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Psychometric properties of a Psychological General Well-Being Index (PGWBI) in the Goodville mobile app users

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Abstract: Mobile applications provide new opportunities to study different aspects of a person's mental health. Emotional well-being is one of such aspects. The current study is the first attempt to assess the emotional well-being of mobile game users. The purpose of the study is to substantiate scientifically the possibility of psychometric investigation of the Goodville mobile application users' emotional well-being. The Psychological General Well-Being Index (PGWBI) was applied as the assessment methodology. Data collection was carried out using the Goodville mobile application: Farm Game Adventure, which is a mixture of the classic mobile farm and an app to achieve and maintain emotional well-being. 6573 protocols to the PGWBI questionnaire were studied. Psychometric data analysis was performed using Rasch Measurement analysis. The obtained results demonstrated that the mobile game can be effectively used for remote psychological data collection. The scientific justification of the psychological data remote collection possibility is realized through the analysis of the respondents' answers correspondence to the PGWBI items with the measurement principles of Rusch psychometric technology. The PGWBI methodology has proven to be a reliable and valid tool to collect data on the emotional well-being of different population groups via a mobile game use.

Keywords: well-being; PGWBI; mobile app; Rasch measurement

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1. Introduction

The aim of this study was to assess the psychometric properties of a Psychological General Well-Being Index (PGWBI) in the Goodville mobile app users.

Well-being is a broad, multifaceted umbrella construct [1]. Due to the fact that different aspects of well-being are studied in different areas of knowledge – physical, economical, social, emotional, psychological, etc. [2–7] – there is no single definition of this term. At the same time the model of subjective well-being used for many years includes a cognitive assessment of life (life satisfaction) and two affective components: a high level of positive emotions and a low level of negative emotions [1,8,9].

Affective and cognitive elements are related to each other, but at the same time, in comparison with the cognitive ones, they are more dynamic, more influenced by life events and are more closely associated with such character traits as extraversion and neuroticism. On the other hand, the level of satisfaction with life is more dependent on the level of income and job availability and is less changeable as compared to the affective components [1,8].

The term "subjective well-being" can be used as a synonym for "emotional well-being" (EWB), which has the same meaning, i.e. "positive balance of pleasant to unpleasant affect and a cognitive appraisal of satisfaction with life in general" [10,11].

The role of subjective well-being in ensuring a high quality of life can hardly be overestimated. There are both correlations and causal links between well-being and success in various spheres of life and indicators of somatic and mental health [8,12,13].

In 2015 the United Nations has identified good health and well-being as priority goals by 2030 in its Sustainable Development Goals Policy document (UN General Assembly Resolution 70/1) [14]. Well-being is a valid population index (along with morbidity, mortality and economic status) providing the idea of person's life perception from an individual perspective [15]. Thus, the construct of well-being in general and emotional well-being in particular is an indicator of public health. The development of tools that allow the professionals to assess the level of well-being (and its components) on a population scale is an extremely significant step to improve health system policy in different countries.

The well-being characteristics are directly related to the effective functioning of a person in such areas as health, work, family and economy [16]. People with high levels of well-being are more productive in the workplace and more likely to benefit the community [17].

Hence, the construct "emotional well-being"is an integrative term that determines the effectiveness of a person's functioning in terms of his emotional status. It is determined by the peculiarity of the subject's thinking, behavior and experience - characteristics that can be controlled by the person himself. EWB is directly related to his ability to enjoy life, cope with stressful events and be centered on his significant priorities. The above fundamental characteristics of life quality are mainly mediated by a person's ability to manage and improve his emotional response. In general, a person with a sufficient level of EWB is characterized by mood stability, empathy, ability to manage and show emotional reactions, he accepts himself and others, has positive life perception and is free from anxiety. Development of a strategy for the dynamic EWB construct assessment allows us to provide a tool for its consistent management in the structure of the selfadjusting system of the human psyche.

EWB is an integral part of the "well-being" construct, including, among other things, physical and social well-being in the realization of one's social role and well-being on the workplace. The findings of cross-sectional, longitudinal and experimental studies have confirmed the relationship of the well-being construct with such components of an individual's functioning as self health concept, longevity, health-related behavior, mental and somatic diseases, social cohesion, productivity, factors of physical and social environment [15]. A high level of parameters, determining well-being is associated with a decreased risk of morbidity and injuries, better functioning of the immune system, faster recovery and increased life expectancy [18].

The EWB construct can be measured. Progress in psychology, neuroscience, and the assessment theory suggests that the components of the well-being construct can be measured with a certain degree of accuracy [19]. There are two fundamental approaches to measure the well-being construct [7]: (a) based on psychometric criteria (when the severity of the well-being construct domains is determined) and (b) utilitarian (when individual or group data of a certain state are assessed, e.g. in the range from "0 death to"1 the optimal level of health).

Psychometrically mediated assessment of well-being constructs in general and EWB in particular, is based on the subjective assessment of the respondent. This, in turn, may lead to the likelihood of data distortion, possibly due to the social desirability of the response. One of the ways to solve this problem is to assess the psychometric properties of the applied methods.

Currently the issues of improving the emotional well-being of a person become especially relevant against the background of the pandemic, which doubled (from 25 to 50 %) the proportion of people experiencing a depressed mood [20]. With the outbreak of COVID-19 the hypothesis about the significant impact of the pandemic on mental health and well-being of the population began to be confirmed [21–25]. Herewith, there is reason to believe that emotional well-being suffered dramatically. So, in China, the onset of the epidemic led to a 74 % decline in overall emotional well-being [26]. However, anti-epidemic measures, including lockdowns in various countries, and the direct individual adaptation abilities of people have shown that the level of maladjustment provoked by the pandemic is labile. Thus, in the UK psychological distress rose from the prepandemic levels of 20.8 % in 2019 to 29.5 % in April 2020 and then declined significantly to the prepandemic levels by September (20.8 %) [27].

The pandemic makes it difficult to personally seek professional help, which increasingly prompted the use modern information technologies, in particular, mobile applications, to solve arising emotional problems in users.

There have been many attempts to apply modern mobile information technologies to improve emotional well-being and help patients with mental disorders [28,29]. At the same time, the Goodville: Farm Game Adventure mobile application from GoodGamesSoft is the first entertainment (not serious) game known to us, which, apart from entertainment, is aimed to "maintain emotional well-being" of the user [30].

To assess the emotional well-being of users, the well-known Psychological General Well-Being Index (PGWBI) method, created by the American psychologist Harold Dupuy in the 1960-1980s was chosen. The questionnaire consists of 22 items, allowing the specialists to assess the state on a rating scale from 0 to 5 points in six domains: anxiety, depression, positive well-being, self-control, general health and vitality. To assess each domain from 3 to 5 items of the questionnaire are used. The amount of points on all scales allows us to obtain an overall index of subjective well-being, ranging from 0 to 110 points [31–34].

Psychodiagnostic methods to assess emotional well-being in the framework of entertaining mobile games have not been previously used. So, the goal of the research was to study the psychometric properties of a Psychological General Well-Being Index (PGWBI) in the Goodville mobile app users.

The PGWBI has proven to be a reliable and valid tool to collect data on the emotional well-being of different population groups by means of a mobile game.

2. Materials and Methods

The total amount of 6573 consecutive patterns to the Psychological General Well-Being Index (PGWBI) questionnaire [31,33] were obtained. Data collection was carried out using the mobile game Goodville: Farm Game Adventure, which is a mixture of the classic mobile farm and an app to achieve and maintain emotional well-being [30].

The above mobile application allows the user not only to relax (have a good time), but it also provides information on modern and effective ways to achieve emotional well-being and allows him to assess its degree using current psychodiagnostic techniques. The PGWBI is one of these methods and the article is devoted to its psychometric analysis

Psychometric data analysis was performed using Rasch Measurement (RM) technology. The conceptual core of RM is based on the probabilistic construction of a functional relationship between the patterns of responses to items, item difficulties and the total score according to the scale. Technological RM algorithms provide the construction of an objective additive scale and its quality assessment of compliance with real psychodiagnostic data. The original idea of RM is based on simple logic: the subject's diagnostic responses are determined by two variables – the measure of item difficulty to which the response is given, and the measure of person's construct. Initially, the numerical values of these variables are unknown. However, using special mathematical techniques it is possible to establish the most probable values of the construct and item difficulty measures which are equivalent to each diagnostic response and each total score on the scale. The basic RM equation predicts probability or a chance of obtaining a key response to a diagnostic item of the scale. From this equation, applied to all responses and items, the measurement equal-interval scale unit, called a 'logit' is formed. Mathematically, the procedure for measurement scale construction in RM is carried out on the base of solving a system of differential equations using maximum likelihood method and has an iterative character. The procedure is repeated until the most probable values of the construct and item difficulty measures are defined. The calculated values are presented in the form of logits - decimal fractions with negative and positive signs that form scale of construct measurement. A logit equal to "0"corresponds to a 50 % probability of providing key responses to all items of average difficulty. In terms of interpretation, a zero logit reflects the average level of the construct. Each measure of construct, expressed as a logit, has calculated equivalent relationship with a certain total score. Thus, total raw score as a measuring construct indicator is mathematically substantiated.

Psychometric analysis of data based on RM included the following aspects:

- obtaining responses from a targeted sample of respondents;
- construction of initial matrix of responses of respondents;
- calculation of initial model parameters (response chances, item difficulties, construct measures);
- iterative calculation using maximum likelihood method and Newton-Raphson technique of the most probable values of model parameters (measures of item difficulties, construct measures), equivalent to total raw score of the scale;
- constructing of a scale consisting of total scores, equivalent construct measures expressed in logits and individual measurement errors for each logit value;
- assessing of construct validity of each diagnostic item of psychodiagnostic technique;
- calculation reliability and discrimination indicators (separation statistics) of psychometric scale;
- dividing the scale into statistically significant levels of construct severity.

Goodness-of-fit of persons' responses and goodness-of-fit of items were assessed using WMS and UMS residual indices. WMS is weighted mean square residue index that takes into account outliers in responses, UMS is unweighted mean square residue index. Reference scores of residual indices correspond to the range 0.6 – 1.3. Responses and items with index values below 0.6 are extremely predictable and worsen predictive properties of psychometric scale. Index values exceeding 1.3 indicate that response patterns and items are functioning in an unpredictable way, make excessive noise, thus reducing validity of measurement. Goodness-of-fit indices can be viewed as indicators of item construct validity. Assessing of reliability and discrimination included calculation of reliability index, separation index and index of strata. Reliability index characterizes scale internal consistency. Its value interpretation is equivalent to that of Kuder–Richardson reliability coefficient. Reliability index value should be not less than 0.7. The ideal value is 0.95. Index of strata shows the number of statistically significant strata able to be differentiated by the scale in target sample of respondents. Minimum sufficient of strata is 3.

Determination of construct severity levels was carried out by calculation statistical difference between logits using joined standard error and one-sided criterion of 95 % probability.

The one-sided criterion of 95 % probability (Z = 1.645) was chosen based on fact that in the scale constructed using RM model, all measures of construct are placed in the ascending order. Therefore, statistical calculation of difference between logits is concerned only one-sided statistical hypothesis, i.e. whether the value of each subsequent logit is greater than the previous one. The formula for calculation statistical difference between scale measures is as follows:

$$L_i - L_j < 1.645\sqrt{SEM_{L_i}^2 + SEM_{L_j}^2}, \quad (1)$$

where L_i is a logit with a lower value, L_j is a logit with a higher value, 1,645 is a Z-score for a one-sided test of probability density criterion equal to 95 %, SEM_{L_i} — individual standard error of logit L_i, SEM_{L_j} — individual standard error of logit L_j. If the right side of the inequality exceeds the left- one, difference between measures (values) in logits is statistically significant. Then measure L_i becomes lower boundary of previous level of construct severity, and measure L_j becomes lower boundary of the next level. Measure preceding L_j is upper boundary of the previous level. Further calculations are repeated until the last measure of scale. The level boundaries, expressed in logits, are automatically matched by equivalent total raw scores. Division of the scale into statistically significant levels was carried out sequentially, starting with logit with minimum value, and ended when measure L_j was the last logit with maximum value on the scale. Interpretation of severity levels was based on determination of severity degree of construct, which corresponds to each metric level. The first metric level reflects the lowest level of severity. The lower threshold measure is equivalent to a zero total raw score. All scores belonging to level do not statistically differ from logit with minimal value, which corresponds to a zero total score. In this regard, the first metric level is always interpreted as an extremely low (minimum) level of construct severity. In similar way the last metric level in Rasch scales reflects the maximum degree of construct severity. Metric level containing a zero logit always refers to average level of

severity. This is due to the fact that all measures corresponding to this level do not differ metrically from a zero logit.

3. Results

3.1. Selection of valid response patterns

Data were obtained in amount of 6573 sequences of responses (patterns) to PGWBI items. Selection of valid patterns was carried out based on values of goodness-of-fit residual indices (WMS, UMS). All items were analysed as one general scale of emotional well-being. During the selection process 100 highly predictable patterns (WMS <0.6, UMS <0.6) were removed, including zero, equal, and low-dispersion responses and 1739 responses with a high level of noise (WMS> 1.3, UMS> 1.3). 4735 response patterns (i.e. 70 % from the total sample) were remained for further assessment.

3.2. General Well-Being scale

Table 1 shows values of items difficulties and values of items goodness-of-fit indices for General Well-Being scale.

Table 1. Values of items difficulties and values of items goodness-of-fit indices for General Well-Being scale.

Item	Difficulty	WMS	UMS
1	-0.71	1.16	1.30
2	0.10	1.41	1.61
3	-0.68	0.84	0.81
4	-0.94	1.17	1.21
5	-0.72	0.90	0.89
6	-0.09	1.08	1.06
7	-0.69	0.76	0.77
8	0.16	0.94	0.95
9	-0.46	1.02	1.01
10	-1.15	1.02	0.97
11	-0.74	0.89	0.86
12	0.48	0.97	0.96
13	-0.36	1.12	1.11
14	-1.24	1.16	1.15
15	0.71	1.33	1.32
16	0.09	1.02	1.00
17	-0.55	0.76	0.74
18	-0.31	0.90	0.88
19	-0.42	0.81	0.79
20	-0.17	0.77	0.76
21	0.06	1.06	1.04
22	-0.47	0.98	0.98

The analysis of difficulty parameter values showed that the difficulties of items are within the average range. All items (excluding 2) showed acceptable goodness of fit. Two items (# 2 and # 15) had the worst goodness-of-fit indicators. Item # 2 (WMS = 1.41; WMS = 1.61) deals with a serious physical illness concern, item # 15 (WMS = 1.33; UMS = 1.32) describes a state of fun and cheerfulness. The General Well-Being scale has excellent reliability (0.95). The separation index of the respondents was 4.89. Number of strata = 6.05. 12 statistically independent levels of the General Well-Being severity were defined using the Rusch variable index. Table 2 presents the criteria for each level, including total scores, values in logits with standard errors.

Table 2. The levels of General Well-Being expression.

Total score	Measure in logits	Standard error	Level of severity	Interpretation
0 6	-6,5067 -3,4122	1,83 0,43	0	absent
7 15	-3,2421 -2,3604	0,40 0,28	1	considerably decreased
16 25	-2,2817 -1,7121	0,28 0,23	2	low level
26 36	-1,6593 -1,1943	0,23 0,21	3	low level
37 48	-1,1522 -0,7139	0,20 0,20	4	moderately decreased
49 60	-0,6752 -0,2433	0,20 0,20	5	moderate
61 72	-0,2026 0,2775	0,20 0,22	6	moderate
73 83	0,3249 0,8482	0,22 0,24	7	moderate
84 92	0,9067 1,4432	0,24 0,28	8	moderately increased
93 100	1,5223 2,2226	0,28 0,36	9	high
101 106	2,3562 3,3382	0,37 0,54	10	considerably increased
107 110	3,6684 6,1051	0,61 1,84	11	extremely high

Below (Figure 1) is the histogram of General Well-Being levels distribution among the population of users.

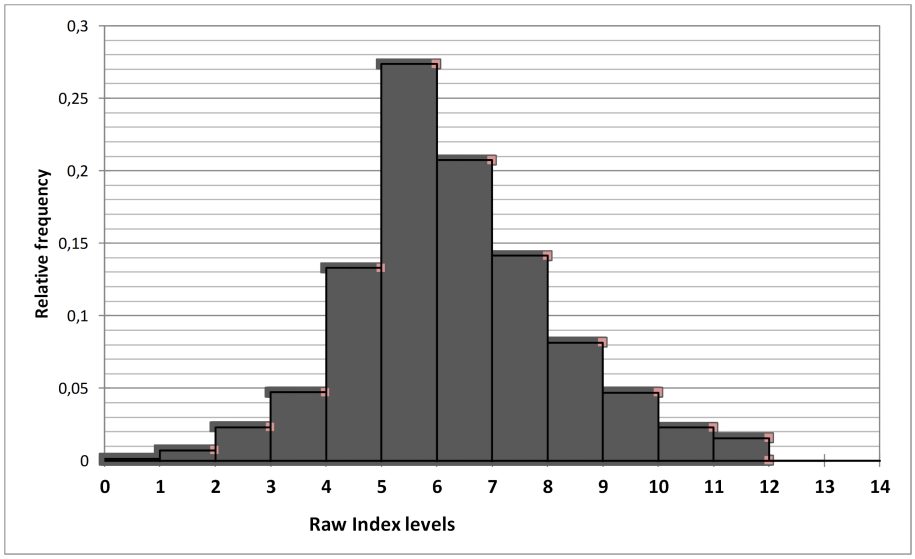

Рис. 1. Distribution histogram of General Well-Being expression levels in the population of users.

Assessment of conformity with normal distribution showed no significance. However, a visual assessment of the histogram shows predominance of medium and increased levels of General Well-Being in the sample of users ($p < 0.05$). Less than 25 % of users have low levels of emotional well-being.

Analysis of differences among users from various countries did not reveal significant differences in levels of General Well-Being (tables 3, 4, 5).

Table 3. Descriptive statistics by the General Well-Being level in different countries.

№	Country	Number of users	Minimum	Maximum	Mean	Std. deviation
1	Australia	264	0,000	11,000	5,678	1,804
2	Belarus	191	1,000	10,000	5,576	1,366
3	Canada	322	1,000	11,000	5,960	1,821
4	India	111	3,000	11,000	5,712	1,371
5	New Zealand	58	3,000	11,000	5,845	1,814
6	Phillippines	25	2,000	11,000	5,360	1,977
7	Singapore	60	3,000	10,000	5,867	1,599
8	USA	3454	0,000	11,000	5,796	1,895

Table 4. Kruskal–Wallis General Well-Being test score.

Indicator	Value
K (Observed value)	7,604
K (Critical value)	14,067
DF	7
p-value (Two-tailed)	0,369
Alpha	0,05

Table 5. General Well-Being P-values for all countries.

Country	1	2	3	4	5	6	7	8
1	1	0,551	0,991	0,144	0,997	0,790	1,000	0,901
2	0,551	1	0,105	0,950	0,458	0,994	0,982	0,964
3	0,991	0,105	1	0,020	1,000	0,574	0,989	0,163
4	0,144	0,950	0,020	1	0,158	1,000	0,660	0,490
5	0,997	0,458	1,000	0,158	1	0,620	0,990	0,854
6	0,790	0,994	0,574	1,000	0,620	1	0,915	0,943
7	1,000	0,982	0,989	0,660	0,990	0,915	1	1,000
8	0,901	0,964	0,163	0,490	0,854	0,943	1,000	1

3.3. Anxiety scale

The GWBS anxiety scale includes 5 items. Table 6 shows the values of difficulty and goodness-of-fit indices of the anxiety scale items.

Table 6. The values of the difficulty and goodness-of-fit indices of the Anxiety scale items.

Item	Difficulty	WMS	UMS
5	0.78	0.93	0.92
8	-0.42	1.02	1.01
17	0.55	0.84	0.82
19	0.37	1.19	1.16
22	0.44	1.03	1

Item difficulties are in moderate range. Construct validity of items is acceptable. The scale reliability is from modest to high (0.87).

Table 7 presents the criteria for each level, including summary scores, measures in logits with standard errors. The scale consists of 6 levels of anxiety.

Table 7. Anxiety expression levels.

Total score	Measure in logits	Standard error	Level of severity	Interpretation
0 3	-5,7388 -2,7024	1,90 0,76	0	absent
4 7	-2,1751 -0,9728	0,70 0,58	1	low level
8 12	-0,6563 0,3449	0,55 0,47	2	average level
13 17	0,5602 1,4609	0,46 0,50	3	moderately increased
18 21	1,7295 2,7761	0,53 0,66	4	high
22 25	3,2481 6,0316	0,72 1,87	5	extremely high

Below in Figure 2 the distribution histogram of Anxiety expression levels in the users population is presented.

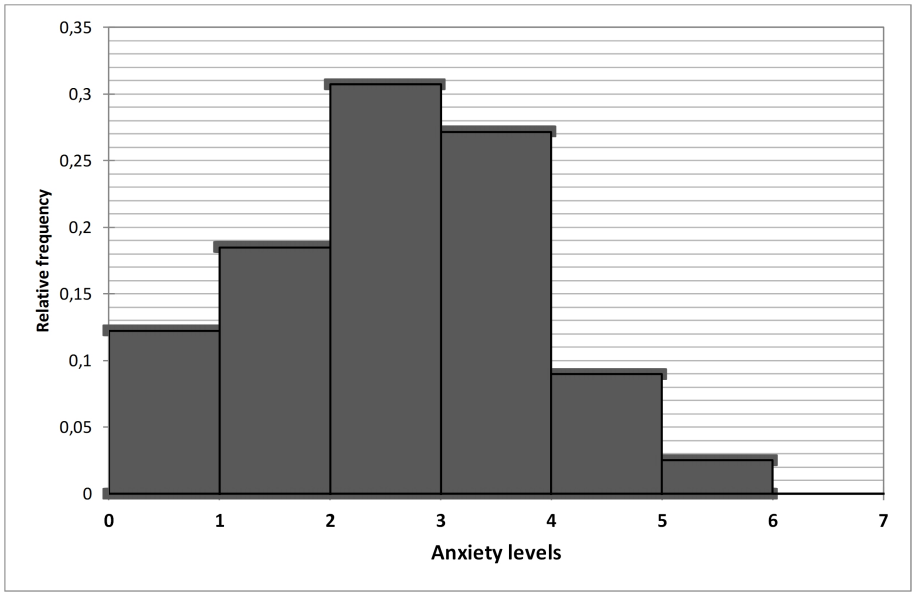

Рис. 2. The distribution histogram of Anxiety expression levels in the users population.

As it follows from the Histogram 2, the most widespread (more than one half of the users, $p<0.05$) were the levels with average and moderately increased anxiety. Only 13 % of users do not report anxiety. The equal percentage (13 %) of users have high levels of anxiety.

No significant statistical differences were found among different countries in terms of the anxiety level (tables 8, 9, 10).

Table 8. Discriptive statistics according to the Anxiety levels.

№	Country	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
1	Australia	264	0	264	0,000	5,000	2,038	1,248
2	Belarus	191	0	191	0,000	5,000	2,199	1,037
3	Canada	322	0	322	0,000	5,000	1,916	1,229
4	India	111	0	111	0,000	4,000	2,279	0,886
5	New Zealand	58	0	58	0,000	4,000	1,862	1,115
6	Phillippines	25	0	25	0,000	5,000	2,480	1,327
7	Singapore	60	0	60	0,000	4,000	2,083	1,062
8	USA	3454	0	3454	0,000	5,000	2,114	1,252

Table 9. Kruskal–Wallis test values to assess differences in Anxiety levels.

Indicator	Value
K (Observed value)	18,098
K (Critical value)	14,067
DF	7
p-value (Two-tailed)	0,012
Alpha	0,05

Table 10. Anxiety P-values for all countries.

Country	№	1	2	3	4	5	6	7	8
Australia	**1**	1	0,551	0,991	0,144	0,997	0,790	1,000	0,901
Belarus	**2**	0,551	1	0,105	0,950	0,458	0,994	0,982	0,964
Canada	**3**	0,991	0,105	1	**0,020**	1,000	0,574	0,989	0,163
India	**4**	0,144	0,950	**0,020**	1	0,158	1,000	0,660	0,490
New Zealand	**5**	0,997	0,458	1,000	0,158	1	0,620	0,990	0,854
Phillippines	**6**	0,790	0,994	0,574	1,000	0,620	1	0,915	0,943
Singapore	**7**	1,000	0,982	0,989	0,660	0,990	0,915	1	1,000
USA	**8**	0,901	0,964	0,163	0,490	0,854	0,943	1,000	1

Only India and Canada are statistically different in terms of Anxiety levels (table 10). The above level is higher among Indian users.

3.4. Depression scale

The Depression scale included only three items. Item scores have been inverted, i.e. counted in reverse. This is due to the fact that in initial version of the scale the lower the total score is, the more severe is depression. Such an alignment contradicts the principles of psychometrics, since a zero score corresponds to the maximum severity of depression, while a zero score should correspond to the minimum severity of the construct.

Table 11 shows indicators of difficulty and values of goodness-of-fit indices of the Depression scale items.

Table 11. Indicators of difficulty and values of goodness-of-fit indices of the Depression scale items.

Item	Difficulty	WMS	UMS
3	0.54	0.92	0.89
7	0.51	1.12	1.06
11	0.65	1.00	0.96

Difficulties of items corresponds to the moderate difficulty range. Construct validity of items is acceptable (Table 11). Scale reliability is moderate (0.81). Separation index is 2.06. Number of strata is 3.09. The scale includes 6 levels of depression severity (Table 12). In Table 12 the criteria for each level are presented, including total scores, measures in logits with standard errors.

Table 12. Depression expression levels.

Total score	Measure in logits	Standard error	Level of severity	Interpretation
0 2	-5,2074 -2,5094	1,93 1,01	0	absent
3 4	-1,5909 -0,8527	0,91 0,81	0	moderately decreased
5 6	-0,2674 0,2046	0,72 0,66	2	average level
7 10	0,6083 1,7344	0,62 0,64	3	moderately increased
11 14	2,1631 4,2252	0,68 1,11	4	high
15	5,5906	1,89	5	extremely high

Below, in Figure 3 , the distribution histogram of Depression severity levels among users is presented. As it follows from the histogram, the most common levels are the ones with absence, low and moderately elevated depression.

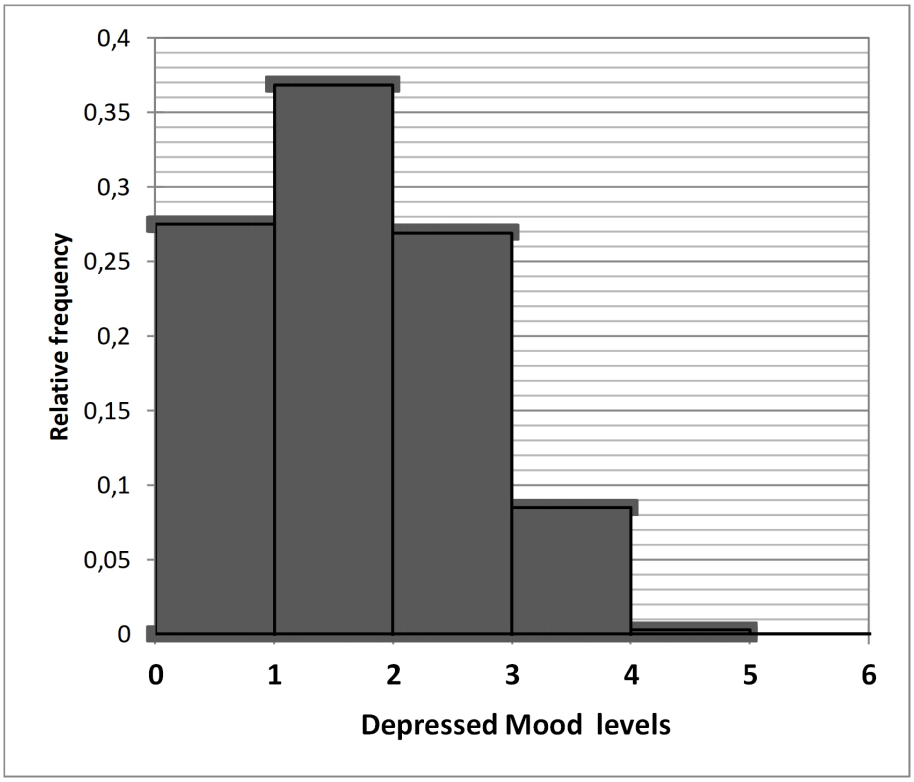

Рис. 3. Distribution histogram of the Depression severity levels in the users population.

Table 13 provides descriptive statistics for different countries in terms of levels of depression severity. Assessment of differences between countries in terms of depression showed significant statistical differences (tables 14, 15).

Table 13. Descriptive statistics by the Depression level in different countries.

№	Country	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
1	Australia	264	0	264	0,000	4.000	1.235	0.997
2	Belarus	191	0	191	0.000	4.000	1.188	0.825
3	Canada	322	0	322	0.000	3.000	1.047	0.904
4	India	111	0	111	0.000	3.000	1.423	0.781
5	New Zealand	58	0	58	0.000	3.000	1.052	0.926
6	Phillippines	25	0	25	0.000	4.000	1.680	0.988
7	Singapore	60	0	60	0.000	3.000	1.150	0.880
8	USA	3454	0	3454	0.000	4.000	1.170	0.946

As it follows from the Table 13, the average number of levels corresponds to moderately reduced depression severity in the majority of countries.

Table 14. Depression values of the Kruskal-Wallis test.

Indicator	Value
K (Observed value)	25.850
K (Critical value)	14.067
DF	7
p-value (Two-tailed)	0.001
Alpha	0,05

Table 15. Depression levels expression in different countries.

Country	Frequency	Sum of ranks	Mean of ranks	Groups	
Canada	322	669174.000	2078.180	A	
New Zealand	58	120928.000	2084.966	A	
Singapore	60	133677.000	2227.950	A	
USA	3454	7724687.500	2236.447	A	
Belarus	191	437929.000	2292.822	A	B
Australia	264	608497.000	2304.913	A	B
India	111	292999.500	2639.635		B
Philippines	25	71963.000	2878.520		B

All countries in terms of the level of depression were divided into two groups. Group A has a statistically lower level of depression while Group B has a statistically higher level of depression (table 15).

3.5. Positive well-being scale

The scale includes 4 items. Table 16 presents the values of item difficulty and quality indices.

Table 16. Values of difficulty and goodness-of-fit indices of the Positive well-being scale items.

Item	Difficulty	WMS	UMS
1	-0,75	1.10	1.12
9	-0.51	0.95	0.94
15	0.75	1.15	1.13
20	-0.17	0.85	0.82

Items are of moderate difficulty. Validity of items is acceptable (Table 16). Scale reliability is moderate (0.81). Separation index is 2.06. Number of strata is 3.08. The scale has 5 levels of Positive well-being. Table 17 presents all indicators by the levels.

Table 17. Values of difficulty and quality indices of the Positive well-being scale items.

Total score	Measure in logits	Standard error	Level of severity	Interpretation
0 4	-5.9668 -2.7375	1.86 0.69	0	absent
5 8	-2.2628 -0.8229	0.69 0.69	1	moderately decreased
9 12	-0.357 0.8018	0.67 0.58	2	average level
13 17	1.1271 2.6048	0.57 0.71	3	high level
18 20	3.2086 5.5554	0.85 1.90	4	considerably increased

Figure 4 below shows the distribution of Positive well-being levels in a sample of users. As it is seen, the average level of Positive well-being is more common. About 32 % of respondents noted low and unsatisfactory levels of Positive well-being.

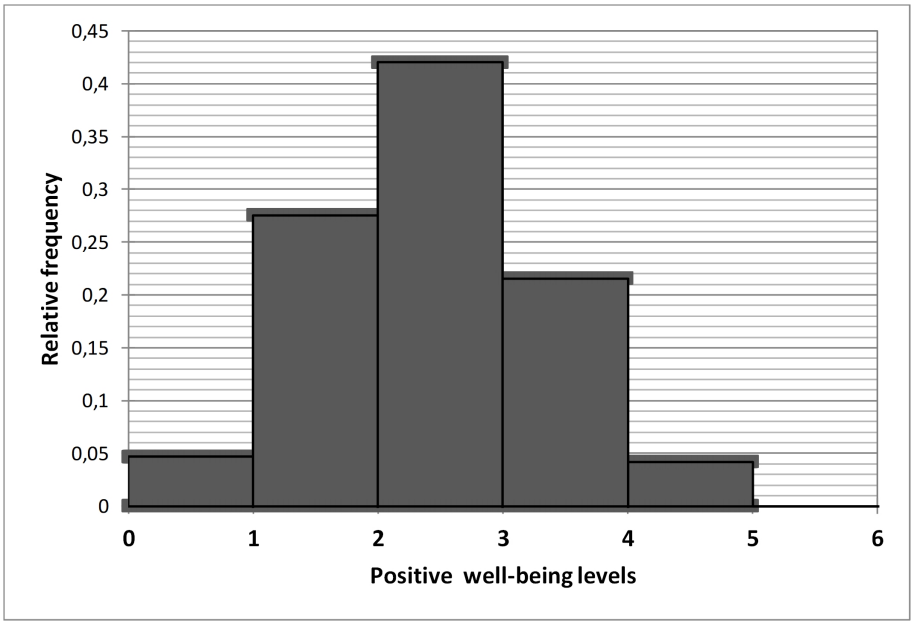

Рис. 4. The distribution histogram of the Positive well-being levels expression in the users population.

The results of comparative Positive well-being level analysis of differences in among users from different countries are presented in the tables 18, 19, 20, 21. As it follows from the presented data, Belarusian users lag behind some countries in terms of Positive well-being.

Table 18. Descriptive statistics by the levels of Positive well-being (expression levels) in different countries.

№	Country	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
1	Australia	264	0	264	0.000	4.000	1.898	0.850
2	Belarus	191	0	191	0.000	3.000	1.670	0.762
3	Canada	322	0	322	0.000	4.000	1.991	0.932
4	India	111	0	111	0.000	4.000	2.108	0.790
5	New Zealand	58	0	58	0.000	4.000	1.948	0.926
6	Philippines	25	0	25	0.000	4.000	1.840	0.850
7	Singapore	60	0	60	0.000	4.000	2.050	0.832
8	USA	3454	0	3454	0.000	4.000	1.932	0.931

Table 19. Assessment of differences among different countries: Positive well-being values of the Kruskal-Wallis test.

Indicator	Value
K (Observed value)	23.570
K (Critical value)	14.067
DF	7
p-value (Two-tailed)	0.001
Alpha	0,05

Table 20. Levels of Positive well-being expression in different countries: multiple pairwise comparisons using the Steel-Dwass-Critchlow-Fligner procedure (Two-tailed test).

Sample	Frequency	Sum of ranks	Mean of ranks	Groups	
2	191	364950.000	1910.733	A	
6	25	52783.000	2111.320	A	B
1	264	580824.000	2200.091	A	B
8	3454	7752468.000	2244.490		B
5	58	131547.000	2268.052		B
3	322	752551.500	2337.116		B
7	60	144599.500	2409.992		B
4	111	280132.000	2523.712		B

Table 21. P-values in terms of Positive well-being for all countries.

Country	1	2	3	4	5	6	7	8
1	1	0.167	0.869	0.211	1.000	1.000	0.918	0.999
2	0.167	1	0.003	< 0.0001	0.469	0.992	0.060	0.007
3	0.869	0.003	1	0.902	1.000	0.985	1.000	0.907
4	0.211	< 0.0001	0.902	1	0.879	0.660	0.999	0.274
5	1.000	0.469	1.000	0.879	1	0.999	0.998	1.000
6	1.000	0.992	0.985	0.660	0.999	1	0.957	0.999
7	0.918	0.060	1.000	0.999	0.998	0.957	1	0.970
8	0.999	0.007	0.907	0.274	1.000	0.999	0.970	1

3.6. Self-control scale

The Self-control includes 3 items. The scale items tend to have a reduced difficulty. The goodness-of-fit index values are in an acceptable range (Table 22).

Table 22. Difficulty and quality indices score of the Self-control scale items.

Item	Difficulty	WMS	UMS
4	-0.71	1.08	1.03
14	-1.03	1.08	0.94
18	0.07	1.03	0.98

The scale is not very reliable (0.71), which is explained by small number of items. The separation index is 1.56. Number of strata is 2.42. Nevertheless, the scale is able to differentiate three levels of self-control. Below in Table 23 the level boundaries are presented.

Table 23. Levels of Self-control expression.

Total score	Measure in logits	Standard error	Level of severity	Interpretation
0	-5.133	1.87	0	absent
4	-1.8854	0.66		
5	-1.4749	0.62	1	low, moderately decreased, moderate
9	-0.1065	0.57		
10	0.2315	0.59	2	moderate , moderately increased, high
13	1.6994	0.92		
14	3.0044	1.41	3	extremely increased
15	4.9429	2.07		

Below in Figure 5 the distribution histogram of Self-control levels in the users population is presented.

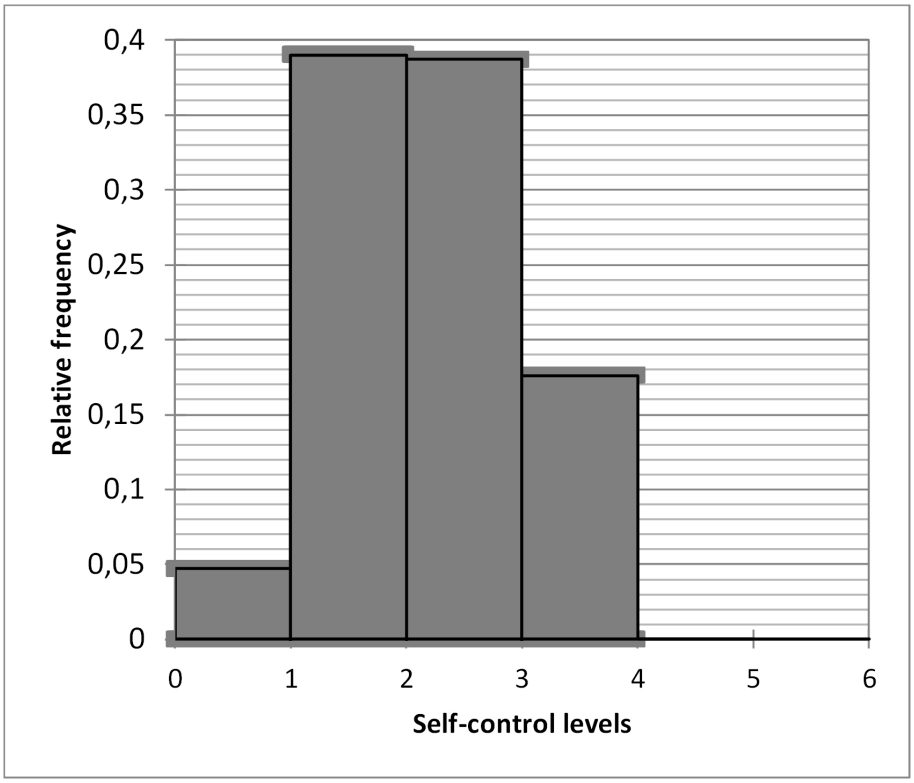

Рис. 5. The distribution histogram of Self-control levels in the population of users.

Unfortunately, due to the low discrimination, it can be concluded that among the population of users dominate levels ranging from low to high self-control, most likely within the range from moderately decreased to moderately increased ones.

The results of the Self-control level comparative analysis among users from different countries presented in Tables 24, 25, 26, 27. No significant differences in the level of Self-control among users from different countries were revealed.

Table 24. Descriptive Statistics by Self-control levels in different countries.

№	Country	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
1	Australia	264	0	264	0.000	3.000	1.595	0.779
2	Belarus	191	0	191	0.000	3.000	1.571	0.627
3	Canada	322	0	322	0.000	3.000	1.758	0.819
4	India	111	0	111	0.000	3.000	1.532	0.672
5	New Zealand	58	0	58	0.000	3.000	1.517	0.800
6	Philippines	25	0	25	0.000	3.000	1.200	0.866
7	Singapore	60	0	60	0.000	3.000	1.483	0.792
8	USA	3454	0	3454	0.000	3.000	1.714	0.824

Table 25. The values of the Kruskal-Wallis test according to the level of Self-control.

Indicator	Value
K (Observed value)	32.617
K (Critical value)	14.067
DF	7
p-value (Two-tailed)	< 0.0001
Alpha	0,05

Table 26. Levels of Self-control expression in different countries: multiple pairwise comparisons using the Steel-Dwass-Critchlow-Fligner procedure (Two-tailed test).

Sample	Frequency	Sum of ranks	Mean of ranks	Groups	
6	25	38736.500	1549.460	A	
7	60	115437.000	1923.950	A	B
5	58	115005.500	1982.853	A	B
4	111	220664.000	1987.964	A	B
2	191	398277.500	2085.223	A	B
1	264	551144.000	2087.667	A	B
8	3454	7864248.000	2276.852	A	B
3	322	756342.500	2348.890		B

Table 27. P-values in terms of Self-control for all countries.

Country	1	2	3	4	5	6	7	8
1	1	1.000	0.152	0.998	0.999	0.313	0.976	0.231
2	1.000	1	0.175	0.984	0.995	0.203	0.938	0.378
3	0.152	0.175	1	0.101	0.412	0.042	0.206	0.974
4	0.998	0.984	0.101	1	1.000	0.491	1.000	0.212
5	0.999	0.995	0.412	1.000	1	0.749	1.000	0.613
6	0.313	0.203	0.042	0.491	0.749	1	0.838	0.065
7	0.976	0.938	0.206	1.000	1.000	0.838	1	0.347
8	0.231	0.378	0.974	0.212	0.613	0.065	0.347	1

3.7. Vitality scale

The scale includes 4 items with moderate difficulties and with acceptable construct validity (Table 28).

Table 28. Difficulty and goodness-of-fit index values of the Vitality scale items.

Item	Difficulty	WMS	UMS
6	-0.16	1.02	1.03
12	0.61	1.17	1.14
16	0.09	0.82	0.82
21	0.08	0.98	0.97

The scale reliability is moderate (0.84). Separation index is 2.32. The number of strata is 3.43. The scale differentiates 5 statistically independent levels of vitality. The level boundaries are shown in Table 29 .

Table 29 provides criteria for each level, including total scores, measures in logits with standard errors.

Table 29. Statistically significant levels of Vitality.

Total score	Measure in logits	Standard error	Level of severity	Interpretation
0 4	-5.558 -2.3852	1.86 0.66	0	absent
5 8	-1.9609 -0.6823	0.64 0.67	1	low, moderately decreased
9 12	-0.2265 1.0295	0.68 0.61	2	moderate, moderately increased
13 16	1.3978 2.5891	0.60 0.68	3	high
17 20	3.0943 6.028	0.75 1.89	4	extremely increased

Distribution of Vitality levels in the users population is shown in Figure 6.

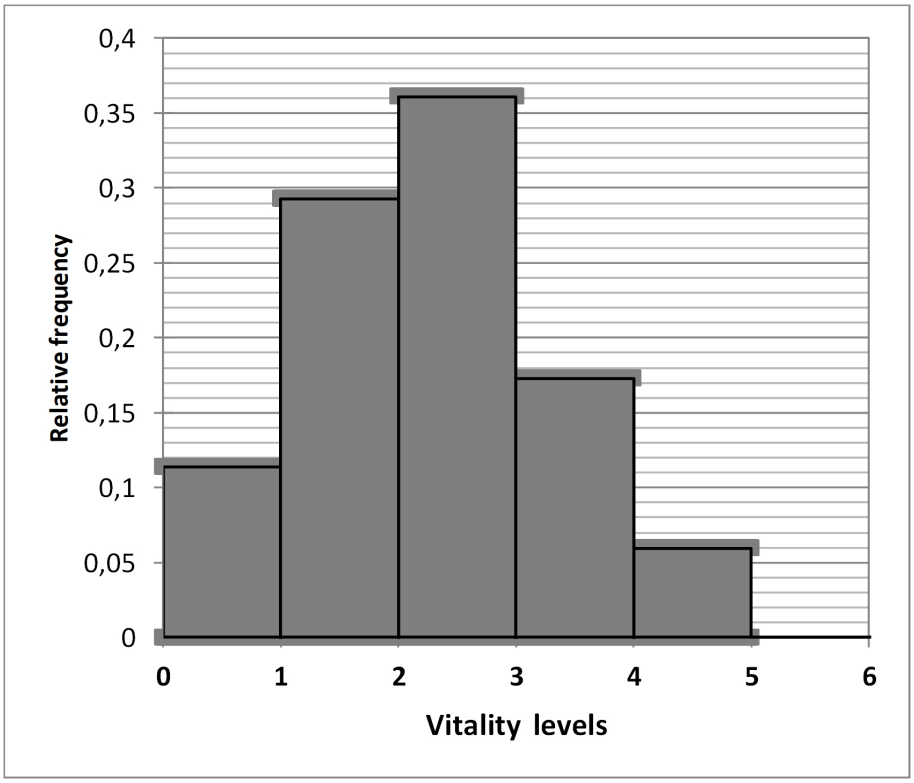

Рис. 6. The distribution histogram of Vitality levels in the users population.

As it follows from the data assessment, a fairly large proportion of users (more than 40 %) report very low (11 %) and low (30 %) levels of Vitality. Only 23 % describe their physical condition as completely good. In the users population dominate low and medium levels.

The findings of a comparative assessment of differences in the level of physical well-being| vitality among users from different countries are shown in tables 30, 31, 32, 33. Indian users showed the highest level of Vitality.

Table 30. Descriptive statistics by the Vitality level in different countries.

№	Country	Observations	Obs. with missing data	Obs. without missing data	Minimum	Maximum	Mean	Std. deviation
1	Australia	264	0	264	0.000	4.000	1.636	1.077
2	Belarus	191	0	191	0.000	4.000	1.586	0.901
3	Canada	322	0	322	0.000	4.000	1.876	1.019
4	India	111	0	111	0.000	4.000	2.261	0.783
5	New Zealand	58	0	58	0.000	4.000	1.655	1.018
6	Philippines	25	0	25	0.000	4.000	2.040	0.841
7	Singapore	60	0	60	0.000	4.000	2.083	0.889
8	USA	3454	0	3454	0.000	4.000	1.754	1.069

Table 31. Values of Kruskal-Wallis test by the level of Vitality.

Indicator	Value
K (Observed value)	57.788
K (Critical value)	14.067
DF	7
p-value (Two-tailed)	< 0.0001
Alpha	0,05

Table 32. Vitality levels in different countries: multiple pairwise comparisons using the Steel-Dwass-Critchlow-Fligner procedure (Two-tailed test).

Country	Frequency	Sum of ranks	Mean of ranks	Groups		
Belarus	191	389366.500	2038.568	A		
Australia	264	550688.000	2085.939	A	B	
New Zealand	58	124760.000	2151.034	A	B	
USA	3454	7678567.000	2223.094	A	B	
Canada	322	761241.500	2364.104	A	B	
Philippines	25	63469.000	2538.760	A	B	C
Singapore	60	159165.500	2652.758		B	C
India	111	332597.500	2996.374			C

Table 33. Vitality P-values for all countries.

Country	1	2	3	4	5	6	7	8
1	1	1.000	0.159	< 0.0001	1.000	0.631	0.051	0.714
2	1.000	1	0.075	< 0.0001	0.999	0.444	0.011	0.568
3	0.159	0.075	1	0.000	0.942	0.999	0.779	0.580
4	< 0.0001	< 0.0001	0.000	1	0.001	0.317	0.763	< 0.0001
5	1.000	0.999	0.942	0.001	1	0.932	0.369	1.000
6	0.631	0.444	0.999	0.317	0.932	1	0.999	0.923
7	0.051	0.011	0.779	0.763	0.369	0.999	1	0.180
8	0.714	0.568	0.580	< 0.0001	1.000	0.923	0.180	1

3.8. General Health scale

The scale includes 3 items with moderate and reduced difficulties. All items have acceptable goodness-of-fit index values. Table 34 presents indicators of difficulty and values of goodness-of-fit indices of items on the General health scale.

Table 34. Difficulties and goodness-of-fit index values of the General Health scale items.

Item	Difficulty	WMS	UMS
2	0.19	0.98	0.99
10	-1.01	1.14	1.07
13	-0.25	0.92	0.91

303 The reliability of the scale is moderate (0.76). Separation index is low (1.78). The number of
304 strata also has low values (2.7). At the same time the scale differentiates 5 statistically significant
305 levels of General Health expression (Table 35).

Table 35. General Health expression levels.

Total score	Measure in logits	Standard error	Level of severity	Interpretation
0	-5.0543	1.97	0	extremely low
4	-1.7121	0.58		
5	-1.3887	0.56	1	moderately decreased, moderate
9	-0.0566	0.64		
10	0.3987	0.71	2	moderate, high
13	2.2377	0.90		
14	3.2945	1.19	3	extremely high
15	4.8112	1.95		

306 Distribution of General Health levels among users is shown in Figure 7.

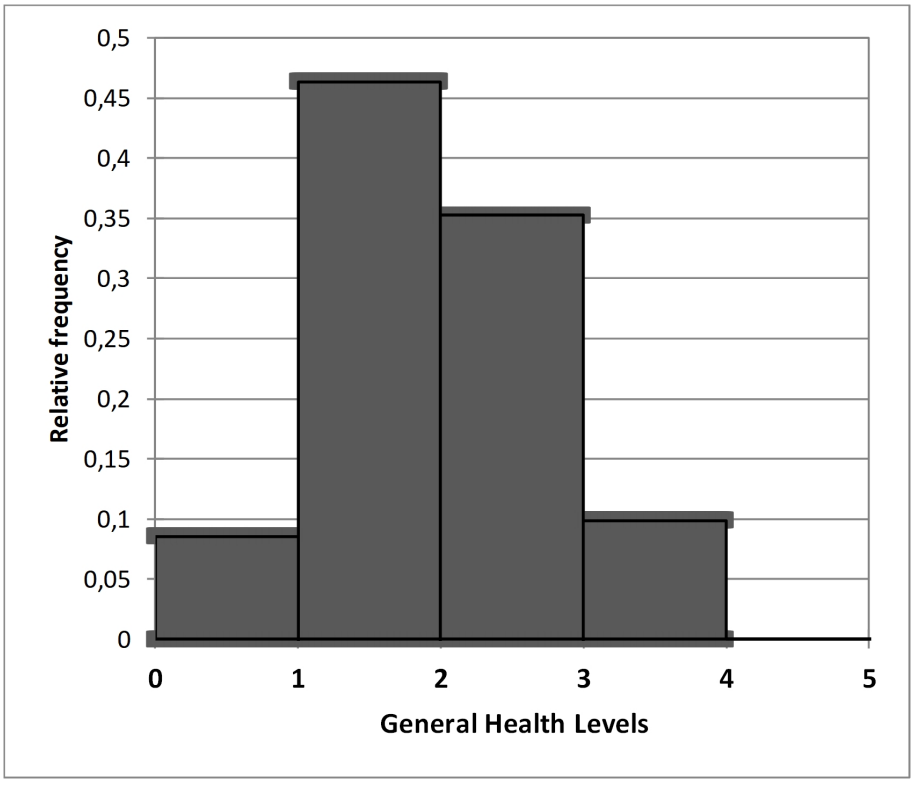

Рис. 7. The distribution histogram of the General Health levels in users population.

As it follows from the data assessment the overwhelming majority of users (80 %) note that they have moderately low, medium and high levels of General health. Less than 10 % characterize their General health as bad.

The data of General health level differences obtained in the course of comparative analysis of users from different countries are given in tables 36, 37. No statistically significant differences in the level of General health among users from different countries were revealed.

Table 36. General health level descriptive statistics in different countries.

№	Country	Observations	Minimum	Maximum	Mean	Std. deviation
1	Australia	264	0.000	3.000	1.409	0.745
2	Belarus	191	0.000	3.000	1.576	0.728
3	Canada	322	0.000	3.000	1.494	0.782
4	India	111	0.000	3.000	1.315	0.763
5	New Zealand	58	0.000	3.000	1.379	0.745
6	Phillippines	25	0.000	3.000	1.280	0.614
7	Singapore	60	0.000	3.000	1.517	0.701
8	USA	3454	0.000	3.000	1.466	0.793

Table 37. Values of the Kruskal-Wallis test by the level of General health.

Indicator	Value
K (Observed value)	13.647
K (Critical value)	14.067
DF	7
p-value (Two-tailed)	0.058
Alpha	0,05

3.9. Intercorrelation links between scales

The values of the correlation coefficients are presented below in tables 38 (raw scores) and 39 (levels). Indicators on all scales of the questionnaire have significant moderate and high correlations with each other.

Table 38. Correlation links between the questionnaire scales (raw points).

Variables	GWB	ANX	DEP	PWB	SC	VT	GH
GWB	1	-0.902	-0.864	0.840	0.811	0.819	0.776
ANX	-0.902	1	0.799	-0.669	-0.693	-0.621	-0.646
DEP	-0.864	0.799	1	-0.643	-0.695	-0.573	-0.631
PWB	0.840	-0.669	-0.643	1	0.621	0.746	0.547
SC	0.811	-0.693	-0.695	0.621	1	0.571	0.553
VT	0.819	-0.621	-0.573	0.746	0.571	1	0.586
GH	0.776	-0.646	-0.631	0.547	0.553	0.586	1

Table 39. Correlation links between the questionnaire scales (levels).

Variables	GWB	ANX	DEP	PWB	SC	VT	GH
GWB	1	-0.861	-0.801	0.793	0.754	0.778	0.727
ANX	-0.861	1	0.743	-0.617	-0.643	-0.580	-0.592
DEP	-0.801	0.743	1	-0.584	-0.634	-0.517	-0.565
PWB	0.793	-0.617	-0.584	1	0.562	0.681	0.500
SC	0.754	-0.643	-0.634	0.562	1	0.514	0.502
VT	0.778	-0.580	-0.517	0.681	0.514	1	0.544
GH	0.727	-0.592	-0.565	0.500	0.502	0.544	1

The analysis of correlations shows their expected character. For example, the Depression scale (DEP) has positive relationships with the Anxiety scale (ANX) and negative correlations with positive questionnaire scales (General well-being (GWB), Positive well-being (PWB), Self-control (SC), Vitality (VT), General health (GH)).

4. Discussion

For the first time findings of the research confirmed validity of mobile games application for collecting psychological data from different population groups. The questionnaire scales have close correlations with each other. This is expected, since all scales of the questionnaire describe different aspects of one and the same construct, i.e. emotional well-being.

This aim of this study was to measure emotional well-being by collecting data using a mobile game. The PGWBI questionnaire including 7 scales was used. The players provided their responses to the questionnaire items in the mobile game.

The effectiveness of remote psychological data collection technology is realized through the analysis of respondents' answers compliance to PGWBI items with the measurement principles of Rusch psychometric technology. The selection of responses was carried out according to the values of response quality indices. Based on the obtained data a psychometric analysis of all scales was performed with Rasch Measurement technology application.

The results of the analysis showed validity and satisfactory reliability of the questionnaire scales. All scales were divided into statistically significant levels of a construct.

5. Conclusions

The obtained results demonstrated that the mobile game Goodville: Farm Game Adventure can be effectively used to collect psychological data remotely using the Psychological General Well-Being Index (PGWBI).

Rasch Measurement procedures make it possible to select valid patterns of responses to conduct a full psychometric analysis of questionnaire scales used to assess psychological constructs in a mobile game in case of remote data collection.

The PGWBI methodology has proven to be a reliable and valid tool to collect data on the emotional well-being of different population groups via the use of a mobile game.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study in the form of confirmation with the terms of use of the application and granting permission to use user data. User data was collected and processed in an abbreviated, anonymized form.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to privacy.

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Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations

The following abbreviations are used in this manuscript:

ANX	Anxiety
DEP	Depression
GH	General health
GWB	General well-being
PGWBI	Psychological General Well-Being Index
PWB	Positive well-being
SC	Self-control
VT	Vitality
UMS	Unweighted mean squares //Невзвешенный среднеквадратичный индекс остатков
WMS	Weighted mean squares //Взвешенный среднеквадратичный индекс остатков

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