.138	0.926	1.721	2.105
Trouble falling or staying asleep, or sleeping too much	1.644	0.677	1.418	1.788
Feeling tired or having little energy	2.137	0.694	1.614	2.029
Poor appetite or overeating	1.673	1.603	2.441	2.944
Feeling bad about yourself or that you are a failure or have let yourself or your family down	3.072	1.318	2.045	2.370
Trouble concentrating on things, such as reading the newspaper or watching television	2.555	1.283	2.026	2.425
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.231	1.342	2.090	2.501
Thoughts that you would be better off dead, or of hurting yourself	2.242	2.331	2.901	3.301

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S18 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 55-59 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.063	0.391	1.189	1.646
Feeling down, depressed, or hopeless	3.222	0.366	1.158	1.550
Trouble falling or staying asleep, or sleeping too much	1.501	0.006	0.870	1.296
Feeling tired or having little energy	2.469	0.136	1.012	1.438
Poor appetite or overeating	1.824	0.890	1.620	2.133
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.925	0.949	1.521	1.896
Trouble concentrating on things, such as reading the newspaper or watching television	2.854	0.731	1.387	1.851
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.465	0.829	1.485	1.962
Thoughts that you would be better off dead, or of hurting yourself	2.161	1.907	2.465	2.954

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S19 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 60-64 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.067	1.023	1.763	2.178
Feeling down, depressed, or hopeless	3.247	1.024	1.700	2.124
Trouble falling or staying asleep, or sleeping too much	1.575	0.768	1.493	1.938
Feeling tired or having little energy	2.376	0.829	1.632	2.095
Poor appetite or overeating	1.873	1.557	2.243	2.729
Feeling bad about yourself or that you are a failure or have let yourself or your family down	3.250	1.392	2.030	2.427
Trouble concentrating on things, such as reading the newspaper or watching television	2.709	1.284	1.931	2.319
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.406	1.391	2.084	2.479
Thoughts that you would be better off dead, or of hurting yourself	2.717	2.276	2.749	3.087

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S20 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 60-64 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.341	0.477	1.301	1.727
Feeling down, depressed, or hopeless	2.920	0.472	1.297	1.754
Trouble falling or staying asleep, or sleeping too much	1.403	0.083	0.998	1.475
Feeling tired or having little energy	2.506	0.272	1.196	1.644
Poor appetite or overeating	1.636	1.094	1.892	2.478
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.545	1.083	1.789	2.229
Trouble concentrating on things, such as reading the newspaper or watching television	2.617	0.882	1.632	2.056
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.133	1.051	1.777	2.289
Thoughts that you would be better off dead, or of hurting yourself	1.995	2.138	2.721	3.229

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S21 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 65-69 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.405	1.021	1.759	2.183
Feeling down, depressed, or hopeless	2.962	1.087	1.815	2.210
Trouble falling or staying asleep, or sleeping too much	1.465	0.732	1.508	1.993
Feeling tired or having little energy	2.419	0.810	1.697	2.073
Poor appetite or overeating	1.688	1.558	2.249	2.764
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.762	1.572	2.239	2.579
Trouble concentrating on things, such as reading the newspaper or watching television	2.791	1.336	2.031	2.479
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.484	1.371	2.069	2.466
Thoughts that you would be better off dead, or of hurting yourself	2.555	2.247	2.836	3.224

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from "Pesquisa Nacional de Saúde - 2019", accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S22 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 65-69 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	2.935	0.534	1.442	1.883
Feeling down, depressed, or hopeless	2.854	0.487	1.306	1.719
Trouble falling or staying asleep, or sleeping too much	1.267	0.090	1.039	1.519
Feeling tired or having little energy	2.260	0.270	1.251	1.680
Poor appetite or overeating	1.545	1.098	1.894	2.475
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.515	1.173	1.856	2.346
Trouble concentrating on things, such as reading the newspaper or watching television	2.366	0.953	1.709	2.149
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.154	1.066	1.775	2.243
Thoughts that you would be better off dead, or of hurting yourself	2.266	2.030	2.496	2.897

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S23 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 70-74 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.060	1.052	1.899	2.252
Feeling down, depressed, or hopeless	2.838	1.100	1.911	2.346
Trouble falling or staying asleep, or sleeping too much	1.207	0.847	1.780	2.181
Feeling tired or having little energy	2.195	0.908	1.741	2.153
Poor appetite or overeating	1.542	1.722	2.603	3.185
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.899	1.586	2.339	2.665
Trouble concentrating on things, such as reading the newspaper or watching television	2.530	1.390	2.123	2.580
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.091	1.502	2.342	2.788
Thoughts that you would be better off dead, or of hurting yourself	2.869	2.226	2.824	3.092

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from "Pesquisa Nacional de Saúde - 2019", accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S24 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 70-74 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.012	0.572	1.407	1.832
Feeling down, depressed, or hopeless	2.799	0.533	1.338	1.762
Trouble falling or staying asleep, or sleeping too much	1.185	0.096	1.052	1.618
Feeling tired or having little energy	2.456	0.275	1.213	1.688
Poor appetite or overeating	1.532	0.967	1.816	2.458
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.582	1.227	1.845	2.198
Trouble concentrating on things, such as reading the newspaper or watching television	2.329	1.059	1.809	2.220
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.148	1.094	1.841	2.281
Thoughts that you would be better off dead, or of hurting yourself	2.121	2.169	2.729	3.101

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S25 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals between 75-79 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.135	0.987	1.759	2.074
Feeling down, depressed, or hopeless	2.982	1.001	1.734	2.121
Trouble falling or staying asleep, or sleeping too much	1.297	0.677	1.457	1.866
Feeling tired or having little energy	2.595	0.710	1.615	2.068
Poor appetite or overeating	1.935	1.335	2.040	2.491
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.866	1.483	2.194	2.657
Trouble concentrating on things, such as reading the newspaper or watching television	2.461	1.252	1.960	2.274
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.288	1.212	1.913	2.315
Thoughts that you would be better off dead, or of hurting yourself	2.377	2.306	2.856	3.192

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S26 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals between 75-79 years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.013	0.617	1.395	1.796
Feeling down, depressed, or hopeless	2.340	0.559	1.462	1.927
Trouble falling or staying asleep, or sleeping too much	1.271	-0.025	0.938	1.419
Feeling tired or having little energy	2.133	0.382	1.212	1.708
Poor appetite or overeating	1.470	0.962	1.800	2.397
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.345	1.301	1.994	2.326
Trouble concentrating on things, such as reading the newspaper or watching television	2.227	0.966	1.697	2.126
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	1.934	1.111	1.886	2.367
Thoughts that you would be better off dead, or of hurting yourself	1.839	2.253	2.937	3.246

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S27 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for male individuals with 80+ years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	2.637	1.042	1.699	2.119
Feeling down, depressed, or hopeless	2.303	1.078	1.755	2.155
Trouble falling or staying asleep, or sleeping too much	1.187	0.704	1.436	1.830
Feeling tired or having little energy	2.107	0.730	1.577	2.009
Poor appetite or overeating	1.498	1.327	2.122	2.632
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.111	1.831	2.573	2.861
Trouble concentrating on things, such as reading the newspaper or watching television	2.242	1.157	1.757	2.183
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.123	1.073	1.730	2.029
Thoughts that you would be better off dead, or of hurting yourself	1.810	2.656	3.295	3.816

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A Patella and A. Matijasevich, 2013, Cadernos de Saúde Pública, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from "Pesquisa Nacional de Saúde - 2019", accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S28 - Patient Health Questionnaire 9 (PHQ-9) item response theory parameters for female individuals with 80+ years

PHQ-9 Item	α (item discrimination)	β (item difficulty)		
		Not at all \geq several days	Several days \geq more than half of the days	More than half of the days \geq nearly every day
Little interest or pleasure in doing things	3.173	0.577	1.258	1.616
Feeling down, depressed, or hopeless	2.180	0.603	1.468	1.939
Trouble falling or staying asleep, or sleeping too much	1.181	0.057	0.885	1.468
Feeling tired or having little energy	2.304	0.359	1.176	1.605
Poor appetite or overeating	1.506	0.857	1.645	2.196
Feeling bad about yourself or that you are a failure or have let yourself or your family down	2.071	1.430	2.137	2.576
Trouble concentrating on things, such as reading the newspaper or watching television	2.536	0.800	1.423	1.753
Moving or speaking so slowly that other people could have noticed. Or the opposite being so fidgety or restless that you have been moving around a lot more than usual	2.057	0.849	1.493	1.889
Thoughts that you would be better off dead, or of hurting yourself	1.515	2.557	3.301	3.716

Note: PHQ-9 is from “Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral” by I.S. Santos, B.F. Tavares, T.N. Munhoz, L.S.P. de Almeida, N.T.B. da Silva, B.D. Tams, M.A. Patella and A. Matijasevich, 2013, *Cadernos de Saúde Pública*, 29(8), 1533–1543 (<https://doi.org/10.1590/0102-311X00144612>) CC BY-NC. Data from “Pesquisa Nacional de Saúde - 2019”, accessible at <https://www.ibge.gov.br/estatisticas/sociais/saude/9160-pesquisa-nacional-de-saude.html>.

Table S29 - CFA fit indices

Age Group	SRMR	RMSEA	CFI	TLI	ω
15-19 Male	0.072	0.062	0.984	0.978	0.856
15-19 Female	0.066	0.080	0.989	0.985	0.909
20-24 Male	0.070	0.061	0.987	0.983	0.870
20-24 Female	0.066	0.077	0.986	0.982	0.891
25-29 Male	0.073	0.063	0.987	0.983	0.873
25-29 Female	0.066	0.079	0.988	0.984	0.906
30-34 Male	0.069	0.060	0.988	0.984	0.879
30-34 Female	0.062	0.075	0.989	0.985	0.903
35-39 Male	0.069	0.061	0.988	0.985	0.880
35-39 Female	0.055	0.070	0.991	0.988	0.904
40-44 Male	0.053	0.052	0.993	0.991	0.885
40-44 Female	0.060	0.072	0.990	0.987	0.901
45-49 Male	0.062	0.059	0.991	0.988	0.888
45-49 Female	0.047	0.061	0.994	0.992	0.902
50-54 Male	0.052	0.052	0.993	0.991	0.889
50-54 Female	0.055	0.067	0.992	0.989	0.899
55-59 Male	0.051	0.048	0.993	0.991	0.871
55-59 Female	0.039	0.054	0.996	0.994	0.902
60-64 Male	0.043	0.041	0.996	0.994	0.883
60-64 Female	0.047	0.050	0.995	0.993	0.884
65-69 Male	0.053	0.047	0.994	0.992	0.872
65-69 Female	0.049	0.052	0.993	0.991	0.868
70-74 Male	0.059	0.048	0.991	0.989	0.844
70-74 Female	0.053	0.056	0.992	0.989	0.867
75-79 Male	0.058	0.047	0.994	0.992	0.866
75-79 Female	0.058	0.059	0.989	0.985	0.855
80+ Male	0.064	0.053	0.987	0.982	0.830
80 + Female	0.066	0.066	0.987	0.983	0.863

Note: SRMR: Standardized root mean square residuals; RMSEA, Root Mean Square Error of Approximation; CFI, Comparative Fit Index; TLI, Tucker-Lewis Index; ω , Lucke's reliability ω from "Lucke JF. The α and the ω of congeneric test theory: An extension of reliability and internal consistency to heterogeneous tests. *Applied Psychological Measurement*. 2005 Jan;29(1):65-81."