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Title: Further validation of psychometric evaluation of the modified Kessler seven-item questionnaire (K7) for measuring psychological distress in rural Bangladesh. A cross-sectional study

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Abstract

Objectives This investigation expected to approve the psychometric properties of the modified 7-items Kessler psychological distress scale (K7) for measuring psychological distress in rural Bangladesh.

Design Cross-sctional study.

Setting Narail district, Bangladesh.

Participants A random sample of 300 adults of age 18–90 years was recruited in July-August 2018 using mobile data collection tools (CommCare)

Outcome measure Validation of the K7 was the major outcome. Sociodemographic factors were measured to assess for DIF adjustment. Rasch analysis was carried out for further validation of the modified K7 version was applied among different cohort for potential use in clinical settings. SPSS25 and RUMM2030 was used for analyses.

Results: Results showed good overall fit, as indicated by a non-significant item-trait interaction ($\chi 2$ = 44.54, df = 28, p =0.0245). Both item fit (mean = 0.30, SD = 1.22) and person fit residual values (mean = –0.18, SD = 0.85) showed perfect fit, as indicated with their SD values less than the recommended value 1.4. Reliability was very good as indicated by a person separation index (PSI) = 0.85 and Cronbach's Alpha (CA) = 0.89. All individual items were ordered thresholds, and showed perfect fit. The K7 showed adequate internal consistency, reliability, unidimensionality and free from local dependency. The K7 also showed similar functioning for different age, sex, educational attainment and socio-economic conditions.

Conclusions: Further validation of K7 in different population confirmed that the tool is psychometrically robust and suitable for routine measure of psychological distress and thus provides an effective screening instrument among the rural Bangladeshi population. Research should seek to continually apply the K7 in

different clinical settings in Bangladesh to determine a valid cutoff score for assessment of the severity of psychological distress. The K7 tool can be tested in other developing countries where socio-demographic characteristics are similar to those in Bangladesh.

Keywords: Kessler psychological distress scale, Rasch analysis, Validation, Rural Bangladesh

Strengths and limitations of this study

- This study provides the first reliable data on the Kessler K7 questionnaire from a general population of a typical rural district in Bangladesh.
- This study used primary data on K7 and associated covariates.
- The data were collected through face-to-face interviews of people from a typical rural district that represents Bangladesh using mobile data collection tool CommCare.
- The sophisticated Rasch analysis technique was applied to validate the K7. The study provides a unique opportunity to assess psychological distress in a rural population of Bangladesh.
- The potential drawback of this study is that it is based on a single-occasion collection of data from a rural district in Bangladesh. While we have attempted to check the situation of our previously validated model whether the K7 perfectly match all the assumption of Rasch properties. Moreover, the study needs to be repeated in a random sample of the clinical setting in different rural districts to be truly representative of the national population.

Background

Globally, one out of four individuals is influenced by mental or psychological distress at some point in their lives [1]. Almost 66% of the individuals with psychological distress never look for assistance because they were unaware of, or neglect their disorder [2]. Due to a rapid growth of psychiatric disorders, there is a need to identify the conditions quickly and in a cost-effective manner [3]. Early diagnosis of psychological distress has been seen as an essential measure to guarantee successful and focused onto ensure effective and targeted intervention among patients with psychological distress [4]. In recent years, the researchers are interested for early diagnosis of psychological distress using tools with less number of items for measuring psychological distress among the general population [5]. Therefore, the development and continued validation of the tools used for measuring psychological distress are critical, especially for early detection of psychological instability.

Over the last three decades, various tools have been used to measure psychological distress [6-8]. However, their extensive list of items was limited to the use of a powerful tool targeted at the general population. The Kessler 10-item questionnaire (K10) is an exception that was developed by Professors' Kessler and Mroczek in 1992, to be utilised in the United States National Health Interview Survey as a brief measure of non-explicit psychological distress along the anxiety-depression spectrum [9]. The K10 includes ten items (evaluated on five-point Likert-type scales, where 1 = none of the time to 5 = all of the time) dedicated to measuring psychological distress. Kessler 10 items questionnaire is not a diagnostic tool, but it measures severity levels associated with psychological distress and thus has been utilised to recognise individuals needing a further appraisal for anxiety and depression. The K10 tool was initially developed to recognise the levels of non-specific psychological distress in the general population and was employed in many countries including the Australia, Canada and USA [10-13]. The World Health Organization's World Mental Health Survey also used this tool [14]. The tool has also exhibited

a substantial association with severe mental illnesses [15]. As such, clinicians recommend utilisation of the K10 to screen for psychiatric illness [16, 17]. Although K10 is quick and a cost-effective tool to screen psychological distress among general people [9], its cross-cultural validity was not employed in any rural settings including among rural population in Bangladesh.

Bangladesh is a densely populated country with a population of 167 million people [18]; around 65% of them live in rural area [19]. Psychological distress has been found to be a significant public health concern especially in these areas [20-22]. The prevalence of mental disorders in such areas varies notably, ranging from 6.5% to 31% of the total population, conceivably due to the utilisation of diverse conventions, measuring tools and various meanings associated with mental disorders [23]. Further, there has been no culturally sensitive tool available for rapid screening of psychological distress in Bangladesh. Recently, Uddin et al. [24] validated the K10 scale using Rasch analysis technique in a rural area of Bangladesh and proposed a modified version with seven items (K7) that proved to be robust with four-point liker type scale instead of the five-point scale of the original K10. The modified K7 version followed all assumptions of Rasch analysis and produced a unidimensional tool for measuring psychological distress.

The validated K7 scale offers a progressively useful screening tool for measuring and identifying psychological distress among the rural population of Bangladesh. This K7 model provides additional benefits as it can be applied in clinical settings to measure psychological distress through a shortened version of the Kessler 10 items questionnaire. The culturally validated instrument of the K7 scale can provide an increasingly productive resource for health care services and can apply in other developing countries with similar socio-demographic characteristics. However, for application in clinical settings,

further validation of the K7 scale with its four-response categories, as applied in different populations is required.

Therefore, the current study aims to provide additional validation of the modified version of the K7 scale for potential application within clinical settings in diverse populations.

Materials and Methods

Study Population

Bangladesh is a nation of 167 million individuals parted into 64 districts [18]. Adult Participants aged 18 to 90 years were selected from the Narail Upazilla, which is found around 200 km south-west of Dhaka, the capital city of Bangladesh, between August and September of 2018. The study area that includes a geographic area and 300 survey points of data collection gathered from the three unions (Auria, Banshgram and Bhardabila), has been described in detail in Fig. 1.

Sample Size and Statistical Power

Three hundred sample is appropriate for a Rasch examination since large sample sizes can result in type 1 errors that falsely dismiss an item for not fitting in the Rasch model [25]. A sample size of 300 is viewed as sufficiently substantial to ensure 99% confidence that the item difficulty would be within ±½ logit of its stable value [26].

Sampling Frame

Data were collected from three unions (smallest rural administrative unit) out of nine unions, excluding the four which were selected previously from the 13 unions of Narail Upazilla [27]. The selected unions are Auria, Banshgram and Bhardabila. One village (a smallest territorial and social unit for

administrative and representative purposes), from each of the chosen unions, were randomly selected at the second level. The selected villages are Baliadanga, Fulshor and Rogunathpur. Two paras (further divisions of the village) from each selected village were randomly chosen at the third level. In total, 40 adults (18–59 years old) and 40 older adults (60–90 years old) from each of the villages/wards were interviewed. Three hundred and twenty participants were interviewed for data collection. To maintain unbiasedness, we have used 300 with an equal proportion of adults and older adults, further divided into a similar proportion of gender.

Data collection using CommCare and its advantage over using printed questionnaire

Mobile data collection is a method employed to collect any qualitative and quantitative inputs via a mobile device (e.g. mobile phone, tablet, etc.). The introduction of mobile devices has mitigated tedious process, making it more fun and efficient [28]. The most noteworthy are the difficulties of paper based data collection are mentioned as follows safeguarding against human mistakes, slow reporting and delays in data entry, a lack of flexibility in deploying programmatic changes, poor location information and disturbances to recipient connections [29]. With the proper implementation of the mobile data collection tool, these issues can be solved [30]. CommCare (www.commcarehq.org) is a customisable, mobile platform, which empowers non-developers to build mobile applications for data collection [31]. CommCare allows the mobile applications to run offline and gathered information can be transmitted to CommCareHQ when internet connectivity becomes accessible [32].

The current study followed a strict protocol to ensure a smooth launch when the application was finalised and was thoroughly tested before training began [33]. We pilot tested the software with 30 people and found some minor problems as some respondents did not understand the application correctly. We addressed these concerns and then upgraded the version before distributing it for final data collection.

Modified Kessler Psychological Distress Scale (K7)

The K10 measures, how regularly members have encountered manifestations of anxiety and depressive disorders in the past four weeks before screening [9]. However, Uddin et al. [24] validated K10 using Rasch analysis in rural Bangladesh and found that seven-item (K7) was more suitable to use in rural Bangladesh rather than ten items (K10) [24]. For use in clinical settings, further validation is required. In that context, additional data has been collected from different location using K7 to ensure the integrity of the findings prior to use in a clinical setting in rural Bangladesh. Respondents were asked, 'During the past four weeks, how often did you feel: 1) nervous; 2) so nervous that nothing could calm you down; 3) hopeless; 4) restless or fidgety; 5) so restless you could not sit still; 6) so depressed that nothing could cheer you up; 7) everything was an effort;' Items are rated on a four-point liker type scale: all of the time (score 4), most or some of the time (score 3), a little of the time (score 2) and none of the time (score 1).

Outcome measure and differential item functioning (DIF)

The primary outcome measure was the validity of the K7 scale using Rasch analysis. Demographic details were collected for age, gender and level of education and socio-economic conditions. Age, sorted as either adult (18 to 59 years) or older adult (60 to 90 years), sex (male or female), education (no education or at least primary) and socio-economic conditions (low (insufficient funds most/some of the time) and high (balance/sufficient funds all the time)) which were used as DIF factors.

The Rasch Model

The Rasch model was named after Danish mathematician Georg Rasch [34]. The model shows what is required in reactions to items if estimation (at the measurement level) is to be accomplished most accurately. Two versions of the Rasch model are available: dichotomous [34] and polytomous [35]. The polytomous Rasch model was utilised in this investigation.

The Rasch analysis utilised in this investigation was conducted using the software package RUMM 2030 [36]. The Rasch model makes a few hypotheses that should be assessed to guarantee an instrument has Rasch properties. The most ordinarily evaluated Rasch suspicions are a) unidimensionality, b) local independence and c) invariability. As indicated by the Rasch demonstrate, the overall fit of the model is defined by Chi-square item-trait interaction statistics [37]. A non-significant chi-square *p*-value is required. A Bonferroni adjustment of significance value [38] is typically used to assess statistical significance. Item-person interaction statistics are exhibited as z-statistics (mean = 0 and standard deviation (SD) =1), showing ideal fit. Individual item fit (IFR) measurements incorporate the residuals satisfactorily when inside the range ± 2.5 and a non-significant chi-square value [39].

A "threshold" parameter is characterized by two response options where either response is similarly likely. Disordered thresholds demonstrate that the respondents are not ready to segregate between the responses choices. Disordered thresholds result in item misfit and can be redressed by combining two neighbouring response options [40]. Unidimensionality suggests that the scale estimates just a single build [41]. For a scale to be unidimensional, under 5% of the t-tests ought to be significant, or the binomial distributions confidence interval's lower bound should overlap 5% [42]. The person-item residuals correlation matrix used to determine whether there is any local dependency between the items, and it is generally agreed that 0.3 is a more suitable value [43]. Differential item functioning (DIF) happens when two groups with a similar dimension of the developed estimate react differently [44, 45]. Rasch examination gives a marker of reliability. In RUMM 2030, this is given by the Person Separating Index (PSI) [46]. The PSI is comparable to Cronbach's alpha (CA); a value near 1 shows high internal consistency and a value under 0.7 demonstrates model misfit [47].

Patient and public involvement

Our study participants are the general people with or without any particular disease. There was a public involvement in conducting the research including informing the district commissioner, district police super, civil surgeon, and the public representatives such as the Chairman of the union parishad. We conducted a pilot survey and arranged a focus group discussion regarding the understanding of the questionnaire by the general people. To maintain an approximately equal number of male and female participants, one female was interviewed immediately after a male participant. Participants did not involve in the recruitment to and conduct of the study. Although the results are being published in peer-reviewed journals, the results will be disseminated via community briefs and presentations at national and international conferences.

Results

Table 1 describes the socio-demographic characteristics of the participants by gender (male vs female). The mean (standard deviation (SD), range) age of the participants was 52.0 years (15.6, 18-90). A considerably large proportion (45.0%) of the populations did not have any formal education, with only 1.3% attaining a bachelor's degree or above. The socio-economic condition for most respondents (about 41.3%) was occasional financial instability, 32.3% experienced a precarious financial situation, 25.3% experienced balance and 1.0% held sufficient funds most of the time. Overall 23.7% of participants were engaged in business, farming and students activities; none of these respondents was female. Most of the participants were married (81.3%) and 36.8% participants were current smokers.

Table 1 Sociodemographic characteristic of Gender in Narail Upazilla in Bangladesh

Characteristic	**Total (300)**	**Female (150)**	**Male (150)**
	Mean (SD)	Mean (SD)	Mean (SD)
Age (in years)	52 (15.7)	51.7 (15.5)	52.8 (16.0)
Age In group	Number (%)	Number (%)	Number (%)
Adult	150 (50.0)	75 (50.0)	75 (50.0)
Elderly	150 (50.0)	75 (50.0)	75 (50.0)

Level of education (in years)			
No education	135 (45.0)	80 (53.3)	55 (36.7)
Primary (1-5)	80 (26.7)	36 (24)	44 (29.3)
Secondary (6-9)	64 (21.3)	31 (20.7)	33 (22)
SSC or HSC Pass (10-12)	17 (5.7)	3 (2.0)	14 (9.3)
Degree or equivalent (13 -16)	4 (1.3)	0	4 (2.7)
Socio-economic condition:			
Insufficient funds most of the time	97 (32.3)	62 (41.3)	35 (23.3)
Insufficient funds some of the time	124 (41.3)	50 (33.3)	74 (49.3)
Balance	76 (25.3)	37 (24.7)	39 (26)
Sufficient funds most of the time	3 (1.0)	1 (0.7)	2 (1.3)
Occupation			
Student	5 (1.7)	0	5 (3.3)
Farmers in your own land	42 (14.0)	0	42 (28)
Business	24 (8.0)	0	24 (16)
Govt/Private Job	3 (1.0)	1 (0.7)	2 (1.3)
Daily Labour	44 (14.7)	0	44 (29.3)
Housewives	122 (40.7)	122 (81.3)	0 (0)
Unemployed	1 (0.3)	0	1 (0.7)
Retired	31 (10.3)	19 (12.7)	12 (8)
Cannot work due to disability	28 (9.3)	8 (5.3)	20 (13.3)
Marital status			
Married	244 (81.3)	107 (71.3)	137 (91.3)
Widow	46 (15.3)	41 (27.3)	5 (3.3)
Unmarried/never married	9 (3.0)	1 (0.7)	8 (5.3)
Divorced/separated	1 (0.3)	1 (0.7)	0
Smoking Status			
Never smoker	115 (38.5)	66 (44.3)	49 (32.7)
Past smoker	2 (0.7)	0	2 (1.3)
Current smoker	39 (13.0)	1 (0.7)	38 (25.3)
Do not smoke but consume gul etc	110 (36.8)	78 (52.3)	32 (21.3)
Current smoking consumes gul and eating tobacco etc	32 (10.7)	4 (2.7)	28 (18.7)
Smoke and consume other addicted items, gaja, wine, etc.	80 (26.7)	36 (24)	44 (29.3)

Further validation of K7 scale showed good overall fit to the Rasch model ($\chi 2 = 44.54$ df = 28, p = 0.0245). The items fit residual (IFR) (M = 0.30, SD = 1.22) and the person fit residuals (PFR) (M = -0.18, SD = 0.85) were within the acceptable range (Table 2). All seven items were found to have ordered thresholds (Fig. 2), suggesting no problems with the 4-point liker-type scale used in the modified questionnaire.

Table 2 Overall model fit statistics for the further validation of the K7 scale

Model fit statistics	Total sample N=300
Overall model fit, Chi-square value	44.54
Degree of freedom (DF)	28
P	0.0245
Item fit residuals (mean (SD))	0.30 (1.22)
Person fit residuals (mean (SD))	–0.18 (0.85)
Person separation index (PSI)	0.85
Coefficient alpha	0.89
Unidimensionality test (% that goes beyond 95% CI)	3.7% CI (1.2 - 6.1)

No misfit or overfit items were identified with significant chi-square probability values. There was neither high positive nor high negative residual values (± 2.5) observed. All seven individuals' item fit statistics showed a good fit (Table 3). The value of the PSI (0.85) is analogous to Cronbach's alpha (0.89) for the original set of seven items with four response categories indicating that the scale worked well to separate persons. A visual examination of the threshold map (Fig. 2) showed that the estimates of the thresholds defined the categories in all seven items form distinctive regions of the continuum. We also examined the category probability curve of each item and found all adjacent categories were the same (Fig. 3).

Table 3 Individuals' item fit statistics of further validation of the K7 scale

	Individuals' items fit statistics of K7 scale				
Items	Location	SE	Residual	χ^2	P value
Feel nervous (2)	-0.944	0.124	-0.224	8.78	0.067
Feel so nervous (3)	0.139	0.123	-0.177	5.91	0.206
Feel hopeless (4)	0.049	0.112	1.215	1.23	0.874
Feel restless or fidgety (5)	-0.843	0.110	1.993	13.09	0.011
Feel so restless (6)	-0.573	0.110	-0.743	3.58	0.466
Everything was an effort (8)	1.645	0.115	-1.222	7.58	0.108
Feel so sad (9)	0.528	0.117	1.095	4.39	0.356

The K7 scale was assessed for DIF across gender (male/female), age (adults/older adults), education (no education/some education) and socio-economic conditions (low/high) (Table 4). No significant DIF was

found for any of the items. The unidimensionality of the K7 scale was supported by independent t-tests comparing the person estimates with the principal component analysis (PCA) of the residuals; our findings indicated that only 3.7% (95% Confidence Interval: 1.2% to 6.1%) of cases showed statistically significant differences (Table 2 and Figure 4). There were no correlation coefficients above 0.30 on the person-item residual correlation matrix, indicating no local dependency of the items (Table 5).

Table 4 DIF on age, gender, educational attainment and socio-economic conditions on K7 scale

Items	DIF on Age				DIF on Gender			
	MS	F	DF	Prob	MS	F	DF	Prob
Feel nervous (2)	1.81	2.25	1	0.135	1.26	1.55	1	0.215
Feel so nervous (3)	1.18	1.46	1	0.228	0.14	0.17	1	0.682
Feel hopeless (4)	0.85	0.87	1	0.351	3.45	3.61	1	0.059
Feel restless or fidgety (5)	0.81	0.80	1	0.373	0.93	0.92	1	0.339
Feel so restless (6)	2.20	2.79	1	0.096	0.16	0.20	1	0.655
Everything was an effort (8)	0.25	0.34	1	0.560	0.64	0.88	1	0.351
Feel so sad (9)	0.77	0.79	1	0.374	0.06	0.06	1	0.800
Items	DIF on Educational attainment				DIF on Socio-economic Conditions			
	MS	F	DF	Prob	MS	F	DF	Prob
Feel nervous (2)	0.44	0.55	1	0.458	0.00	0.01	1	0.939
Feel so nervous (3)	0.19	0.22	1	0.637	0.34	0.41	1	0.521
Feel hopeless (4)	0.02	0.02	1	0.897	0.84	0.88	1	0.351
Feel restless or fidgety (5)	0.29	0.28	1	0.597	2.18	2.15	1	0.144
Feel so restless (6)	0.02	0.02	1	0.883	0.27	0.34	1	0.559
Everything was an effort (8)	1.83	2.48	1	0.117	0.48	0.65	1	0.421
Feel so sad (9)	0.01	0.01	1	0.917	0.00	0.00	1	0.955

Table 5 Residuals correlation matrix of the K7 scale

Items	Feel nervous (2)	Feel so nervous (3)	Feel hopeless (4)	Feel restless (5)	Feel so restless (6)	Everything was an effort (8)	Feel so sad (9)
Feel nervous (2)	1						
Feel so nervous (3)	0.278	1					
Feel hopeless (4)	-0.128	-0.191	1				

Feel restless (5)	-0.284	-0.298	-0.204	1			
Feel so restless (6)	-0.276	-0.188	-0.240	0.032	1		
Everything was an effort (8)	-0.254	-0.228	-0.142	-0.193	-0.142	1	
Feel so sad (9)	-0.183	-0.213	-0.125	-0.253	-0.215	0.039	1

Discussion

The inspiration behind the paper was to evaluate the appropriateness of the modified K7 scale (which was prior validated from K10) survey for measuring psychological distress in rural Bangladesh for its adaptation in clinical settings. This paper includes Rasch examination to investigate a few issues concerning the K7. The article also incorporates the validity of the category scorings framework, the fit of individual items and an evaluation of the potential predisposition of age-sex distribution, education attainment and socio-economic status.

The K10 scale has recently experienced a thorough psychometric examination in rural Bangladesh and found K7 scale was a valid instrument to measure psychological distress in rural Bangladesh [24]. However, further validation was required to confirm its use in clinical settings. From the Rasch examination point of view, the underlying illustrative examination focused on the present rural samples of Bangladesh. The modified K7 scale with four response classifications showed no redundancy (little impact on the scale) and no misfit. Besides, items were all order thresholds, and scale demonstrated no proof of multi-dimensionality.

It has commonly been assumed that, deduction of items from the scale would reduce at least some redundancy [48-51]. However, our examination recognised that Cronbach's alpha for the K7 scale (0.89) was comparable to the earlier validated K7 Cronbach's alpha (0.88) [16]; besides, the PSI of K7 (0.85)

was equivalent to the previously validated K7 (0.84) [24]. Previous study demonstrated some redundancy in Cronbach's alpha when contrasting K10 (0.93) and K6 (0.89) [52]. Notwithstanding, the current study demonstrates the prevalent estimation of Cronbach's alpha K7 (0.89) contrasted with the earlier validated K7 (0.88) and K10 (0.87). Therefore, the current study further confirms that the K7 scale is a robust tool compared to the K10 [24] in measuring psychological distress in rural Bangladesh.

It is widely held view that sexual orientation contrasts in psychological research are omnipresent [53, 54], so it is fundamental to confirm whether the model is influenced by sex or not. The K7 scale demonstrated no DIF on sex, and is appropriate for any gender, which supports the previous discoveries announced in Australia [54] and Bangladesh [24]. Another essential factor is age, as there was an discrepancy with the association among age and psychological distress [55]. An investigation led by Kessler et al. recorded a conventional arrangement of disparity in the association among age [56]. However, different investigations exhibited a stable nonlinear connection between age and psychological distress in a few cross-sectional epidemiologic studies [55, 57, 58]. The evident from this study suggests that there is no age inclination (adults and older adults).

Higher levels of psychological distress are present among individuals with lower educational attainment compared with higher educational attainment [54, 59]. The level of education may influence psychological distress questionnaire responses and may affect the measurement of psychological distress levels. A negative relationship between socioeconomic position and psychological distress has been established in the literature [60], with the low socioeconomic status associated with a higher level of psychological distress [61]. Follow-up on these development methods provides an evaluation mechanism regarding the K7 scale and specifically explores whether it is equally valid across socio-economic

conditions and is consistent with educational achievement. We have found that the K7 scale is equally applicable to any educational level as well as any socio-economic status.

Use of the Rasch estimation demonstrated in this study has strengthened the viability of the K7 scale for measuring psychological distress in rural Bangladesh. The scale demonstrates a high reliability, ordered thresholds and no proof of DIF. The scale additionally demonstrated high PSI (0.85) and reliability (0.89), which showed the power of the test of fit. This study provides significant evidence that a complete score of psychological distress can be measured, to accelerate finding a legitimate cut-off score for rural people in Bangladesh. Building up a cut-off score can help with evaluating the level of the severity of psychological distress.

This paper demonstrates how the Rasch model can be used for intensive examination and improvement of estimation instruments. The Rasch model display disentangles estimation issues, for example, lack of invariance (invariance is a property of the model parameters, which "only holds when the fit of the model to the data is precise in the population"[62]. However, in real-life applications lack of invariance will always be found due to the probabilistic nature of the IRT models), which was disregarded in conventional analysis [63]. Lessening the number of response categories as well as the number of items may likewise improve the properties of the scale [24, 64]. It can, therefore, be argued persuasively that the information on the general rural population in regard to psychological distress dependent on the re-examined seven-item scale from the K10, with four-response category, is better than the original scale.

The Rasch examination contributes valuable information on dimensions of psychological distress among the general rural population of Bangladesh. The investigation based on a data set with a wide age distribution, from whom data were collected directly through a face-to-face interview. Mobile data

collection platform CommCare (www.commcarehq.org) [33] was used for data collection. This enhanced data collection method may assist clinicians by offering a new clinical and research utility. Further, the K7 scale applied by this strategy may work as a productive screener for psychological distress in various medicinal services settings, including primary and integrated care facilities. This can caution clinicians to patients who may benefit from a progressively exhaustive psychological assessment or a possible referral for psychiatric care. The K7 scale may likewise assume a job in distinguishing psychological distress earlier and make it more probable that patients receive appropriate care in health services settings. Moreover, the K7 scale can be made openly accessible in any health care setting as well as on the web. Given its smallness and straightforwardness in both on the web and paper format, K7 scale might be supported to individuals searching for a self-detailed assessment measure.

The potential limitation of this investigation is that it depends on single-occasion data from people in a rural region of Bangladesh. While we have attempted further approve the K7 scale in the rural area of Narail for use in a clinical setting, the investigation would be improved if a national delegate sample were available.

Conclusion

In conclusion, the study recommended the utilisation of K7 scale in rural Bangladesh. The research gleaned from this study finding suggests that a seven-item scale taken from the K10, with four-response categories, would give a robust psychometric scale. The K7 scale satisfies all the assumptions of the Rasch model. The model has appeared to contain no DIF on age, sex distribution, educational attainment and different socio-economic conditions. The K7 scale has no local dependency, and the scale is unidimensional. Further examination of K7 scale affirmed that the tool could also be utilised in medical settings to offer huge advantages as a standard measure of psychological screening instrument for

evaluating psychological distress among the rural Bangladeshi population. Besides, the tool can be applied in other developing nations where the similar socio-demographic attributes exist. In addition, the tool can be connected within clinical settings to provide a national dimension with telemedicine, where mental health conditions cannot be analysed.

Abbreviations

CA: Cronbach's Alpha, DIF: Differential Item Functioning, IFR: Item Fit Residuals, IRT: Item Response Theory, K7: Modified Seven Item Scale of Kessler Psychological Distress Scale, K10: Kessler Psychological Distress Scale, PCA: Principal Component Analysis PFR: Person Fit Residuals; PSI: Person Separation Index, SD: Standard Deviation

Declarations

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Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Author Contributions

MNU and FMAI jointly structured the examination. MNU analysed the data and drafted the manuscript. FMAI supervised and reviewed the manuscript. All authors contributed to the development of the manuscript, read, and endorsed its final version.

Ethics approval and consent to participate

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The ethics committee of the Swinburne University of Technology Human Ethics Committee (SHR Project 2015/065 extended endorsement got in July 2018) has granted ethical approvals. Written informed consent was acquired from every individual member incorporated into the study.

Consent for publication

None applicable

Competing interests:

The authors declare that they have no competing interest

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Fig. 1 The study location that includes a geographic area and data collection points

Fig. 2 Threshold maps of the of further validation of K7 scale

Fig. 3 Category probability curve of all the items

Fig. 4 Dimensionality testing of K7 scale

Consent Form:

Interviewer note: Should be completed from one of the eligible members of aged ≥ 18 years

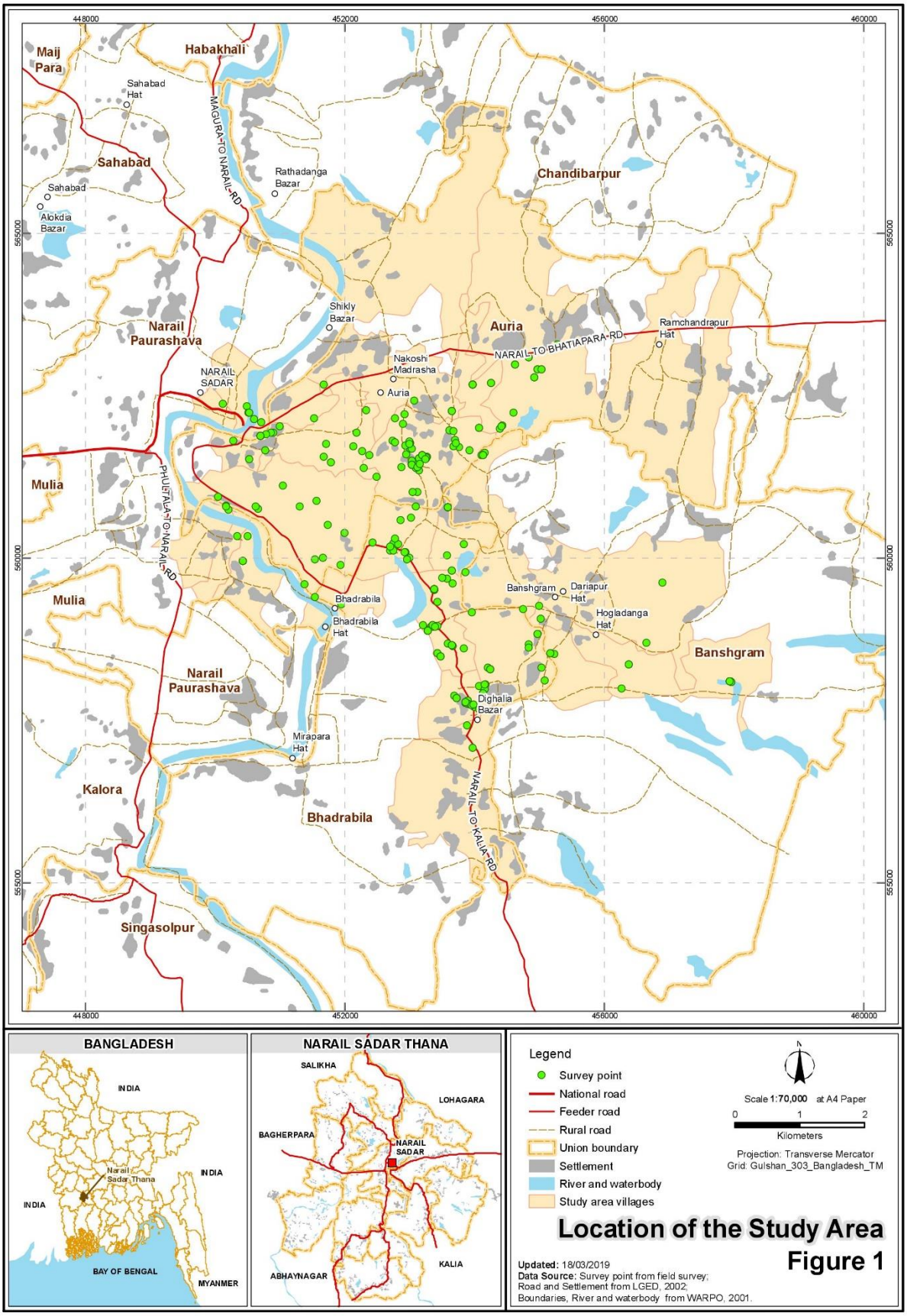
Patient's consent

We are screening to identify people with depression and its risk factors, in people of aged ≥ 18 years. The survey will increase your awareness of the disease outcome and it's risk factors. The community will be benefitted from this study through the intervention programs those the Organisation for Rural Community Development intend to conduct in the future. We do not expect any risk for you if you participate in this study. Upon the completion, the results will be published in both national and international Journal but your individual information will be kept confidential and your identification will not be disclosed. We expect to continue our study for a longer period for which we may invite you again to participate in our study. However, you are free to change your mind and can withdraw from the study anytime without any obligation if you want.

Please provide your signature or thumb imprint if you agree

Signature/thumb imprint

Signature by the interviewer if the participant cannot provide signature.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Dighalia Bazar
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Narail Sadar Thana
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NARAIL SADAR
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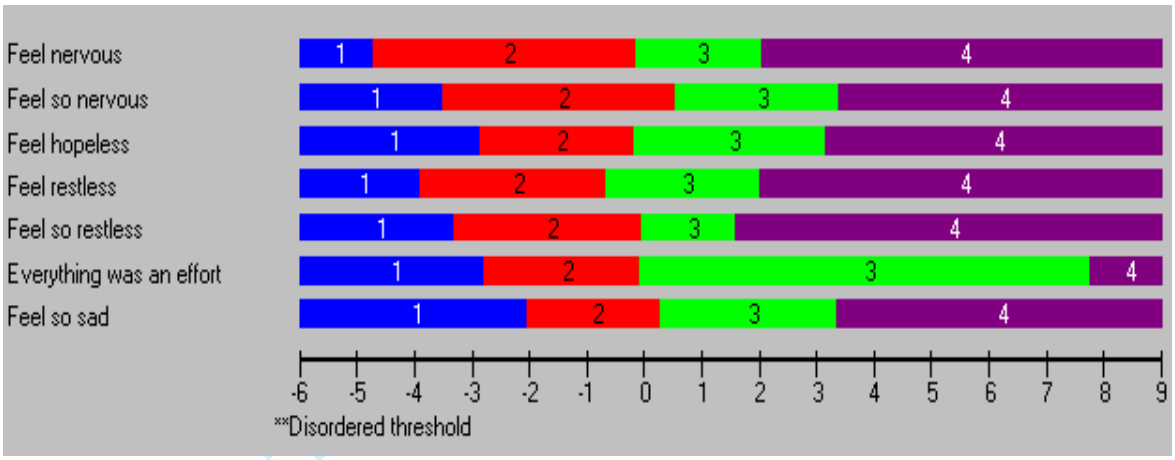
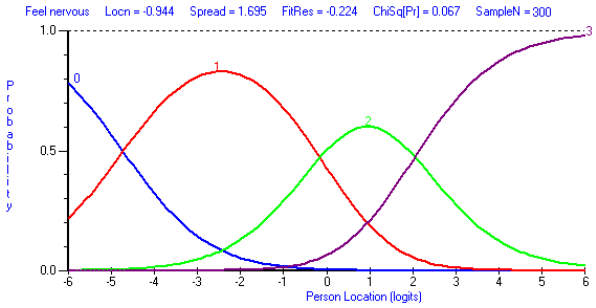
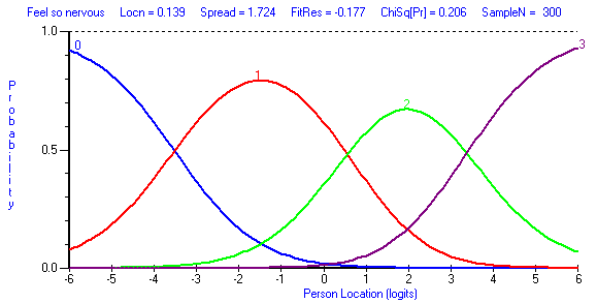
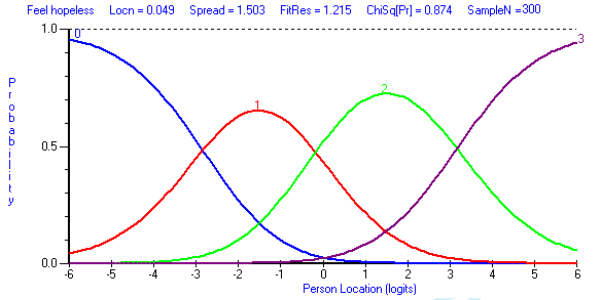
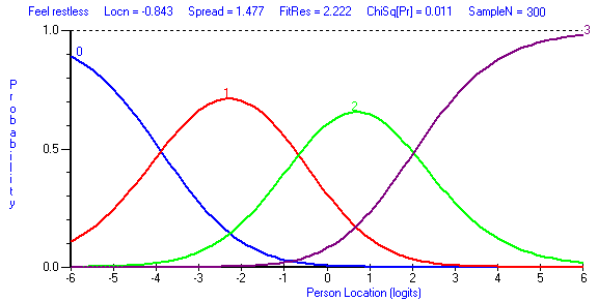
Projection: Transverse Mercator
Grid: Gulshan_303_Bangladesh_TM
Location of the Study Area
Figure 1
Updated: 18/03/2019
Data Source: Survey point from field survey;
Road and Settlement from LGED, 2002;
Boundaries, River and waterbody from WARPO, 2001.

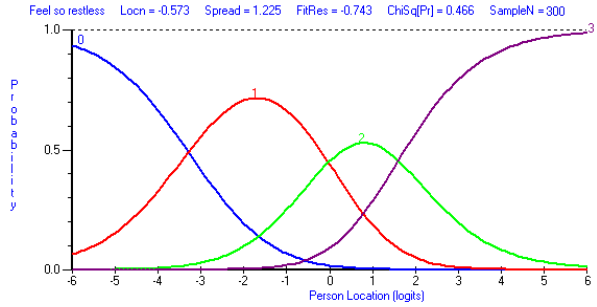


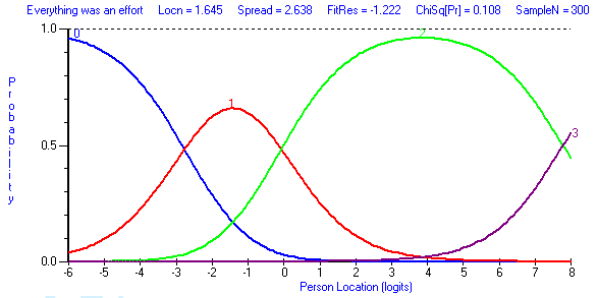


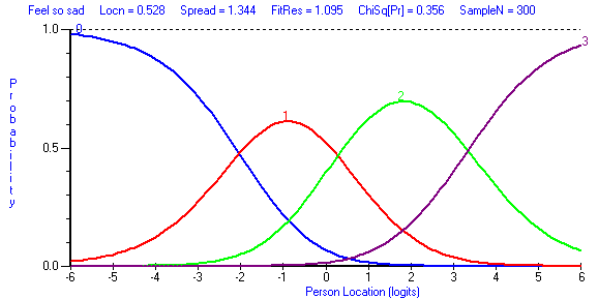


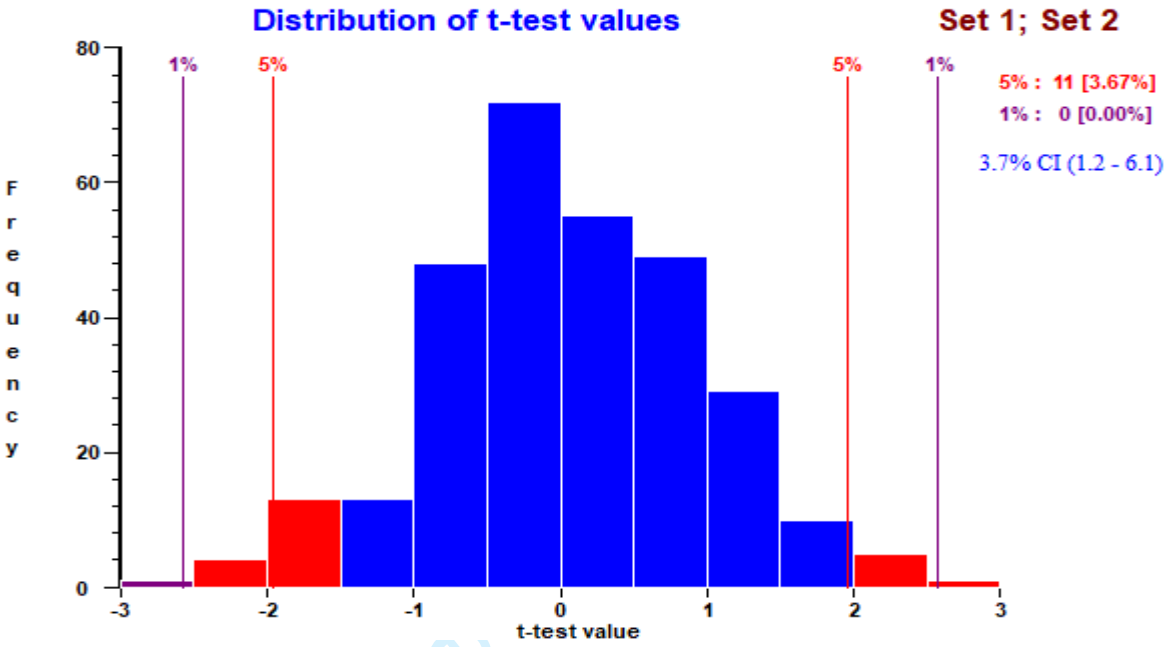












STROBE 2007 Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Pages 1-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Pages 2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4, background
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 6, paragraph 2
Methods			
Study design	4	Present key elements of study design early in the paper	Page 6 , sampling frame
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 6, study population
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Pages 6-7, sample size and statistical power and sample frame, data collection using CommCare and also more details in the protocol paper (ref 27)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 8 Outcome measure and differential item functioning (DIF)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Page 7, 9 and pages 10-12
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	Page 6, sample size and statistical power
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Pages 8-9, the Rasch model
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Pages 8-9, the Rasch model
		(*b*) Describe any methods used to examine subgroups and interactions	Pages 8-9, the Rasch model
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Page 7, sampling frame and In protocol paper (ref 27)
		(*e*) Describe any sensitivity analyses	

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Pages 10-11
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1, Overview of respondents and on pages 10-11
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	Page 12-14
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 12-14, Table 2-5
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 14, Discussion, paragraph 1
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 17, Paragraph 2
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Pages 14-17
Generalisability	21	Discuss the generalisability (external validity) of the study results	Pages 17-18, Conclusion
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 18, Funding

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Psychometric evaluation of the modified Kessler seven-item version (K7) for measuring psychological distress using Rasch analysis. A cross-sectional study in a rural district of Bangladesh.

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Keywords:	Kessler psychological distress scale, Rasch analysis, Validation, Rural Bangladesh, K7

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Title: Psychometric evaluation of the modified Kessler seven-item version (K7) for measuring psychological distress using Rasch analysis. A cross-sectional study in a rural district of Bangladesh.

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Abstract

Objectives This investigation expected to validate the psychometric properties of the modified 7-item Kessler psychological distress scale (K7) for measuring psychological distress in healthy rural population of Bangladesh.

Design Cross-sectional study.

Setting Narail district, Bangladesh.

Participants A random sample of 300 adults of age 18–90 years were recruited. Face-to-face interviews were conducted between July and August 2018 using an Android phone installed with a mobile data collection application known as CommCare.

Outcome measure Validation of the K7 was the major outcome. Sociodemographic factors were measured to assess for Differential Item Functioning (DIF) to check if the tool functions equally in different factors. Rasch analysis was carried out for the validation of the K7 scale in the healthy rural population of Bangladesh. RUMM2030 was used for the analyses.

Results: Results showed good overall fit, as indicated by a non-significant item-trait interaction ($\chi2$=44.54, df=28, p=0.0245) compared with a Bonferroni adjusted p-value of 0.007. Both item fit (mean=0.30, SD=1.22) and person fit residuals (mean=–0.18, SD=0.85) showed perfect fit. Reliability was very good as indicated by a person separation index (PSI)=0.85 and Cronbach's Alpha (CA)=0.89. All individual items were ordered thresholds. The K7 scale showed adequate reliability, unidimensionality and was free from local dependency. The K7 scale also showed similar functioning for adults and older adults, males and females, no education and any level of education, and at least some financial instability vs. no financial instability.

Conclusions: Validation of K7 scale confirmed that the tool is suitable for measuring psychological distress among the rural Bangladeshi population. Further research should validate the K7 scale in different rural settings in Bangladesh to determine a valid cutoff score for assessment of severity levels

of psychological distress. The K7 scale should also be tested in other developing countries where socio-demographic characteristics are similar to those of Bangladesh.

Keywords: Kessler psychological distress scale, Rasch analysis, Validation, Rural Bangladesh

Strengths and limitations of this study

- This study provides the first reliable data on the Kessler K7 scale from a general population of a typical rural district of Bangladesh.
- This study used primary data on a K7 scale and application of the Rasch analysis technique was applied to validate the K7 scale instead of Classical Test Theory (CCT).
- The data were collected through face-to-face interviews to increase the accuracy of data.
- The study provides a unique opportunity to assess psychological distress in a rural population of Bangladesh by using reasonably fewer items.
- The potential drawback of this study is that it is based on a single-occasion collection of data from a rural district in Bangladesh which preventing test-retest evaluation or comparison of alternate versions of the same measures.

Background

Globally, one out of every four individuals is influenced by mental or psychological distress at some point in their lives [1]. Almost 66% of individuals experiencing psychological distress fail to look for assistance because they were unaware of, or neglect their disorder [2]. Due to the rapid growth of mental disorders, there is a need to identify risk conditions quickly in a cost-effective manner [3]. Early diagnosis of psychological distress has been seen as an essential measure to guarantee successful, focused, effective and targeted intervention for patients experiencing psychological distress [4]. In recent years, researchers have primarily been interested in early diagnosis of psychological distress and used tools with a very limited number of items for measuring psychological distress among the general population [5]. Therefore, the development and continued validation of the tools used for measuring psychological distress is critical, especially for early detection of psychological instability.

Typically, large epidemiologic studies of mental health have used detailed and interviewer-administered diagnostic interviews; replicating this method is considered cost-effective for general population [6]. A variety of these diagnostic screening interviews are now accessible, these include the Diagnostic Interview Schedule [7], Composite International Diagnostic Interview [8], and the Mini-International Neuropsychiatric Interview [9]. Dimensional measures of non-specific psychological distress have come to take on new importance because it distinguishes people based on severity level rather than purely on diagnosis. Over the last three decades, large-scale epidemiological studies used screening measures to provide a quick measure of the prevalence of psychological distress [10-13]. However, most of the tools have an extensive list of items which have been limited to the use of widely accepted tools aimed at the screening of psychological distress among the general population.

The Kessler 10-item scale (K10) is an exception. Developed by Professors' Kessler and Mroczek in 1992, K10 was designed to be utilised in the United States National Health Interview Survey as a brief measure of non-explicit psychological distress along with the anxiety-depression spectrum [14]. The K10 and the six-item scale K6 was developed concurrently with experimental instruments for assessing psychological distress in people with a variety of mental disorders [15]. The six items for K6 is included in K10. The K10 and the K6 have been translated and validated in at least 14 countries worldwide [6, 16-18]. The K10 tool was initially developed to recognise the levels of non-specific psychological distress in the general population and was employed in many countries including Australia, Canada and the USA [15, 19-21]. The World Health Organization's World Mental Health Survey also used this tool [22]. The tool has also identified a substantial association with severe mental illnesses [23]. As such, clinicians recommend utilisation of the K10 and the K6 to screen for psychological distress [24, 25]. Although both scales have been validated with various populations and languages, research has indicated that the factor structures of the K10 and the K6 scales differ. For example, one study outlined discrepancies between the K6's one-factor and two-factor structures [16] while another study outlined discrepancies between the K10's two-factor and four-factor structures [17]. In addition, both the K10 and the K6 cross-cultural validity was not employed in any rural settings including the rural populations of Bangladesh. Such variations in factor structures suggest that further research is needed on the psychometric properties of the K10 and the K6 instruments.

Bangladesh is a densely populated country with a population of 167 million people; around 65% of them live in rural areas [26, 27]. Psychological distress has been found to be a significant public health concern especially in rural areas [28-31]. The prevalence of mental disorders varies notably in rural areas, ranging from 6.5% to 31% of the total population, conceivably due to the utilisation of diverse conventions, different measuring tools and various meanings associated with mental disorders [32]. Further, there has

been no culturally sensitive tool available for rapid screening of psychological distress in Bangladesh. Recently, Uddin et al. validated the K10 scale using the Rasch analysis technique in a rural area of Bangladesh and proposed a modified version of a seven items K7 scale. The K7, which is a subset of the K10 proved to be robust containing a four-point liker type scale instead of the five-point scale of the original K10. The modified K7 version followed all assumptions of Rasch analysis and produced a unidimensional tool for measuring psychological distress.

The K7 scale provides additional benefits. One is related to brevity offering ease of administration, and the other is low cost to measure psychological distress through a shortened version of the K10 scale. Given the widespread use of the K10 and the K6 scales, including the translated Bengali versions of K10 scale [18], it is noteworthy that no empirical validation studies with Bengali speaking populations have been reported in the literature review. The culturally validated instrument of the K7 scale can provide an increasingly productive resource for health care services and can be applied in other developing countries with similar socio-demographic characteristics. However, further validation of the K7 scale with its four-response categories is required to be used for rural populations of Bangladesh. Therefore, the current study aims to provide validation of the modified version of the K7 scale for potential application within healthy population settings in rural Bangladesh.

Materials and Methods

Study Population

Bangladesh is a nation of 167 million individuals divided into 64 districts [26]. The male to female ratio (48.9 to 51.1) was consistent in all over in Bangladesh [33]. Around 72.9% of individuals attained primary education or above as opposed to 27.1% had no education of the national population [34]. With respect to the availability of funds, the population having insufficient funds some or most of the time

accounted for 23.2% in Bangladesh [35]. Adult participants aged 18 to 90 years were selected from the Narail Upazilla, which is located around 200 km south-west of Dhaka, the capital city of Bangladesh. Interviews were conducted between July and August of 2018. The study area includes a specific geographic area and 300 survey points of data collection. Data were gathered from three unions (Auria, Banshgram and Bhardabila) of the region. This has been described in detail in Fig. 1.

Sample Size and Statistical Power

A sample size of 300 adults of age 18-90 was used for this study. This sample size is appropriate for a Rasch examination since large samples can potentially result in type 1 error that falsely dismiss an item for not fitting the Rasch model [36]. A sample size of 300 is viewed as sufficiently substantial to ensure 99% confidence that the item difficulty would be within ±½ logit of its stable value [37].

Sampling Frame

The cross-sectional study recruited a multi-stage cluster random sample of 320 participant from the rural district Narail of Bangladesh in the period of July-August 2018. Data were collected from three unions (the smallest rural administrative units) out of nine unions, excluding the four which were selected previously from the 13 unions of Narail Upazilla [38]. The selected unions are Auria, Banshgram and Bhardabila. One village (the smallest territorial and social unit for administrative and representative purposes), from each of the chosen unions, were randomly selected at the second level. The selected villages were Baliadanga, Fulshor and Rogunathpur. Two paras (further divisions of the village) from each selected village were randomly chosen at the third level. In total, 40 adults (18–59 years old) and 40 older adults (60–90 years old) from each of the villages/wards were interviewed. Interviewers used a mobile data collection platform CommCare on their android phone to collect data from the respondents. To mitigate the effect of selection bias, 320 respondents were used with an equal proportion of adults

and older adults, further partitioned into gender. This study excluded 20 participants randomly as 300 participants were deemed sufficient for the Rasch Measurement Theory.

Data collection using CommCare and its advantage over using a printed questionnaire

Mobile data collection is a method employed to collect qualitative and quantitative inputs via a mobile device (e.g. mobile phone, tablet, etc.). The introduction of mobile devices has mitigated streamlined and making them more economical and less time consuming [39]. Other benefits include minimising minimisation of human errors, speeding up reporting, increased flexibility in deploying programmatic changes, and provision of accurate location information [40]. With the correct implementation of the mobile data collection tool, these benefits can all be successfully implemented [41]. CommCare is a customisable, mobile platform, which empowers non-developers to build mobile applications for data collection [42]. CommCare allows mobile applications to run offline where gathered information can be transmitted to CommCareHQ as internet connectivity becomes accessible [43].

The current study followed a strict protocol to ensure a smooth launch after the CommCare application was finalised by pre-testing before training began [44]. The application was pilot tested with 30 people. The testing found some minor problems associated with respondents not understanding the application correctly. These concerns were addressed through an upgraded version of the application which was then distributed for final data collection.

Modified Kessler Psychological Distress Scale (K7)

The K7 measures developed asked respondents to consider how regularly they encountered of depressive and anxiety symptoms in the preceding four weeks before screening. Respondents were asked to express how often the following seven symptoms occurred: they felt nervous, so nervous that nothing could calm

them down, hopeless, restless or fidgety, so restless that they could not sit still, so depressed that nothing could cheer them up, everything was an effort [18]. Items were rated on a four-point liker type scale. The answer to each question was allocated to a value of one, two, three, or four: "none of the time," "a little of the time," "some or most of the time" or "all the time" respectively.

Outcome measure

The K7 scale is the main outcome measure for assessing psychological distress using Rasch analysis. Demographic details were collected for age, gender and level of education and socio-economic conditions.

The Rasch Model

The Rasch model was named after Danish mathematician Georg Rasch [45]. The model shows what is required for reactions to items if estimation (at the measurement level) is to be accomplished most accurately. Two versions of the Rasch model are available: dichotomous [45] and polytomous [46]. In this case, the polytomous Rasch model was used. The Rasch model consists mainly of two forms, the rating scale model and the partial credit model, which can be used with polytomous results. The partial credit model is the norm under RUMM2030, which does not restrict threshold parameters and enables them to differ by item [47]. The likelihood ratio check, which is available in the RUMM2030 programme, tests unregulated parameterization (partial credit model) toward reparameterization. The non-statistical result shows that the definition of the rating scale is to be used, although statistically significant results indicate that the partial credit model should be used [48]. An analysis was undertaken, and a significant finding was found which encourages the use of the partial credit model.

The Rasch analysis utilised in this investigation was conducted using the software package RUMM 2030 [49]. The Rasch model makes a few hypotheses that should be assessed to guarantee an instrument has

Rasch properties. The most ordinarily evaluated Rasch suspicions are a) unidimensionality, b) local independence and c) invariability. Local independence means that the scores are related to each other only through the construct, whereas unidimensionality means that only one construct is being measured and the invariance criterion implies that generally an instrument should function in the same way for all individuals [50, 51]. As indicated by the Rasch demonstrate, the overall fit of the model is defined by Chi-square item-trait interaction statistics [52]. With non-significance, at a Bonferroni-corrected level of 0.007 (0.05/7 items), indicating adequate fit [53-56]. Item-person interaction statistics are exhibited as z-statistics (mean=0 and standard deviation (SD)=1) and show ideal fit. Individual item fit (IFR) measurements incorporate the residuals satisfactorily when inside the range ± 2.5 and a non-significant chi-square value [57].

A "threshold" parameter is characterized by two response options where either response is equally likely. Disordered thresholds demonstrate that the respondents are not able to segregate between the response's choices. Disordered thresholds result in item misfit and can be redressed by combining two neighbouring response options [58]. Following the principal component analysis (PCA) of the residuals, the associations between items and the first PCA variables are used to describe two subsets of products. The independent t-test is then used to determine the difference between the two subsets. The individual estimates, with a non-significant result or the lower bound variance of the binomial distributions by 5% indicate no evidence of multidimensionality [59]. The person-item residuals correlation matrix can be used to determine whether there is any local dependency between the items, and correlations less than 0.3 are generally considered to be acceptable [48]. Differential item functioning (DIF) investigates whether items operate similar function across different groups. An analysis of variance (ANOVA) has been carried out for each item that compares scores across each group factor level (Age, sorted as either adult (18 to 59 years) or older adult (60 to 85 years), sex (male or female), education (no education or at least primary) and socio-economic conditions low (insufficient funds most/some of the time) and high

(balance/sufficient funds all the time)) and across construct levels. DIF was found to be present if the ANOVA was significant with the Bonferroni correction (Bonferroni adjusted *p*-value of .05/7=.007) [60, 61]. Rasch examination also gives a marker of reliability. In RUMM 2030, this is given by the Person Separation Index (PSI). The PSI of the Rasch analysis consists of indices developed as an approximation of the proportion of the true or error-free variance. This applies throughout the distribution of person estimates relative to the sum of this variance and error variance in these estimates. With Rasch measurement, instead of reliability indices, the person separation index is used. However, the person separation index is analogous to Cronbach's alpha (CA) [62]. A value near 1 shows high internal consistency and a value under 0.7 demonstrates low scale reliability [63].

Patient and public involvement Study participants were the generally people without any disease. Public involvement for the research was obtained primarily informing the district commissioner, district police super, civil surgeon, and various public representatives such as the Chairman of the union Parishad. A pilot survey was conducted and arranged a focus group discussion involving the general public arranged as the questionnaire was developed. To maintain an approximately equal number of male and female participants, one female was interviewed immediately after each male participant. Participants were not involved in the recruitment and conduct of the study. Results will be disseminated via community briefs and presented at national and international conferences. Patient consent form can be found in the supplementary materials.

Results

Table 1 describes the socio-demographic characteristics of the participants by gender (male vs female). The mean (standard deviation (SD), range) age of the participants was 52.0 years (15.6, 18-90). A considerably large proportion (45.0%) of the populations did not have any formal education, with only 1.3% attaining a bachelor's degree or above. The socio-economic condition for most respondents (about

41.3%) was occasional financial instability, 32.3% experienced a precarious financial situation, 25.3% experienced balance and 1.0% held sufficient funds most of the time

Table 1 Sociodemographic characteristic of Gender in Narail Upazila in Bangladesh

Characteristic	**Total (300)**	**Female (150)**	**Male (150)**
	Mean (SD)	Mean (SD)	Mean (SD)
Age (in years)	52 (15.7)	51.7 (15.5)	52.8 (16.0)
Age In group	Number (%)	Number (%)	Number (%)
Adult	150 (50.0)	75 (50.0)	75 (50.0)
Elderly	150 (50.0)	75 (50.0)	75 (50.0)
Level of education (number of years schooling)			
No education	135 (45.0)	80 (53.3)	55 (36.7)
Primary (1-5)	80 (26.7)	36 (24)	44 (29.3)
Secondary (6-9)	64 (21.3)	31 (20.7)	33 (22)
SSC or HSC Pass (10-12)	17 (5.7)	3 (2.0)	14 (9.3)
Degree or equivalent (13 -16)	4 (1.3)	0	4 (2.7)
Socio-economic condition:			
Insufficient funds most of the time	97 (32.3)	62 (41.3)	35 (23.3)
Insufficient funds some of the time	124 (41.3)	50 (33.3)	74 (49.3)
Balance	76 (25.3)	37 (24.7)	39 (26)
Sufficient funds most of the time	3 (1.0)	1 (0.7)	2 (1.3)

The validation of the K7 scale showed good overall fit to the Rasch model with the Bonferroni adjusted p-value of 0.007 ($\chi2 = 44.54$ df = 28, p = 0.0245). The items fit residual (IFR) (mean = 0.30, SD = 1.22) and the person fit residuals (PFR) (mean= -0.18, SD = 0.85) were within the acceptable range (Table 2). All seven items were found to have ordered thresholds (Fig. 2), suggesting the respondents have no difficulty differentiating between the response's choices with the 4-point liker-type scale used in the K7 scale.

Table 2 Overall model fit statistics of the K7 scale

Model fit statistics	Total sample N=300
Overall model fit, Chi-square value	44.54
Degree of freedom (DF)	28
*P value	0.0245

Item fit residuals (mean (SD))	0.30 (1.22)
Person fit residuals (mean (SD))	–0.18 (0.85)
Person separation index (PSI)	0.85
Coefficient alpha	0.89
Unidimensionality test (% that goes beyond 95% CI)	3.7% CI (1.2 - 6.1)

**The p-value 0.007 means the significance at level 0.05 because the number of items is seven (0.05/7=0.007). Therefore, any p-value greater than 0.007 would consider to be non-significant*

No misfit or overfit items were identified with significant chi-square probability values. There was neither high positive nor high negative residual values (± 2.5) observed. All seven individuals' item fit statistics showed a good fit with the Bonferroni adjusted p value of 0.007 (Table 3). The value of the PSI (0.85) for the original set of seven items with four response categories indicated that the scale worked well to separate persons. The value of the Cronbach's alpha (0.89) of the K7 scale demonstrates good internal consistency. A visual examination of the threshold map (Fig. 2) showed that the estimates of the thresholds defined the categories in all seven items that formed distinctive regions of the continuum. We also examined the category probability curve in which each response options systematically take turns, showing the highest probability of endorsement (Fig. 3).

Table 3 Individuals' item fit statistics of the K7 scale

	Individuals' items fit statistics of K7 scale				
Items	Location	SE	Residual	χ^2	P value
Feel nervous (2)	-0.944	0.124	-0.224	8.78	0.067
Feel so nervous (3)	0.139	0.123	-0.177	5.91	0.206
Feel hopeless (4)	0.049	0.112	1.215	1.23	0.874
Feel restless or fidgety (5)	-0.843	0.110	1.993	13.09	0.011
Feel so restless (6)	-0.573	0.110	-0.743	3.58	0.466
Everything was an effort (8)	1.645	0.115	-1.222	7.58	0.108
Feel so sad (9)	0.528	0.117	1.095	4.39	0.356

SE=Standard error, P value= Probability value

The K7 scale was assessed for DIF across gender (male/female), age (adults/older adults), education (no education/some education) and socio-economic conditions (low/high) (Table 4). No significant DIF was found for any of the items. The unidimensionality of the K7 scale was supported by independent t-tests comparing the person estimates with the principal component analysis (PCA) of the residuals; our findings indicated that only 3.7% (95% Confidence Interval: 1.2% to 6.1%) of cases showed statistically significant differences (Table 2 and Figure 4). There were no correlation coefficients above 0.30 on the person-item residual correlation matrix, indicating no local dependency of the items (Appendix 1)).

Table 4 DIF on age, gender, educational attainment and socio-economic conditions on K7 scale

Items	DIF on Age				DIF on Gender			
	MS	F	DF	P-value	MS	F	DF	P-value
Feel nervous (2)	1.81	2.25	1	0.135	1.26	1.55	1	0.215
Feel so nervous (3)	1.18	1.46	1	0.228	0.14	0.17	1	0.682
Feel hopeless (4)	0.85	0.87	1	0.351	3.45	3.61	1	0.059
Feel restless or fidgety (5)	0.81	0.80	1	0.373	0.93	0.92	1	0.339
Feel so restless (6)	2.20	2.79	1	0.096	0.16	0.20	1	0.655
Everything was an effort (8)	0.25	0.34	1	0.560	0.64	0.88	1	0.351
Feel so sad (9)	0.77	0.79	1	0.374	0.06	0.06	1	0.800
Items	DIF on Educational attainment				DIF on Socio-economic Conditions			
	MS	F	DF	P-value	MS	F	DF	P-value
Feel nervous (2)	0.44	0.55	1	0.458	0.00	0.01	1	0.939
Feel so nervous (3)	0.19	0.22	1	0.637	0.34	0.41	1	0.521
Feel hopeless (4)	0.02	0.02	1	0.897	0.84	0.88	1	0.351
Feel restless or fidgety (5)	0.29	0.28	1	0.597	2.18	2.15	1	0.144
Feel so restless (6)	0.02	0.02	1	0.883	0.27	0.34	1	0.559
Everything was an effort (8)	1.83	2.48	1	0.117	0.48	0.65	1	0.421
Feel so sad (9)	0.01	0.01	1	0.917	0.00	0.00	1	0.955

DIF= Differential Item Functioning, MS= mean square, F= F test value, DF=Degrees of Freedom, P-value= Probability value

Figure 5 shows the person-item threshold distribution of the K7 scale. The person distribution is shown in the top half and the item thresholds in the bottom half. The average value of individual logit for the

K7 scale was -0.227 showing well-targeted persons and items fit for the K7 scale. While a negative mean value for the K7 measure may suggest that the participant was located at a lower level (e.g. psychological distress) than the average level of the scale. Overall, the K7 scale was not too difficult to endorse.

Discussion

The current study investigated the psychometric performance of the K7 in a sample of a healthy and rural Bangladeshi population. The inspiration behind the paper was to evaluate the appropriateness of the modified K7 scale (which was prior validated from the K10 scale) survey for measuring psychological distress in rural Bangladesh. This paper includes Rasch examination to investigate a few issues concerning the K7 scale. The article also incorporates the validity of the category scorings framework, the fit of individual items and an evaluation of the potential predisposition of age-sex distribution, education attainment and socio-economic status.

The K10 scale has recently experienced a thorough psychometric examination in rural Bangladesh prompting the development of a K7 scale to measure psychological distress in rural Bangladesh [18]. However, further K7 validation was required to confirm its use in rural settings. From the Rasch examination point of view, the underlying illustrative examination focused on the present rural samples of Bangladesh. The modified K7 scale with four response classifications showed no redundancy (little impact on the scale) and no misfit. Moreover, items were all order thresholds, while scale demonstrated no proof of multi-dimensionality.

It was stated earlier that the scale would be one-dimensional, an important assumption for the implementation of IRT used to develop K10 [15]. There is a difference in outcomes for different populations with respect to the dimensional structure of the instrument. In some research, K10 and K6 were proposed as unidimensional scales [15, 25]. However, other research proposed multidimensional

of K10 and K6 scale [16, 17]. In line of the previous study reported K10 and K6 as unidimensional scales, the findings of the current study further confirm the K7 as a unidimensional scale as it was earlier proposed by Uddin et.al [18].

Several previous studies conducted around the world did not use Rasch analysis to validate the K10 or K6 [14, 24, 64-69]. A comparison of this study with previous studies is limited using PSI. However, Uddin et al. [18] used Rasch analysis and developed the K7 scale that would be suitable for rural Bangladesh. The current study recognised that the K7 scale CA was marginally below from the previous estimates of CA; and the PSI was marginally superior to the previous estimates of PSI [18]. Moreover, reliability (CA) was high in the current study and consistent with previous research [15, 66, 70, 71]. Therefore, the current study results suggest that the translated items measure the same overall construct of psychological distress in rural Bangladesh.

There has been controversy over the DIF associated with gender in psychological distress assessment [72-74]. The predominant mental health problems are widely accepted as being associated with the level of education, specifically, as it decreases psychological distress increases [73, 75-77]. The K7 scale demonstrated no DIF on sex and education level, which supports previous research findings from Australia [73], Japan [78] and Bangladesh [18]. An investigation led by Kessler et al. recorded a conventional arrangement of disparity in the association among age [79]. However, different investigations exhibited a stable nonlinear connection between age and psychological distress in a few cross-sectional epidemiologic studies [80-83]. A negative relationship between socioeconomic position and psychological distress has been established in the literature [84], with low socioeconomic status associated with a higher level of psychological distress [85]. Although there may still be an association

between age/SES with psychological distress, the lack of DIF simply means that items function the same way with regards to their psychometric properties, irrespective of age and SES group.

To our knowledge, this was the first psychometric assessment on the K7 scale to measure psychological distress in Rural Bangladesh. Use of the Rasch estimation demonstrated in this study has strengthened the viability of the K7 scale for measuring psychological distress in rural Bangladesh. The scale demonstrates ordered thresholds with no proof of DIF. Moreover, the scale showed high PSI (0.85) and CA (0.89), which also showed the power of the test for fit. This study provides significant evidence that a complete score of psychological distress can be measured and accelerates the finding of a legitimate cut-off score for rural people in Bangladesh. Building up a cut-off score can help with evaluating the severity levels of psychological distress.

The Rasch examination contributes valuable information on dimensions of psychological distress among the general rural population of Bangladesh. The study was based on a data set with a wide age distribution, where data were collected directly through face-to-face interviews. Interviewers used a mobile data collection platform CommCare to collect data from the respondents to minimising human error and speeding up reporting [44]. Further, the K7 scale applied by this method may work as a productive screener for psychological distress across various service settings, including primary and integrated care facilities. This can caution clinicians to patients who may benefit from a psychological distress assessment. The K7 scale can be made openly accessible in any health care setting as well as on the web. Given its portability and straightforwardness in both web and paper formats, the K7 scale could be made accessible individuals searching for a self-administer assessment measure.

The primary limitation of this study is that it depends on single-occasion data from people in a rural region of Bangladesh, though we have attempted to validate the K7 scale in the rural area of Narail. The investigation would be improved if a national delegate sample were available. The concern with fit statistics associated with the Rasch analysis is that the greater the sample size, the higher the likelihood of finding the probability of detecting deviations from the Rasch model [86, 87]. Nevertheless, there are no clear guidelines for sample size when implementing the Rasch Measurement Theory. [88]. Thus, we used the sample size of 300, which is more favoured [86]. Replication studies with large populated samples of Bengali speakers may improve generalisation.

Conclusion

In conclusion, the study recommended the utilisation of the K7 scale in rural Bangladesh. The research gleaned from this study suggests that a seven-item scale taken from the K10, with four-response categories, would offer a robust psychometric scale. The K7 scale satisfies all the assumptions of the Rasch model. Examination of the K7 scale affirmed that the tool could also be utilised as a standard measure of psychological distress. It could therefore provide a screening instrument for evaluating psychological distress among the rural Bangladeshi population. Further, the tool can be applied in other developing nations experiencing similar socio-demographic attributes. In addition, the tool can be connected within service settings to provide a national dimension using telemedicine, where mental health conditions cannot be analysed.

Supplementary file

Additional materials related to patient consent form can be found in the supplementary file.

Abbreviations

CA: Cronbach's Alpha, DIF: Differential Item Functioning, IFR: Item Fit Residuals, IRT: Item Response Theory, K7: Modified Seven Item Scale of Kessler Psychological Distress Scale, K10: Kessler Psychological Distress Scale, PCA: Principal Component Analysis PFR: Person Fit Residuals; PSI: Person Separation Index, SD: Standard Deviation

Declarations

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Data sharing statement

The datasets used and/or analysed for the current study are available from the corresponding author upon request.

Author Contributions

MNU and FMAI jointly structured the examination. MNU analysed the data and drafted the manuscript. FMAI supervised and reviewed the manuscript. All authors contributed to the development of the manuscript, read, and endorsed its final version.

Ethics approval and consent to participate

All procedures performed in studies involving human participants were conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The ethics committee of the Swinburne University of Technology Human Ethics Committee (SHR Project 2015/065 extended endorsement got in July 2018) has granted ethics approvals. Written informed consent was acquired from every individual member incorporated into the study.

Consent for publication

None applicable

Competing interests:

The authors declare that they have no competing interest

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Fig. 1 The study location that includes a geographic area and data collection points

Fig. 2 Threshold maps of the K7 scale

Fig. 3 Category probability curve of all the items of the K7 scale

Fig. 4 Dimensionality testing of the K7 scale

Fig. 5 Person item threshold distribution map of the K7 scale.

Fig. 1 The study location that includes a geographic area and data collection points

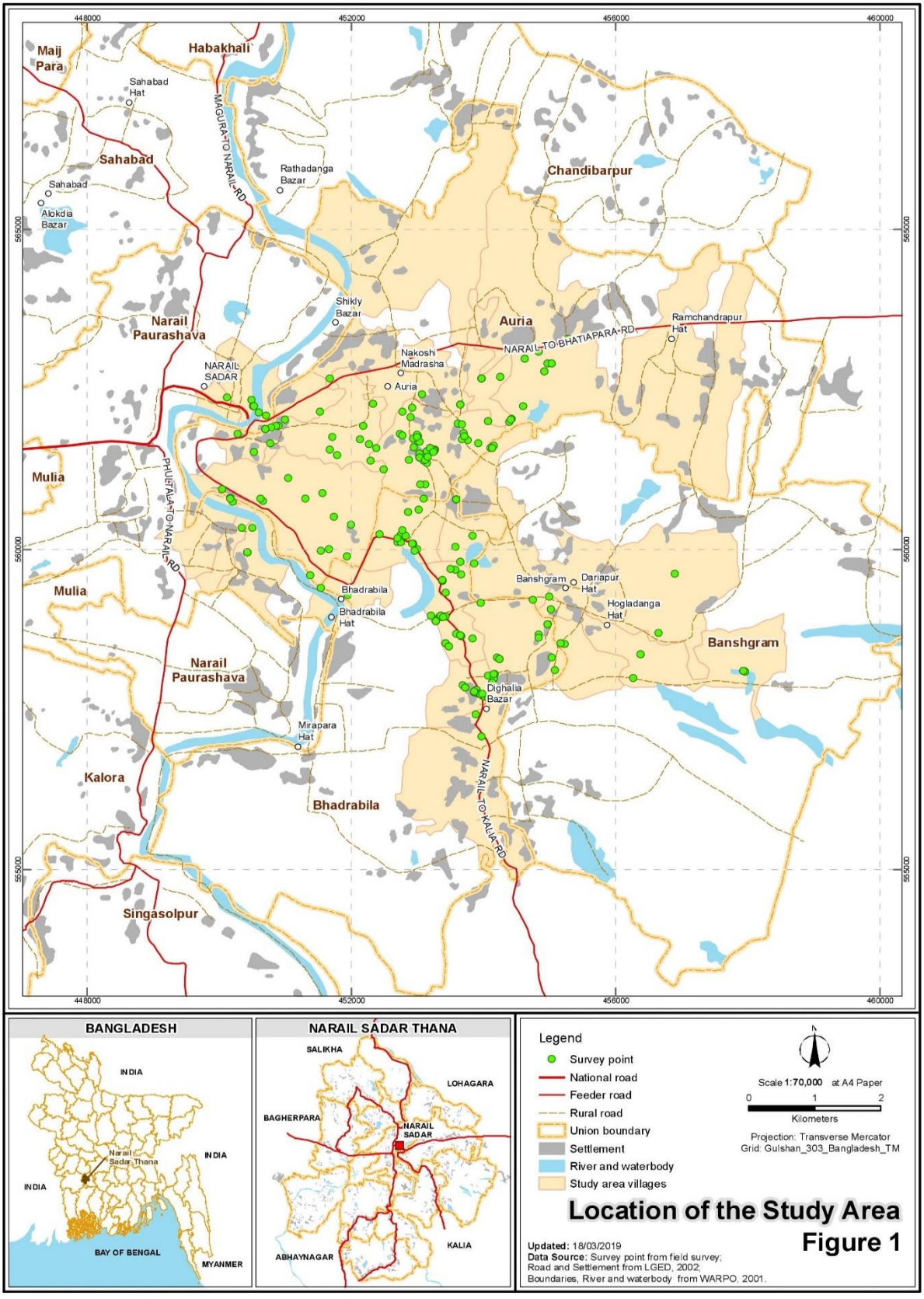


Fig. 2 Threshold maps of the K7 scale

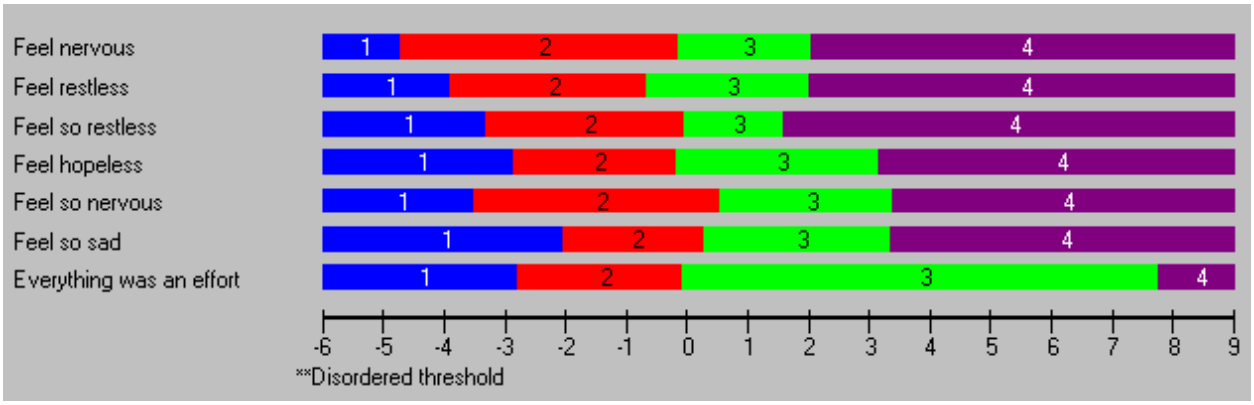


Fig. 3 Category probability curve of all the items of K7 scale

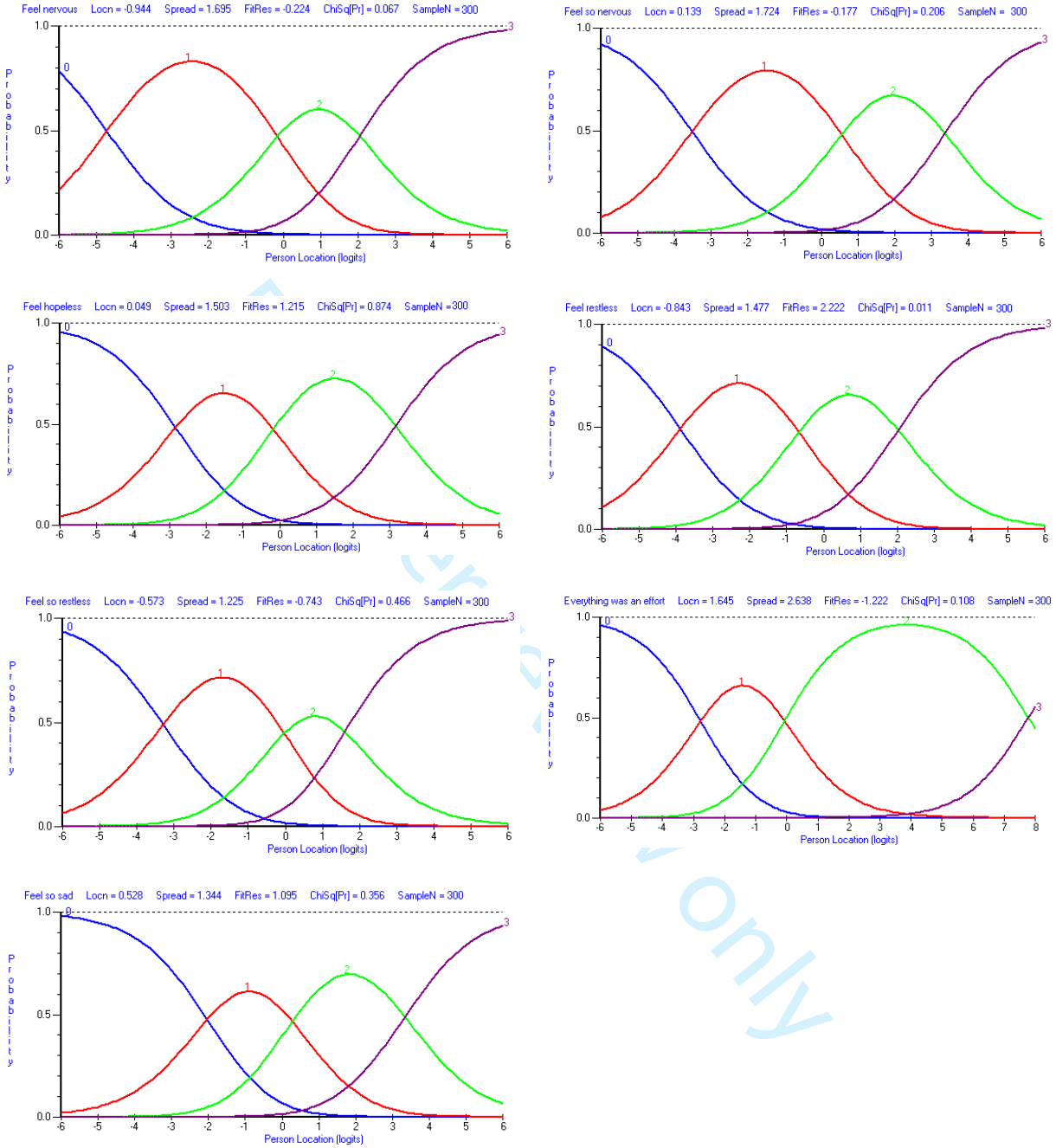


Fig. 4 Dimensionality testing of the K7 scale

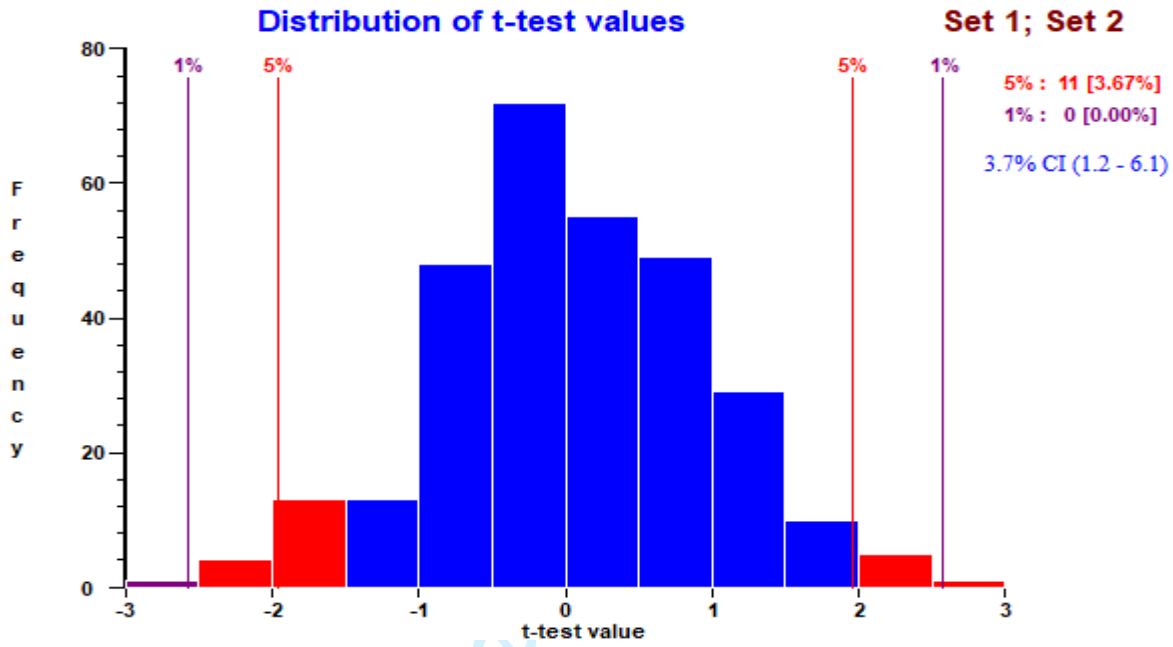
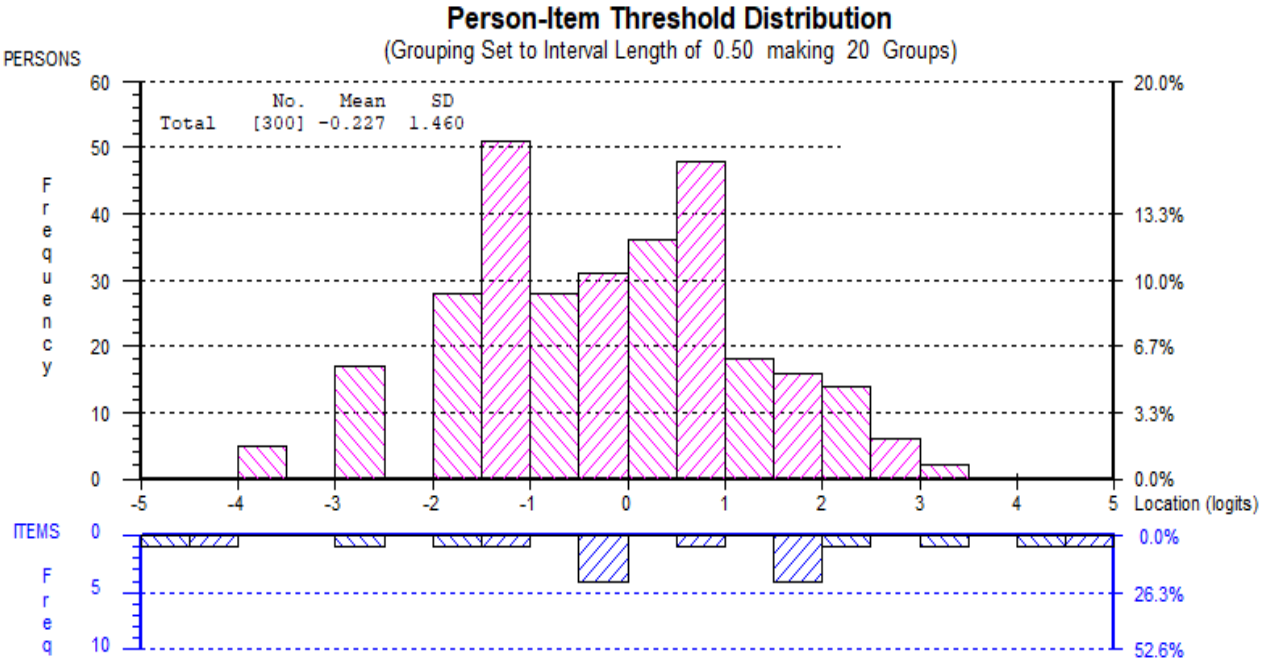


Fig. 5 Person item threshold distribution map of the K7 scale.



Consent Form:

Interviewer note: Should be completed from one of the eligible members of aged ≥ 18 years

Patient's consent

We are screening to identify people with depression and its risk factors, in people of aged ≥ 18 years. The survey will increase your awareness of the disease outcome and it's risk factors. The community will be benefitted from this study through the intervention programs those the Organisation for Rural Community Development intend to conduct in the future. We do not expect any risk for you if you participate in this study. Upon the completion, the results will be published in both national and international Journal, but your individual information will be kept confidential and your identification will not be disclosed. We expect to continue our study for a longer period for which we may invite you again to participate in our study. However, you are free to change your mind and can withdraw from the study anytime without any obligation if you want.

Please provide your signature or thumb imprint if you agree

Signature/thumb imprint

Signature by the interviewer if the participant cannot provide signature.

Appendix Residuals correlation matrix of the K7 scale

Items	Feel nervous (2)	Feel so nervous (3)	Feel hopeless (4)	Feel restless (5)	Feel so restless (6)	Everything was an effort (8)	Feel so sad (9)
Feel nervous (2)	1						
Feel so nervous (3)	0.278	1					
Feel hopeless (4)	-0.128	-0.191	1				
Feel restless (5)	-0.284	-0.298	-0.204	1			
Feel so restless (6)	-0.276	-0.188	-0.240	0.032	1		
Everything was an effort (8)	-0.254	-0.228	-0.142	-0.193	-0.142	1	
Feel so sad (9)	-0.183	-0.213	-0.125	-0.253	-0.215	0.039	1

STROBE 2007 Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	Pages 1-3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	Pages 2-3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Page 4, background
Objectives	3	State specific objectives, including any prespecified hypotheses	Page 6, paragraph 2
Methods			
Study design	4	Present key elements of study design early in the paper	Page 6 , sampling frame
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Page 6, study population
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	Pages 7-8, sample size and statistical power and sample frame, data collection using CommCare and also more details in the protocol paper (ref 38)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Page 9 Outcome measure and socio-economic variables
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Pages 8-11
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	Page 7, sample size and statistical power
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Pages 8-9, the Rasch model
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Pages 9-11, the Rasch model
		(*b*) Describe any methods used to examine subgroups and interactions	Pages 9-11, the Rasch model
		(*c*) Explain how missing data were addressed	N/A
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	Pages 7-8, sampling frame and In protocol paper (ref 27)
		(*e*) Describe any sensitivity analyses	

Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	Pages 11-12
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1, Overview of respondents and on pages 11-12
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	Page 12-15
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	Page 12-15, Table 2-5
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	Page 15, Discussion, paragraph 1 and 2
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Page 18, Paragraph 1
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Pages 15-18
Generalisability	21	Discuss the generalisability (external validity) of the study results	Page 18, Conclusion
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	Page 19, Funding

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.