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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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2 3	1	Title: Further validation of psychometric evaluation of the modified Kessler seven-item
4 5	2	questionnaire (K7) for measuring psychological distress in rural Bangladesh. A cross-sectional
6 7	3	study
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25 Word Count (3427)26 Abstract

Objectives This investigation expected to approve the psychometric properties of the modified 7-items

28 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

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2 3	49	fferent clinical settings in Bangladesh to determine a valid cutoff score for assessment of the severity
4 5	50	f psychological distress. The K7 tool can be tested in other developing countries where socio-
6 7	51	emographic characteristics are similar to those in Bangladesh.
8 9 10	52	
11 12	53	eywords: Kessler psychological distress scale, Rasch analysis, Validation, Rural Bangladesh
13 14	54	trengths and limitations of this study
15 16 17	55	> This study provides the first reliable data on the Kessler K7 questionnaire from a general
17 18 19	56	population of a typical rural district in Bangladesh.
20 21	57	This study used primary data on K7 and associated covariates.
22 23	58	> The data were collected through face-to-face interviews of people from a typical rural district that
24 25 26	59	represents Bangladesh using mobile data collection tool CommCare.
27 28	60	> The sophisticated Rasch analysis technique was applied to validate the K7. The study provides a
29 30	61	unique opportunity to assess psychological distress in a rural population of Bangladesh.
31 32 33	62	> The potential drawback of this study is that it is based on a single-occasion collection of data
34 35	63	from a rural district in Bangladesh. While we have attempted to check the situation of our
36 37	64	previously validated model whether the K7 perfectly match all the assumption of Rasch
39 40	65	properties. Moreover, the study needs to be repeated in a random sample of the clinical setting in
41 42	66	different rural districts to be truly representative of the national population.
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73 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

97 a substantial association with severe mental illnesses [15]. As such, clinicians recommend utilisation of 98 the K10 to screen for psychiatric illness [16, 17]. Although K10 is quick and a cost-effective tool to 99 screen psychological distress among general people [9], its cross-cultural validity was not employed in 100 any rural settings including among rural population in Bangladesh.

13 13 102 14 Bangladesh is a densely populated country with a population of 167 million people [18]; around 65% of 15 them live in rural area [19]. Psychological distress has been found to be a significant public health 16 103 17 18 104 concern especially in these areas [20-22]. The prevalence of mental disorders in such areas varies notably, 19 ²⁰ 105 ranging from 6.5% to 31% of the total population, conceivably due to the utilisation of diverse 21 22 ₂₃ 106 conventions, measuring tools and various meanings associated with mental disorders [23]. Further, there 24 25 107 has been no culturally sensitive tool available for rapid screening of psychological distress in Bangladesh. 26 27 28 108 Recently, Uddin et al. [24] validated the K10 scale using Rasch analysis technique in a rural area of 29 ₃₀²⁰109 Bangladesh and proposed a modified version with seven items (K7) that proved to be robust with four-31 point liker type scale instead of the five-point scale of the original K10. The modified K7 version 32 110 33 ³⁴ 111 followed all assumptions of Rasch analysis and produced a unidimensional tool for measuring 35 37 112 36 psychological distress.

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41 1 1 4 The validated K7 scale offers a progressively useful screening tool for measuring and identifying ⁴³ 115 psychological distress among the rural population of Bangladesh. This K7 model provides additional ₄₆ 116 benefits as it can be applied in clinical settings to measure psychological distress through a shortened 48 117 version of the Kessler 10 items questionnaire. The culturally validated instrument of the K7 scale can ⁵⁰ 118 provide an increasingly productive resource for health care services and can apply in other developing 53 119 countries with similar socio-demographic characteristics. However, for application in clinical settings,

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2 12	20	further validation of the K7 scale with its four-response categories, as applied in different populations is
3 4 10	21	required
5 12	<u> </u>	Tequited.
7 12	22	
8 0 1′	22	Therefore, the current study aims to provide additional validation of the modified version of the K7 scale
9 12 10	23	Therefore, the current study ands to provide additional variation of the mounted version of the K7 scale
11 12	24	for potential application within clinical settings in diverse populations.
13 1/	75	
14 ¹	23	
16 l2	26	Materials and Methods
17	<i>-</i> ح	
10 [₂ 19	27	Study Population
20 21 12	28	Bangladesh is a nation of 167 million individuals parted into 64 districts [18]. Adult Participants aged 18
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23 12	29	to 90 years were selected from the Narail Upazilla, which is found around 200 km south-west of Dhaka,
24 25 12	30	the capital city of Bangladesh between August and September of 2018. The study area that includes a
26 27		
27 28 13	31	geographic area and 300 survey points of data collection gathered from the three unions (Auria,
29 30 13	32	Banshoram and Bhardabila) has been described in detail in Fig. 1
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32 13 33	33	
³⁴ 12	34	Sample Size and Statistical Power
35 ¹ 36		
37 13	35	Three hundred sample is appropriate for a Rasch examination since large sample sizes can result in type
38 39 13	36	1 errors that falsely dismiss an item for not fitting in the Rasch model [25] A sample size of 300 is
40	50	r errors that falsery distinss an item for not fitting in the Rasen moder [25]. A sample size of 500 is
41 42	37	viewed as sufficiently substantial to ensure 99% confidence that the item difficulty would be within $\pm \frac{1}{2}$
43	38	logit of its stable value [26]
44 1.	50	
46 13	39	
47 48 ₁₂	40	Sampling Frame
49	τU	
50 51 14	41	Data were collected from three unions (smallest rural administrative unit) out of nine unions, excluding
52 53 14	42	the four which were selected previously from the 13 unions of Narail Upazilla [27]. The selected unions
54 55 -	42	
55]2 56	43	are Auria, Banshgram and Bhardabila. One village (a smallest territorial and social unit for
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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.

151 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.

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168 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).

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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.

187 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.

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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].

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17 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 peerreviewed journals, the results will be disseminated via community briefs and presentations at national and international conferences.

228 **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)

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No education	125 (45 0)	80 (52 2)	55
Primary (1.5)	$\begin{array}{c c} 133 (43.0) \\ \hline 80 (26.7) \end{array}$	<u> </u>	33
Fillinary (1-5)	80 (20.7) 64 (21.2)	<u> </u>	44
Secondary (0-9)	64(21.3)	31(20.7)	3
SSC of HSC Pass (10-12)	1/(5./)	3 (2.0)	14
Degree or equivalent (13 -16)	4 (1.3)	0	
Socio-economic condition:			
Insufficient funds most of the time	97 (32.3)	62 (41.3)	35
Insufficient funds some of the time	124 (41.3)	50 (33.3)	74
Balance	76 (25.3)	37 (24.7)	3
Sufficient funds most of the time	3 (1.0)	1 (0.7)	,
Occupation			
Student	5 (1.7)	0	
Farmers in your own land	42 (14.0)	0	4
Business	24 (8.0)	0	2
Govt/Private Job	3 (1.0)	1 (0.7)	
Daily Labour	44 (14.7)	0	44
Housewives	122 (40.7)	122 (81.3)	
Unemployed	1 (0.3)	0	
Retired	31 (10.3)	19 (12.7)	
Cannot work due to disability	28 (9.3)	8 (5.3)	20
Marital status			
Married	• 244 (81.3)	107 (71.3)	137
Widow	46 (15.3)	41 (27.3)	
Unmarried/never married	9 (3.0)	1 (0.7)	
Divorced/separated	1 (0.3)	1 (0.7)	
Smoking Status			
Never smoker	115 (38.5)	66 (44.3)	49
Past smoker	2 (0.7)	0	
Current smoker	39 (13.0)	1 (0.7)	38
Do not smoke but consume gul etc	110 (36.8)	78 (52.3)	32
Current smoking consumes gul and eating tobacco etc	32 (10.7)	4 (2.7)	28
Smoke and consume other addicted items, gaia, wine, etc.	80 (26 7)	36 (24)	44
	00 (20.7)	50 (21)	

0.0245). The items fit residual (IFR) (M = 0.30, SD = 1.22) and the person fit residuals (PFR) (M = -49 240 51 241 0.18, SD = 0.85) were within the acceptable range (Table 2). All seven items were found to have ordered ⁵³ 54 242 thresholds (Fig. 2), suggesting no problems with the 4-point liker-type scale used in the modified ₅₆ 243 questionnaire.

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Model fit statistics			Tot	al sample N=30	00				
Overall model fit, Chi-square va	lue				44.5				
Degree of freedom (DF)					2				
Р					0.024				
Item fit residuals (mean (SD))				0.30 (1.22					
Person fit residuals (mean (SD))	erson fit residuals (mean (SD))								
Person separation index (PSI)					0.8				
Coefficient alpha					0.8				
Unidimensionality test (% that g	CI)		3.7% C	I (1.2 - 6.1					
for the original set of seven items with four response categories indicating that the scale worked separate persons. A visual examination of the threshold map (Fig. 2) showed that the estimate thresholds defined the categories in all seven items form distinctive regions of the continuum. The examined the category probability curve of each item and found all adjacent categories were the (Fig. 3).									
separate persons. A visual exami thresholds defined the categories examined the category probability (Fig. 3).	nation of the thro in all seven item y curve of each i	eshold ma s form dis tem and f	p (Fig. 2) sh stinctive regi ound all adj	nowed that the ons of the cont acent categories	estimates inuum. W s were the				
separate persons. A visual exami- thresholds defined the categories examined the category probability (Fig. 3). Table 3 Individuals' item fit statis	nation of the thro in all seven item y curve of each i stics of further va	eshold ma s form dis tem and f alidation o	p (Fig. 2) sh stinctive regi ound all adj f the K7 sca tems fit stati	nowed that the ons of the cont acent categories le	estimates inuum. W s were the				
separate persons. A visual exami thresholds defined the categories examined the category probability (Fig. 3). Table 3 Individuals' item fit statis	nation of the thro in all seven item y curve of each i stics of further va	eshold ma s form dis tem and f llidation o ividuals' i SE	p (Fig. 2) sh stinctive regi ound all adj f the K7 sca tems fit stati Residual	howed that the operation on s of the contract categories defined acent categories defined by r^2	estimates inuum. W s were the e P valu				
separate persons. A visual exami thresholds defined the categories examined the category probability (Fig. 3). Table 3 Individuals' item fit statis Items Feel nervous (2)	nation of the thro in all seven item y curve of each i stics of further va Ind Location	eshold ma s form dis tem and f alidation o ividuals' ir SE 0 124	p (Fig. 2) sh stinctive regi ound all adj f the K7 sca tems fit stati Residual -0 224	howed that the operation of the contract categories length is stick of K7 scale χ^2 8 78	estimates inuum. W s were the <u>e</u> P valu				
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separate persons. A visual exami thresholds defined the categories examined the category probability (Fig. 3). Table 3 Individuals' item fit statis Items Feel nervous (2) Feel so nervous (3) Feel hopeless (4) Feel restless or fidgety (5) Feel so restless (6) Everything was an effort (8)	nation of the thro in all seven item y curve of each i stics of further va Location -0.944 0.139 0.049 -0.843 -0.573 1 645	eshold ma s form dis tem and f lidation o ividuals' i SE 0.124 0.123 0.112 0.110 0.110 0.115	p (Fig. 2) sh stinctive regi ound all adju f the K7 sca tems fit stati Residual -0.224 -0.177 1.215 1.993 -0.743 -1 222	howed that the operation of the contract categories acent categories $\frac{\chi^2}{8.78}$ 5.91 1.23 13.09 3.58 7.58	estimates inuum. W s were the P valu 0.06 0.20 0.87 0.01 0.46 0 10				

14	Table 2	Overall	model	fit statistic	s for the	further	validation	of the K7	scale

⁵⁴256 The K7 scale was assessed for DIF across gender (male/female), age (adults/older adults), education (no ⁵⁶ 57 257 education/some education) and socio-economic conditions (low/high) (Table 4). No significant DIF was 12 | P a g e

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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 A	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 E	ducation	al attair	nment	DIF on Se	ocio-ecor	nomic C	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	Feel so nervous	Feel hopeless	Feel restless	Feel so restless	Everythi ng was	Feel so sad (9)
	(2)	(3)	(4)	(5)	(6)	an effort (8)	
Feel nervous (2)	1						
Feel so nervous (3)	0.278	1					
Feel hopeless (4)	-0.128	-0.191	1				

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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	-0.254	-0.228	-0.142	-0.193	-0.142	1	
effort (8)							
Feel so sad (9)	-0.183	-0.213	-0.125	-0.253	-0.215	0.039	1
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13 267 Discussion

¹⁵.268 The inspiration behind the paper was to evaluate the appropriateness of the modified K7 scale (which $_{18}269$ was prior validated from K10) survey for measuring psychological distress in rural Bangladesh for its 20 2 7 0 adaptation in clinical settings. This paper includes Rasch examination to investigate a few issues ²² 271 concerning the K7. The article also incorporates the validity of the category scorings framework, the fit 25 272 of individual items and an evaluation of the potential predisposition of age-sex distribution, education 27 273 attainment and socio-economic status.

³¹ 32 275 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]. 34 276 36 277 However, further validation was required to confirm its use in clinical settings. From the Rasch ³⁸278 examination point of view, the underlying illustrative examination focused on the present rural samples 41 279 of Bangladesh. The modified K7 scale with four response classifications showed no redundancy (little 43 280 impact on the scale) and no misfit. Besides, items were all order thresholds, and scale demonstrated no ⁴⁵ 281 proof of multi-dimensionality.

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It has commonly been assumed that, deduction of items from the scale would reduce at least some 50 283 ⁵² 284 redundancy [48-51]. However, our examination recognised that Cronbach's alpha for the K7 scale (0.89) 5⁴ 285 was comparable to the earlier validated K7 Cronbach's alpha (0.88) [16]; besides, the PSI of K7 (0.85)

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286 was equivalent to the previously validated K7 (0.84) [24]. Previous study demonstrated some redundancy 287 in Cronbach's alpha when contrasting K10 (0.93) and K6 (0.89) [52]. Notwithstanding, the current study 288 demonstrates the prevalent estimation of Cronbach's alpha K7 (0.89) contrasted with the earlier validated 289 K7 (0.88) and K10 (0.87). Therefore, the current study further confirms that the K7 scale is a robust tool 11 290 compared to the K10 [24] in measuring psychological distress in rural Bangladesh.

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16 292 It is widely held view that sexual orientation contrasts in psychological research are omnipresent [53, 17 18 2 9 3 54], so it is fundamental to confirm whether the model is influenced by sex or not. The K7 scale 19 ²⁰ 294 demonstrated no DIF on sex, and is appropriate for any gender, which supports the previous discoveries 21 22 ²²₂₃ 295 announced in Australia [54] and Bangladesh [24]. Another essential factor is age, as there was an 24 25 296 discrepancy with the association among age and psychological distress [55]. An investigation led by 26 ²⁷ 297 Kessler et al. recorded a conventional arrangement of disparity in the association among age [56]. 28 29 ²₃₀298 However, different investigations exhibited a stable nonlinear connection between age and psychological 31 distress in a few cross-sectional epidemiologic studies [55, 57, 58]. The evident from this study suggests 32 299 33 34 300 that there is no age inclination (adults and older adults). 35

38 39 302 Higher levels of psychological distress are present among individuals with lower educational attainment 40 41 303 compared with higher educational attainment [54, 59]. The level of education may influence 42 ⁴³ 304 psychological distress questionnaire responses and may affect the measurement of psychological distress 44 45 ₄₆ 305 levels. A negative relationship between socioeconomic position and psychological distress has been 47 48 306 established in the literature [60], with the low socioeconomic status associated with a higher level of 49 ⁵⁰ 307 psychological distress [61]. Follow-up on these development methods provides an evaluation mechanism 52 53 308 regarding the K7 scale and specifically explores whether it is equally valid across socio-economic

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- 309 conditions and is consistent with educational achievement. We have found that the K7 scale is equally 310 applicable to any educational level as well as any socio-economic status.
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312 Use of the Rasch estimation demonstrated in this study has strengthened the viability of the K7 scale for 11 313 measuring psychological distress in rural Bangladesh. The scale demonstrates a high reliability, ordered 13 314 thresholds and no proof of DIF. The scale additionally demonstrated high PSI (0.85) and reliability 16315 (0.89), which showed the power of the test of fit. This study provides significant evidence that a complete 18 3 1 6 score of psychological distress can be measured, to accelerate finding a legitimate cut-off score for rural ²⁰ 317 people in Bangladesh. Building up a cut-off score can help with evaluating the level of the severity of 22 ⁻⁻₂₃ 318 psychological distress.

²⁷ 320 This paper demonstrates how the Rasch model can be used for intensive examination and improvement 29 ²₃₀ 321 of estimation instruments. The Rasch model display disentangles estimation issues, for example, lack of 31 32 322 invariance (invariance is a property of the model parameters, which "only holds when the fit of the model 33 34 3 2 3 to the data is precise in the population" [62]. However, in real-life applications lack of invariance will 35 ³⁶ 37 324 always be found due to the probabilistic nature of the IRT models), which was disregarded in 38 39 325 conventional analysis [63]. Lessening the number of response categories as well as the number of items 40 41 326 may likewise improve the properties of the scale [24, 64]. It can, therefore, be argued persuasively that 42 ⁴³ 327 the information on the general rural population in regard to psychological distress dependent on the re-44 45 46 328 examined seven-item scale from the K10, with four-response category, is better than the original scale.

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⁵⁰ 330 The Rasch examination contributes valuable information on dimensions of psychological distress among 53 331 the general rural population of Bangladesh. The investigation based on a data set with a wide age 55 332 distribution, from whom data were collected directly through a face-to-face interview. Mobile data

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collection platform CommCare (www.commcarehq.org) [33] was used for data collection. This enhanced

3 4 334 data collection method may assist clinicians by offering a new clinical and research utility. Further, the 5 6 335 K7 scale applied by this strategy may work as a productive screener for psychological distress in various 7 8 336 medicinal services settings, including primary and integrated care facilities. This can caution clinicians 9 10 11 337 to patients who may benefit from a progressively exhaustive psychological assessment or a possible 12 13 338 13 referral for psychiatric care. The K7 scale may likewise assume a job in distinguishing psychological 15 16 3 39 distress earlier and make it more probable that patients receive appropriate care in health services settings. 17 18 3 4 0 Moreover, the K7 scale can be made openly accessible in any health care setting as well as on the web. 19 ²⁰ 341 Given its smallness and straightforwardness in both on the web and paper format, K7 scale might be 22 23 342 supported to individuals searching for a self-detailed assessment measure. 24 25 3 4 3 26 ²⁷ 344 28 The potential limitation of this investigation is that it depends on single-occasion data from people in a 29 ²₃₀ 345 rural region of Bangladesh. While we have attempted further approve the K7 scale in the rural area of 31 32 346 Narail for use in a clinical setting, the investigation would be improved if a national delegate sample 33 34 3 47 were available. 35 ³⁶ 37 348 38 39 349 Conclusion 40 41 3 5 0 In conclusion, the study recommended the utilisation of K7 scale in rural Bangladesh. The research 42 ⁴³ 351 gleaned from this study finding suggests that a seven-item scale taken from the K10, with four-response 44 45 46 352 categories, would give a robust psychometric scale. The K7 scale satisfies all the assumptions of the 47 48 3 5 3 Rasch model. The model has appeared to contain no DIF on age, sex distribution, educational attainment 49 ⁵⁰ 354 and different socio-economic conditions. The K7 scale has no local dependency, and the scale is 51 52 52 53 355 unidimensional. Further examination of K7 scale affirmed that the tool could also be utilised in medical 54 55 356 settings to offer huge advantages as a standard measure of psychological screening instrument for 56

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1 2 357	evaluating psychological distress among the rural Bangladeshi population. Besides, the tool can be
$\frac{3}{5}$ 358	applied in other developing nations where the similar socio-demographic attributes exist. In addition, the
6 7 359	tool can be connected within clinical settings to provide a national dimension with telemedicine, where
8 9 360	mental health conditions cannot be analysed.
10 11 361	
12 13 14 362	Abbreviations
15 16 363	CA: Cronbach's Alpha, DIF: Differential Item Functioning, IFR: Item Fit Residuals, IRT: Item Response
17 18 364	Theory, K7: Modified Seven Item Scale of Kessler Psychological Distress Scale, K10: Kessler
19 20 365	Psychological Distress Scale, PCA: Principal Component Analysis PFR: Person Fit Residuals; PSI:
21 22 22 366	Person Separation Index SD: Standard Deviation
23 2 0 0 0 24 25 367	
26 27 368	Declarations
28 29	Deciarations
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60	For peer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml

1 2 381	Availability of data and materials
3 4 382	The datasets used and/or analysed during the current study are available from the corresponding author
5 6 7 383	on reasonable request
8 0 384	
10	
11 385 12	Author Contributions
$^{13}_{14}386$	MNU and FMAI jointly structured the examination. MNU analysed the data and drafted the manuscript.
16 387	FMAI supervised and reviewed the manuscript. All authors contributed to the development of the
18 388	manuscript, read, and endorsed its final version.
²⁰ 389	
21 22	
23 390 24	Ethics approval and consent to participate
25 391 26	All procedures performed in studies involving human participants were in accordance with the ethical
²⁷ 392 28	standards of the institutional and/or national research committee and with the 1964 Helsinki declaration
²⁹ 30393	and its later amendments or comparable ethical standards. The ethics committee of the Swinburne
31 32 394	University of Technology Human Ethics Committee (SHR Project 2015/065 extended endorsement got
34 395 35	in July 2018) has granted ethical approvals. Written informed consent was acquired from every individual
³⁶ 37 396	member incorporated into the study.
38 39 397	
40 41 398	Consent for publication
42	
⁴³ 399 44	None applicable
45 46 400	
47 48 401	Competing interests:
49 50 402	The authors declare that they have no competing interest
51 ⁴⁰² 52/103	The authors declare that they have no competing interest
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Consent Form:

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

92 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.

04 Please provide your signature or thumb imprint if you agree

608 Signature/thumb imprint

Signature by the interviewer if the participant cannot provide signature.

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Page 27 of 30

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Feel so nervous		
Feel hopeless	1 2 3 4	
Feel restless	1 2 3 4	
Feel so restless	1 2 3 4	
Everything was an effort		1
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STROBE 2007 Statement—Checklist of items that should be included in reports of cross-sectional studies			
Section/Topic	ltem #	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	(<i>a</i>) 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	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings	Pages 8-9, the Rasch model
variables		were chosen and why	
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	

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Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for	Pages 10-11
	_	eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
	_	(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	Table 1, Overview of respondents and o
		exposures and potential confounders	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,	Page 12-14, Table 2-5
		95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(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	Page 17, Paragraph 2
		direction and magnitude of any potential bias	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of	Pages 14-17
		analyses, results from similar studies, and other relevant evidence	
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	Page 18, Funding
		original study on which the present article is based	

*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.

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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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Primary Subject Heading :	Health services research
Secondary Subject Heading:	Health informatics
Keywords:	Kessler psychological distress scale, Rasch analysis, Validation, Rural Bangladesh, K7





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1 2 3	1	Title: Psychometric evaluation of the modified Kessler seven-item version (K7) for measuring
3 4 5	2	psychological distress using Rasch analysis. A cross-sectional study in a rural district of
6 7	3	Bangladesh.
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1 2 3	25	Abstract
4 5	26	Objectives This investigation expected to validate the psychometric properties of the modified 7-item
6 7	27	Kessler psychological distress scale (K7) for measuring psychological distress in healthy rural population
8 9 10	28	of Bangladesh.
11 12	29	Design Cross-sectional study.
13 14	30	Setting Narail district, Bangladesh.
15 16 17	31	Participants A random sample of 300 adults of age 18–90 years were recruited. Face-to-face interviews
17 18 19	32	were conducted between July and August 2018 using an Android phone installed with a mobile data
20 21	33	collection application known as CommCare.
22 23	34	Outcome measure Validation of the K7 was the major outcome. Sociodemographic factors were
24 25 26	35	measured to assess for Differential Item Functioning (DIF) to check if the tool functions equally in
26 27 28 29 30 31 32 33 34 35 36 37	36	different factors. Rasch analysis was carried out for the validation of the K7 scale in the healthy rural
	37	population of Bangladesh. RUMM2030 was used for the analyses.
	38	Results: Results showed good overall fit, as indicated by a non-significant item-trait interaction
	39	(χ 2=44.54, df=28, p=0.0245) compared with a Bonferroni adjusted p-value of 0.007. Both item fit
	40	(mean=0.30, SD=1.22) and person fit residuals (mean=-0.18, SD=0.85) showed perfect fit. Reliability
38 39	41	was very good as indicated by a person separation index (PSI)=0.85 and Cronbach's Alpha (CA)=0.89.
40 41 42	42	All individual items were ordered thresholds. The K7 scale showed adequate reliability,
43 44	43	unidimensionality and was free from local dependency. The K7 scale also showed similar functioning
45 46	44	for adults and older adults, males and females, no education and any level of education, and at least some
47 48 40	45	financial instability vs. no financial instability.
50 51	46	Conclusions: Validation of K7 scale confirmed that the tool is suitable for measuring psychological
52 53	47	distress among the rural Bangladeshi population. Further research should validate the K7 scale in
54 55 56	48	different rural settings in Bangladesh to determine a valid cutoff score for assessment of severity levels
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49	of psychological distress. The K7 scale should also be tested in other developing countries where socio-
50	demographic characteristics are similar to those of Bangladesh.
51	
52	Keywords: Kessler psychological distress scale, Rasch analysis, Validation, Rural Bangladesh
53	Strengths and limitations of this study
54	This study provides the first reliable data on the Kessler K7 scale from a general population of a
55	typical rural district of Bangladesh.
56	> This study used primary data on a K7 scale and application of the Rasch analysis technique was
57	applied to validate the K7 scale instead of Classical Test Theory (CCT).
58	> The data were collected through face-to-face interviews to increase the accuracy of data.
59	> The study provides a unique opportunity to assess psychological distress in a rural population of
60	Bangladesh by using reasonably fewer items.
61	> The potential drawback of this study is that it is based on a single-occasion collection of data
62	from a rural district in Bangladesh which preventing test-retest evaluation or comparison of
63	alternate versions of the same measures.
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74 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.

2 97 The Kessler 10-item scale (K10) is an exception. Developed by Professors' Kessler and Mroczek in 1992, 4 98 K10 was designed to be utilised in the United States National Health Interview Survey as a brief measure 5 6 99 of non-explicit psychological distress along with the anxiety-depression spectrum [14]. The K10 and the 7 8 100 six-item scale K6 was developed concurrently with experimental instruments for assessing psychological 9 10 11 101 distress in people with a variety of mental disorders [15]. The six items for K6 is included in K10. The 12 13 102 K10 and the K6 have been translated and validated in at least 14 countries worldwide [6, 16-18]. The 14 15 K10 tool was initially developed to recognise the levels of non-specific psychological distress in the 16 103 17 18 104 general population and was employed in many countries including Australia, Canada and the USA [15, 19 ²⁰ 105 19-21]. The World Health Organization's World Mental Health Survey also used this tool [22]. The tool 21 22 ₂₃ 106 has also identified a substantial association with severe mental illnesses [23]. As such, clinicians 24 25 107 recommend utilisation of the K10 and the K6 to screen for psychological distress [24, 25]. Although both 26 27 28 108 scales have been validated with various populations and languages, research has indicated that the factor 29 structures of the K10 and the K6 scales differ. For example, one study outlined discrepancies between 31 32 110 the K6's one-factor and two-factor structures [16] while another study outlined discrepancies between 33 ³⁴ 111 the K10's two-factor and four-factor structures [17]. In addition, both the K10 and the K6 cross-cultural 35 37 112 36 validity was not employed in any rural settings including the rural populations of Bangladesh. Such 38 variations in factor structures suggest that further research is needed on the psychometric properties of 39113 41 1 1 4 the K10 and the K6 instruments.

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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 53 119 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 55 120

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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 fourresponse 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.

³139 Materials and Methods

140 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

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145 accounted for 23.2% in Bangladesh [35]. Adult participants aged 18 to 90 years were selected from the 146 Narail Upazilla, which is located around 200 km south-west of Dhaka, the capital city of Bangladesh. 147 Interviews were conducted between July and August of 2018. The study area includes a specific 148 geographic area and 300 survey points of data collection. Data were gathered from three unions (Auria, 11 149 Banshgram and Bhardabila) of the region. This has been described in detail in Fig. 1.

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Sample Size and Statistical Power

18 1 5 2 A sample size of 300 adults of age 18-90 was used for this study. This sample size is appropriate for a ²⁰ 153 Rasch examination since large samples can potentially result in type 1 error that falsely dismiss an item 23 154 for not fitting the Rasch model [36]. A sample size of 300 is viewed as sufficiently substantial to ensure 25 1 5 5 99% confidence that the item difficulty would be within $\pm \frac{1}{2}$ logit of its stable value [37].

₃₀²157 **Sampling Frame**

The cross-sectional study recruited a multi-stage cluster random sample of 320 participant from the rural 32 1 58 ³⁴159 district Narail of Bangladesh in the period of July-August 2018. Data were collected from three unions 37 160 (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 39 161 41 162 Bhardabila. One village (the smallest territorial and social unit for administrative and representative 163 purposes), from each of the chosen unions, were randomly selected at the second level. The selected 46 164 villages were Baliadanga, Fulshor and Rogunathpur. Two paras (further divisions of the village) from 48 165 each selected village were randomly chosen at the third level. In total, 40 adults (18-59 years old) and ⁵⁰ 166 40 older adults (60-90 years old) from each of the villages/wards were interviewed. Interviewers used a 53 167 mobile data collection platform CommCare on their android phone to collect data from the respondents. 55 168 To mitigate the effect of selection bias, 320 respondents were used with an equal proportion of adults

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2 169 3	and older adults, further partitioned into gender. This study excluded 20 participants randomly as 300
4 170 5	participants were deemed sufficient for the Rasch Measurement Theory.
6 7 171	
8 9 172	Data collection using CommCare and its advantage over using a printed questionnaire
11 11 173 12	Mobile data collection is a method employed to collect qualitative and quantitative inputs via a mobile
13 14 174	device (e.g. mobile phone, tablet, etc.). The introduction of mobile devices has mitigated streamlined and
16 175 17	making them more economical and less time consuming [39]. Other benefits include minimising
18 176 19	minimisation of human errors, speeding up reporting, increased flexibility in deploying programmatic
²⁰ 177 21	changes, and provision of accurate location information [40]. With the correct implementation of the
22 23 178 24	mobile data collection tool, these benefits can all be successfully implemented [41]. CommCare is a
25 179 26	customisable, mobile platform, which empowers non-developers to build mobile applications for data
²⁷ 180 28	collection [42]. CommCare allows mobile applications to run offline where gathered information can be
²⁹ 30 181 31	transmitted to CommCareHQ as internet connectivity becomes accessible [43].
32 182 33	
³⁴ 183 35	The current study followed a strict protocol to ensure a smooth launch after the CommCare application
36 37 184	was finalised by pre-testing before training began [44]. The application was pilot tested with 30 people.
39 185 40	The testing found some minor problems associated with respondents not understanding the application
41 186 42	correctly. These concerns were addressed through an upgraded version of the application which was then
43 44 187	distributed for final data collection.
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48 189 49	Modified Kessler Psychological Distress Scale (K7)
⁵⁰ 190 51	The K7 measures developed asked respondents to consider how regularly they encountered of depressive
52 53 191	and anxiety symptoms in the preceding four weeks before screening. Respondents were asked to express
54 55 192 56	how often the following seven symptoms occurred: they felt nervous, so nervous that nothing could calm
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193 them down, hopeless, restless or fidgety, so restless that they could not sit still, so depressed that nothing 194 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 195 196 of the time," "some or most of the time" or "all the time" respectively.

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13 14 198 **Outcome measure**

16 199 The K7 scale is the main outcome measure for assessing psychological distress using Rasch analysis. 18 200 Demographic details were collected for age, gender and level of education and socio-economic ²⁰ 201 conditions.

25 203 **The Rasch Model**

²⁷ 204 The Rasch model was named after Danish mathematician Georg Rasch [45]. The model shows what is 29 ²₃₀ 205 required for reactions to items if estimation (at the measurement level) is to be accomplished most 31 32 206 accurately. Two versions of the Rasch model are available: dichotomous [45] and polytomous [46]. In 33 34 207 this case, the polytomous Rasch model was used. The Rasch model consists mainly of two forms, the 35 ³⁶ 37 208 rating scale model and the partial credit model, which can be used with polytomous results. The partial 38 39 209 credit model is the norm under RUMM2030, which does not restrict threshold parameters and enables 40 41 210 them to differ by item [47]. The likelihood ratio check, which is available in the RUMM2030 programme, 42 ⁴³ 211 tests unregulated parameterization (partial credit model) toward reparameterization. The non-statistical 44 45 46 212 result shows that the definition of the rating scale is to be used, although statistically significant results 47 48 2 1 3 indicate that the partial credit model should be used [48]. An analysis was undertaken, and a significant 49 ⁵⁰ 214 finding was found which encourages the use of the partial credit model. 51

52 53 215 The Rasch analysis utilised in this investigation was conducted using the software package RUMM 2030 55 216 [49]. The Rasch model makes a few hypotheses that should be assessed to guarantee an instrument has

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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 zstatistics (mean=0 and standard deviation (SD)=1) and show ideal fit. Individual item fit (IFR) measurements incorporate the residuals satisfactorily when inside the range \pm 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

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(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.

261 **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 11 | P a g e

- 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 (15
	Mean (SD)	Mean (SD)	Mean (S
Age (in years)	52 (15.7)	51.7 (15.5)	52.8 (1
Age In group	Number (%)	Number (%)	Number
Adult	150 (50.0)	75 (50.0)	75 (5
Elderly	150 (50.0)	75 (50.0)	75 (5
Level of education (number of years schooling)			
No education	135 (45.0)	80 (53.3)	55 (3
Primary (1-5)	80 (26.7)	36 (24)	44 (2
Secondary (6-9)	64 (21.3)	31 (20.7)	33
SSC or HSC Pass (10-12)	17 (5.7)	3 (2.0)	14 (
Degree or equivalent (13 -16)	4 (1.3)	0	4 (
Socio-economic condition:			
Insufficient funds most of the time	97 (32.3)	62 (41.3)	35 (2
Insufficient funds some of the time	124 (41.3)	50 (33.3)	74 (4
Balance	76 (25.3)	37 (24.7)	39
Sufficient funds most of the time	3 (1.0)	1 (0.7)	2 (

33 270 The validation of the K7 scale showed good overall fit to the Rasch model with the Bonferroni adjusted p-value of 0.007 ($\gamma 2 = 44.54 \text{ df} = 28$, p = 0.0245). The items fit residual (IFR) (mean = 0.30, SD = 1.22) 35 271 ³⁷ 272 38 and the person fit residuals (PFR) (mean = -0.18, SD = 0.85) were within the acceptable range (Table 2). 40²⁷³ All seven items were found to have ordered thresholds (Fig. 2), suggesting the respondents have no 42 274 difficulty differentiating between the response's choices with the 4-point liker-type scale used in the K7 44 275 45 scale.

49 277 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

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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 278 ¹⁰ 279 (0.05/7=0.007). Therefore, any p-value greater than 0.007 would consider to be non-significant 280

13 281 No misfit or overfit items were identified with significant chi-square probability values. There was 14 15 282 neither high positive nor high negative residual values (± 2.5) observed. All seven individuals' item fit 16 17 18283statistics showed a good fit with the Bonferroni adjusted p value of 0.007 (Table 3). The value of the PSI 19 20 284 (0.85) for the original set of seven items with four response categories indicated that the scale worked 21 ²²₂₃ 285 well to separate persons. The value of the Cronbach's alpha (0.89) of the K7 scale demonstrates good 24 25²⁸⁶ internal consistency. A visual examination of the threshold map (Fig. 2) showed that the estimates of the 26 27 287 thresholds defined the categories in all seven items that formed distinctive regions of the continuum. We 28 ²⁹ 288 also examined the category probability curve in which each response options systematically take turns, 30 ³¹ 32 289 showing the highest probability of endorsement (Fig. 3).

Location

-0.944

0.139

0.049

-0.843

-0.573

1.645

0.528

Table 3 Individuals' item fit statistics of the K7 scale

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Items

Feel nervous (2)

Feel so nervous (3)

Feel so restless (6)

Feel so sad (9)

Feel restless or fidgety (5)

Everything was an effort (8)

SE=Standard error, P value= Probability value

Feel hopeless (4)

Individuals' items fit statistics of K7 scale

-0.224

-0.177

1.215

1.993

-0.743

-1.222

1.095

P value

0.067

0.206

0.874

0.011

0.466

0.108

0.356

 χ^2

8.78

5.91

1.23

13.09

3.58

7.58

4.39

Residual

SE

0.124

0.123

0.112

0.110

0.110

0.115

0.117

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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)).

Items	DIF on Age				DIF on Gender			
	MS	F	DF	P-value	MS	F	DF	P-value
Feel nervous (2)	1.81	2.25	4 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

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

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 shownin the top half and the item thresholds in the bottom half. The average value of individual logit for the

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308 K7 scale was -0.227 showing well-targeted persons and items fit for the K7 scale. While a negative mean 309 value for the K7 measure may suggest that the participant was located at a lower level (e.g. psychological 310 distress) than the average level of the scale. Overall, the K7 scale was not too difficult to endorse.

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10 11³¹² Discussion

13 3 1 3 The current study investigated the psychometric performance of the K7 in a sample of a healthy and rural 15 314 Bangladeshi population. The inspiration behind the paper was to evaluate the appropriateness of the 17 18 315 modified K7 scale (which was prior validated from the K10 scale) survey for measuring psychological 20 3 1 6 distress in rural Bangladesh. This paper includes Rasch examination to investigate a few issues 22 317 concerning the K7 scale. The article also incorporates the validity of the category scorings framework, ²⁴ ₂₅ 318 the fit of individual items and an evaluation of the potential predisposition of age-sex distribution, ⁻³₂₇ 319 education attainment and socio-economic status.

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³¹ 321 The K10 scale has recently experienced a thorough psychometric examination in rural Bangladesh 33 ³³₃₄ 322 prompting the development of a K7 scale to measure psychological distress in rural Bangladesh [18]. 36 3 2 3 However, further K7 validation was required to confirm its use in rural settings. From the Rasch ³⁸ 324 examination point of view, the underlying illustrative examination focused on the present rural samples 40 41 325 of Bangladesh. The modified K7 scale with four response classifications showed no redundancy (little 43 326 impact on the scale) and no misfit. Moreover, items were all order thresholds, while scale demonstrated 45 327 no proof of multi-dimensionality.

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50 329 It was stated earlier that the scale would be one-dimensional, an important assumption for the 51 52 3 3 0 implementation of IRT used to develop K10 [15]. There is a difference in outcomes for different 53 ⁵⁴ 331 populations with respect to the dimensional structure of the instrument. In some research, K10 and K6 55 56 57 332 were proposed as unidimensional scales [15, 25]. However, other research proposed multidimensional 15 | Page 58 59

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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

356 between age/SES with psychological distress, the lack of DIF simply means that items function the same

357 way with regards to their psychometric properties, irrespective of age and SES group.

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359 To our knowledge, this was the first psychometric assessment on the K7 scale to measure psychological 11 360 distress in Rural Bangladesh. Use of the Rasch estimation demonstrated in this study has strengthened 361 the viability of the K7 scale for measuring psychological distress in rural Bangladesh. The scale 16 362 demonstrates ordered thresholds with no proof of DIF. Moreover, the scale showed high PSI (0.85) and 18 3 6 3 CA (0.89), which also showed the power of the test for fit. This study provides significant evidence that ²⁰ 364 a complete score of psychological distress can be measured and accelerates the finding of a legitimate ⁻⁻₂₃ 365 cut-off score for rural people in Bangladesh. Building up a cut-off score can help with evaluating the 25 366 severity levels of psychological distress.

²₃₀ 368 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 32 369 34 3 7 0 distribution, where data were collected directly through face-to-face interviews. Interviewers used a ³⁶ 37 371 mobile data collection platform CommCare to collect data from the respondents to minimising human 39 372 error and speeding up reporting [44]. Further, the K7 scale applied by this method may work as a 41 373 productive screener for psychological distress across various service settings, including primary and ⁴³ 374 integrated care facilities. This can caution clinicians to patients who may benefit from a psychological 46 375 distress assessment. The K7 scale can be made openly accessible in any health care setting as well as on 48 3 7 6 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.

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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.

388 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

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

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3 Abbreviations

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

409 **Declarations**

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422 Data sharing statement

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

26 Author Contributions

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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
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Fig	. 2 Threshold maps of the K7 scale
Fig	. 3 Category probability curve of all the items of the K7 scale
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Fig	. 4 Dimensionality testing of the K7 scale
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Fig	. 5 Person item threshold distribution map of the K7 scale.
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Fig. 2 Threshold maps of the K7 scale

Feel nervous Feel restless		2	3			4		_
Feel so restless		2	3			4		
Feel hopeless	1	2		3			4	
Feel so nervous	1	2		3			4	
Feel so sad	1	2		3			4	
Everything was an effort	1	2			3			4
	-6 -5 -4 -3 **Disordered threshold	-2 -1	 0 1	2 3	4	5	 6 7	 8 9
	0,							



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.

1 | Page

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)	Everythi ng 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

Section/Topic	ltem #	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					

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

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Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for	Pages 11-12
		eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	
		(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	Table 1, Overview of respondents and on
		exposures and potential confounders	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,	Page 12-15, Table 2-5
		95% confidence interval). Make clear which confounders were adjusted for and why they were included	
		(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		R.	
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	Page 18, Paragraph 1
		direction and magnitude of any potential bias	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of	Pages 15-18
		analyses, results from similar studies, and other relevant evidence	
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	Page 19, Funding
		original study on which the present article is based	

*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.