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Diagnostic test study: Combination Use of Beck Depression Inventory and Two-Question Case-Finding Instrument as a Screening Tool for Depression in the Workplace

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ABSTRACT

Objectives: The present study aimed to validate screening tools that could be used to identify depression among workers.

Design: Diagnostic test study.

Settings: Workers from three Japanese companies agreed to participate.

Participants: Recruitment for the group 1 occurred between January 2001 and February 2004, and it included 90 workers in a company who agreed to participate. One participant did not complete the questionnaires; 89 (98.8%) took part in the study. Recruitment for the group 2 occurred between July 2000 and February 2004 and 1591 workers from three companies agreed to participate. Ninety-one participants did not complete the questionnaire; 1500 (94.2%) took part in the study. Demographic data are shown in Supplementary table 1.

Interventions: -

Primary and secondary outcome measures: The Beck Depression Inventory (BDI) and a two-question case-finding instrument (TQI) were administered to 89 workers and Mini-International Neuropsychiatric Interview was conducted to verify the diagnosis of depression. A second group of 1500 workers completed the BDI and TQI to detect possible sample bias for the distribution of depression. Specificity, sensitivity and PPV were calculated in order to obtain the optimal cutoff scores for BDI and TQI and receiver operating characteristic curves (ROC) and Youden index were applied to further refine the optimal cutoff scores.

Results: When paired together, BDI score ≥ 10 and TQI score of 2 adequately identified workers who had major depressive disorder (MDD) and those who had other psychiatric disorders that are frequently comorbid with MDD.

Conclusions: The combination of BDI score ≥ 10 and TQI score of 2 can adequately screen for current and potential cases of depression among workers. Furthermore, BDI and TQI offer

the advantage of being relatively easy to administer to a large number of workers. Early detection of depression could improve treatment outcomes and decrease economic burden.

Trail registration:-

ARTICLE SUMMARY

Article focus

- Even though the magnitude of productivity loss from depression is substantial, a large number of depressed workers are untreated or inadequately treated.
- The aim of the present study was to establish an efficient way to identify workers who were diagnosed as having MDD (= workers with depression) and those who were not diagnosed as having MDD but had other psychiatric disorders that are frequently comorbid with MDD (= workers with comorbid disorders)

Key messages

- We conclude that combined application of Beck Depression Inventory (BDI) and a two-question case-finding instrument (TQI) is an efficient way to identify not only workers who are depressed but also those who are likely to be depressed in the workplace.
- Although further investigations using larger samples are needed, the BDI and TQI combination is a useful screening tool, especially for big companies that have many employees.

Strengths and limitations of this study

- Our study use relatively large sample for evaluation of the receiver operating characteristic (ROC) curves and Youden Indices in order to calculate the optimal cutoff point for depression in the workplace. Furthermore better sensitivity and specificity was achieved by an additional use of TQI.
- The limitation of our study is that effects of socio-economical and clinical factors which are considered to be associated with depression (e.g., alcohol intake) were not included in the analysis.

INTRODUCTION

Depression is a highly prevalent disorder that is associated with enormous economic costs. Major depressive disorder (MDD) was estimated to affect 18.1 million people living in United States in 2000, and to have lifetime prevalence of 16.2% and an annual prevalence of 6.6%.[1, 2] The total economic burden (both direct and indirect costs) of depression was estimated to be more than 83 billion U.S. dollars and 118 billion euros in the United States and Europe, respectively.[1, 3] In Japan, MDD was estimated to have an annual prevalence of 2.2% and 7.0% of white collar workers were reported to meet the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria for major depressive episode and score more than 40 points (depressive range) on the self-rating depression scale (SDS).[4, 5] The annual societal cost of depression and suicide was estimated at 2.7 trillion yen.[6] Based on the epidemiological trends, depression will become the second-leading cause of global disease burden by 2020,[7] and is expected to rank first in disease burden in high-income countries by the 2030.[8]

The economic burden of depression is attributed to functional impairment of employees due to physical and cognitive symptoms. Moreover, the prevalence of depression is highest in the age group of 15-64 years, which corresponds to the typical working age.[9] Indeed, it was reported that depressed workers in the United States have 1.5-3.2 times more short-term work-disability days per month than people who were not depressed.[10]

Furthermore, the European ESEMeD study revealed that depressed workers had 3-4 times more work-loss days per month compared to workers without depression.[11] In addition to the cost of depression-related absenteeism, presenteeism, the state in which depressed workers stay at work but have reduced productivity as a result of their condition, needs to be considered. Almost half of people with chronic depression reported reduced productivity at work and the costs of productivity loss associated with MDD in the United States (in 2002)

have been estimated at over 31 billion U.S. dollars.[12, 13] Kessler et al. showed that MDD was associated with 8.7 days of absenteeism and 18.2 days of lost productivity per year at a cost of 4,426 U.S. dollars per person annually, and when these data were inflated to the entire adult population of the United States, productivity losses were estimated at 36.6 billion U.S. dollars.[14, 15]

Even though the magnitude of productivity loss from depression is substantial, a large number of depressed workers are untreated or inadequately treated.[2, 16, 17] The increasing duration of untreated illness (DUI) may be associated with worse treatment outcomes of depression.[18] Many studies have reported that DUI is a predictive factor for treatment outcome.[19-21] In addition, early treatment of the first depressive episode is important because our previous study showed that a shorter DUI implied better remission outcomes in patients with the first MDD.[22] Therefore, early identification of depressed workers is crucial in order to improve treatment outcomes and reduce cost.[2, 16] Moreover, since it is difficult to interview and evaluate all employees, an efficient screening tool for depression among workers is needed.

The aim of the present study was to establish an efficient way to identify workers who were diagnosed as having MDD (= workers with depression) and those who were not diagnosed as having MDD but had other psychiatric disorders that are frequently comorbid with MDD (= workers with comorbid disorders). We identified workers with depression using Mini-International Neuropsychiatric Interview (M.I.N.I.) and investigated an optimal pair of cutoff scores using a combination of Beck Depression Inventory (BDI) and a two-question case-finding instrument (TQI) for depression screening. Afterwards, we examined the specificity and sensitivity of the screening procedure for identification of both workers with depression and those with comorbid disorders. The current study is a continuation of the preliminary research conducted in 2003.[23] In addition to the larger sample size used in the current study, we evaluated the receiver operating characteristic (ROC) curves and Youden

Indices in order to calculate the optimal cutoff point for depression in the workplace.

MATERIALS AND METHODS

Participants

We selected two groups of participants. Group 1 was established in order to investigate the optimal pair of cutoff scores of BDI and TQI for screening of depression. Participants in Group 1 answered both BDI and TQI and their diagnosis was confirmed using the M.I.N.I. The M.I.N.I. Japanese version was used as a diagnostic standard for identifying cases. Recruitment occurred between January 2001 and February 2004, and it included 90 workers in a company who agreed to participate. One (1.1%) participant did not complete the questionnaires; 89 (98.8%) took part in the study.

Group 2 was established in order to investigate the sampling bias in the distribution of depression severity among Group 1, which was a relatively small sample size. In Group 2, a large number of subjects were necessary; therefore, only BDI and TQI were performed and the M.I.N.I. assessment was omitted. Recruitment occurred between July 2000 and February 2004 and 1591 workers from three companies agreed to participate. Ninety-one (5.7%) participants did not complete the questionnaire; 1500 (94.2%) took part in the study. Demographic data of participants in each group are shown in Supplementary table 1.

Measurements

Beck Depression Inventory (BDI)

The BDI, developed by Beck et al., is one of the most widely used self-rating questionnaires for measuring the severity of depression.[24] The BDI-I is a 21-item scale (range 0-60). We used the Japanese version of BDI-I, which has been validated and is widely used in

Japan.[25]

Two-question case-finding instrument (TQI)

A two-question depression-screening tool developed by Whooley et al. was extracted from the Primary Care Evaluation of Mental Disorders (PRIME-MD) questionnaire.[26, 27] It includes two questions about depressed mood and anhedonia: (1) “During the past month, have you often been bothered by feeling down, depressed, or hopeless?” and (2) “During the past month, have you often been bothered by little interest or pleasure in doing things?” The TQI operates in the range of many other validated depression-screening tools, and it eases the burden of administration by being succinct. For the two-question instrument, a “yes” answer to either of the two questions was considered to indicate a positive result.

After obtaining consent from the author of the original work, the original TQI was carefully translated into Japanese. The semantic fidelity of the Japanese version of TQI was ascertained by means of back translation, whereby the first Japanese version was translated back into English by an independent researcher blind to the original English version, and any discrepancies between the original and the re-translations were corrected until the two were semantically equivalent.

Criterion Standard

The M.I.N.I. is a short structured diagnostic interview, developed jointly by psychiatrists and clinicians in the United States and Europe, for DSM-IV and International Classification of Diseases, Tenth Edition (ICD-10) psychiatric disorders.[28] With an administration time of approximately 15 minutes, M.I.N.I. was designed to meet the need for a short but accurate structured psychiatric interview for multicenter clinical trials and

epidemiology studies and to be used as a first step in outcome tracking in non-research clinical settings. Trained psychiatrists and clinical psychologists performed the Japanese version of M.I.N.I. structured interview, and the results were used to validate the optimal pair of cutoff scores of BDI and TQI.

Study Design and Procedure

In Group 1, participants were assessed by BDI and TQI and then they were additionally diagnosed using the M.I.N.I. In Group 2, only BDI and TQI assessments were performed. Subsequently, we investigated the frequency distributions of BDI and TQI in two groups and compared them to confirm that there were no significant differences between the two experimental groups. After confirming that Group 1 was not a biased sample, we explored the optimal pair of cutoff scores of BDI and TQI for identifying workers with depression.

The frequency distributions of BDI and TQI were compared using Mann-Whitney U test ($p < 0.05$) to examine whether there were statistical significant differences between the two groups. The sensitivity (Se), specificity (Sp), and positive predictive value (PPV) were calculated for all possible cutoff scores for BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI to identify workers with depression in Group 1. Sensitivity refers to the proportion of correctly identified cases and specificity to the proportion of correctly identified non-cases. PPV is the probability that depressed workers identified using the optimal cutoff score are cases according to the M.I.N.I.

To determine the optimal cutoff point, the receiver operating characteristic (ROC) curve was created for all possible cutoff scores of BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI. The Youden Indices were calculated, concurrently. The ROC curve is a popular graphical method of displaying the discriminatory accuracy of a diagnostic test for distinguishing between two populations. The ROC curve is a plot of Se and 1 - Sp for all

possible cutoff scores of the test. To evaluate the discriminatory ability of a diagnostic test, it is common to summarize the information of the ROC curve into a single global value or index.[29] The Youden Index is the easiest to apply and frequently used in practice. This index can be defined as {Se + Sp - 1} and provides a criterion for the "optimal" threshold value; the threshold value for which Se + Sp -1 is maximized.[30]

Furthermore, we applied the screening thresholds to identify workers with comorbid disorders in additions to those with depression. The Se, Sp, and PPV were calculated for all possible cutoff scores for BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI to identify both workers with depression and those with comorbid disorders. Subsequently, the ROC curve was created and the Youden Indices were calculated.

RESULTS

The frequency distributions of BDI and TQI in each group are presented in Table 1 and 2, respectively. Mann-Whitney U test revealed that there was no significant difference in the frequency distribution of BDI between the two groups. However, significant difference was found in the frequency distributions of TQI between two groups ($p = .003$). The diagnoses of the participants in Group 1 based on M.I.N.I. are listed in Table 3.

Table 1

Frequency distributions of Beck Depression Inventory

	Group 1		Group 2	
Score	N	%	N	%
0	22	24.7	428	28.5
1	11	12.4	213	14.2
2	8	9.0	181	12.1
3	7	7.9	131	8.7
4	3	3.4	104	6.9
5	7	7.9	83	5.5
6	6	6.7	72	4.8
7	5	5.6	47	3.1
8	2	2.2	39	2.6
9	2	2.2	34	2.3
10	3	3.4	27	1.8
11	3	3.4	17	1.1
12	1	1.1	27	1.8
13	1	1.1	16	1.1
14	0	0	13	0.9
15	2	2.2	16	1.1

16	1	1.1	13	0.9
17	1	1.1	10	0.7
18	3	3.4	6	0.4
19	0	0	2	0.1
20	0	0	4	0.3
21	0	0	1	0.1
22	0	0	2	0.1
23	1	1.1	2	0.1
24	0	0	0	0
25	0	0	1	0.1
26	0	0	3	0.2
27	0	0	1	0.1
28	0	0	1	0.1
29	0	0	1	0.1
30	0	0	0	0
31	0	0	1	0.1
32	0	0	0	0
33	0	0	0	0
34	0	0	0	0
35	0	0	0	0
36	0	0	2	0.1
37	0	0	0	0
38	0	0	0	0
39	0	0	0	0
40	0	0	1	0.1
41	0	0	0	0
42	0	0	1	0.1

Table 2

Frequency distributions of two-question case-finding instrument

Number of 'yes' answers	Group 1		Group 2	
	N	%	N	%
0	51	57.3	1097	73.1
1	25	28.1	229	15.3
2	13	14.6	174	11.6

Table 3

The diagnoses of participants in Group 1 according to Mini-International Neuropsychiatric Interview

Diagnosis	N	%
No diagnosis	60	67.4
Substance use disorder	16	17.9
Anxiety disorder	6	6.7
Major depressive disorder	3	3.3
Bipolar disorder	1	1.1
Dysthymia	1	1.1
Bipolar disorder + Substance use disorder	1	1.1
Major depressive disorder + Substance use disorder + Anxiety disorder	1	1.1

The sensitivity, specificity, and PPV for all possible cutoff scores of BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI to identify workers with depression are listed in Table 4. The ROC curves are showed in Supplementary figure 1 and the Youden Indices are listed in Table 4. The maximum value of the Youden Index was derived from neither BDI nor TQI alone but the combination of the BDI and TQI: 0.776 at the point of BDI score ≥ 10 and TQI score = 2. The pair of scores of BDI ≥ 10 and TQI = 2 was considered to be optimal to identify workers with depression; both those whose BDI score was ≥10 and those whose TQI score was = 2 were defined as “cases”.

Table 4

The sensitivity, specificity, positive predictive value (PPV), and Youden Indices for all possible cutoff scores for Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores of BDI and TQI to identify workers who were diagnosed with major depressive disorder.

		Sensitivity	Specificity	PPV	Youden Index
BDI cutoff score					
4		100	56.4	9.7	0.564
5		100	60.0	10.5	0.600
6		75.0	67.0	9.6	0.420
7		75.0	74.1	12.0	0.491
8		75.0	80.0	15.0	0.550
9		75.0	82.3	16.6	0.573
10		75.0	84.7	18.7	0.597
11		50.0	87.0	15.3	0.370
12		50.0	90.5	20.0	0.405
13		50.0	91.7	22.2	0.417
14		50.0	92.9	25.0	0.429
15		50.0	92.9	25.0	0.429
16		25.0	94.1	16.6	0.191
17		25.0	95.2	20.0	0.202
18		0	98.8	25.0	0.214
TQI cutoff score					
1		100	60.0	10.5	0.600
2		75.0	88.2	23.0	0.632
Pairs of cutoff scores					
BDI	TQI				
4	2	100	56.4	9.7	0.564
5	2	100	60.0	10.5	0.600
6	2	100	65.8	12.1	0.658
7	2	100	72.9	14.8	0.729

8	2	100	75.2	16.0	0.752
9	2	100	76.4	16.6	0.764
10	2	100	77.6	17.3	0.776
11	2	75.0	80.0	15.0	0.550
12	2	75.0	82.3	16.6	0.573
13	2	75.0	82.3	16.6	0.573
14	2	75.0	83.5	17.6	0.585
15	2	75.0	83.5	17.6	0.585
16	2	75.0	84.7	18.7	0.597
17	2	75.0	85.8	20.0	0.608
18	2	75.0	87.0	21.4	0.620
4	1	100	47.0	8.1	0.470
5	1	100	49.4	8.5	0.491
6	1	100	52.9	9.0	0.529
7	1	100	55.2	9.5	0.552
8	1	100	56.4	9.7	0.564
9	1	100	56.4	9.7	0.564
10	1	100	56.4	10.0	0.576
11	1	100	57.6	10.0	0.576
12	1	100	57.6	10.5	0.600
13	1	100	60.0	10.5	0.600
14	1	100	60.0	10.5	0.600
15	1	100	60.0	10.5	0.600
16	1	100	60.0	10.5	0.600
17	1	100	60.0	10.5	0.600
18	1	100	60.0	10.5	0.600

The sensitivity, specificity, and PPV at all possible cutoff scores for BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI to identify both workers with depression and those with comorbid disorders are listed in Table 5. The ROC curves are showed in Supplementary figure 2 and the Youden Indices are listed in Table 5. The maximum value of the Youden Index was derived from neither BDI nor TQI alone but from the combination of BDI and TQI: 0.316 at the point of BDI score ≥ 9 and TQI = 2. The combination of BDI ≥ 10 and TQI = 2, which was considered to be optimal to identify workers with depression, showed the Youden Index of 0.281 to identify both workers with depression and those with comorbid disorders. There was little difference in the Youden Index between the two points, and the primary purpose of this screening was to identify workers with depression; therefore, the pair of scores of BDI ≥ 10 and TQI = 2 would be adequate to identify both workers with depression and those with comorbid disorders.

Table 5

The sensitivity, specificity, positive predictive value (PPV), and Youden Indices for all possible cutoff scores for Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores BDI and TQI to identify both workers who were diagnosed as having major depressive disorder (MDD) and those who were not diagnosed as having MDD but had other psychiatric disorders frequently comorbid with MDD.

		Sensitivity	Specificity	PPV	Youden Index
BDI cutoff score					
4		62.0	61.6	43.9	0.237
5		58.6	65.0	44.7	0.236
6		51.7	73.3	48.3	0.250
7		44.8	80.0	52.0	0.248
8		41.3	86.6	60.0	0.280
9		41.3	90.0	66.6	0.313
10		37.9	91.6	68.7	0.295
11		31.0	93.3	69.2	0.243
12		27.5	96.6	80.0	0.242
13		27.5	98.3	88.8	0.259
14		24.1	98.3	87.5	0.224
15		24.1	98.3	87.5	0.224
16		17.2	98.3	83.3	0.155
17		13.7	98.3	80.0	0.121
18		10.3	98.3	75.0	0.086
TQI cutoff score					
1		48.2	60.0	36.8	0.082
2		20.2	88.3	46.1	0.090
Pairs of cutoff scores					
BDI	TQI				
4	2	62.0	61.6	43.9	0.237
5	2	58.6	65.0	44.7	0.236
6	2	55.1	71.6	48.4	0.268

7	2	48.2	78.3	51.8	0.266
8	2	48.2	81.6	56.0	0.299
9	2	48.2	83.3	58.3	0.316
10	2	44.8	83.3	56.5	0.281
11	2	37.9	85.0	55.0	0.229
12	2	34.4	86.6	55.5	0.211
13	2	34.4	86.6	55.5	0.211
14	2	31.0	86.6	52.9	0.177
15	2	31.0	86.6	52.9	0.177
16	2	27.5	86.6	50.0	0.142
17	2	24.1	86.6	46.6	0.108
18	2	20.6	86.6	42.8	0.073
4	1	62.0	48.3	36.7	0.104
5	1	58.6	50.0	36.1	0.086
6	1	58.6	55.0	38.6	0.136
7	1	55.1	56.6	38.0	0.118
8	1	55.1	58.3	39.0	0.135
9	1	55.1	58.3	39.0	0.135
10	1	51.7	58.3	37.5	0.100
11	1	48.2	58.3	37.5	0.100
12	1	48.2	60.0	36.8	0.082
13	1	48.2	60.0	36.8	0.082
14	1	48.2	60.0	36.8	0.082
15	1	48.2	60.0	36.8	0.082
16	1	48.2	60.0	36.8	0.082
17	1	48.2	60.0	36.8	0.082
18	1	48.2	60.0	36.8	0.082

DISCUSSION

The present study revealed that combined implementation of BDI and TQI is useful to screen for depressed workers and the optimal pair of cutoff scores is a BDI score ≥ 10 and a TQI score =2. Furthermore, all diagnosed workers in our sample were considered to be depressed because substance use disorder and anxiety disorder are frequently comorbid with depression and patients with bipolar disorder and dysthymia often experience depression. Our results also suggest that it is also possible to identify workers who are likely to be depressed using two instruments with the cutoff scores; therefore, the combination use is considered to be effective as a screening tool in the workplace.

Several studies have investigated the cutoff point of BDI in general populations and failed to get consistent results.[17, 24] Furthermore, there has been no study that investigated optimal cutoff scores of BDI and TQI in the workplace. Beck suggested that a total score of less than 10 is not associated with depressive disorders; scores between 10 and 18 indicate mild to moderate depression; scores between 19 and 29 correlate with moderate and severe depression; and scores of more than 30 indicate severe depression. Indeed, a BDI score ≥ 10 has been selected as a cutoff in many studies.[31-33] However, Lasa et al. reported that a BDI score ≥ 13 had high sensitivity and specificity for detecting depression and was an optimal cutoff in a general population.[33] We speculate that the difference between the cutoff detected in our study and that reported in the previous study is related to differences between the two study populations. Specifically, almost half of participants in the Lasa study were females (50.16%) and a high BDI score (≥13) was more common among females than males. However, as the majority of participants in the current study were males, difference in terms of gender composition might have contributed to the low cutoff score of BDI in this study as compared to that in the Lasa study. In our study, better sensitivity and specificity was achieved by an additional use of TQI. TQI is less time-consuming; therefore, the combination use of BDI and

TQI as a screening tool in the workplace is considered to be reasonable, especially for companies with large numbers of employees.

Several important limitations of our study design should be considered when interpreting the results. In particular, a relatively small sample size may affect the precision of calculated estimates based on the data presented in our study. Moreover, a statistically significant difference was found in the frequency distribution of TQI between Group 1 and 2, although there was no significant difference in BDI between the two groups. The score range of BDI is wide (0-60), and it has been proved that BDI can be used as a measure of depression symptom severity. On the other hand, the score range of TQI is 0 – 2, and TQI is considered to be a tool that can help to make the diagnosis of depression, but not to evaluate symptom severity. Therefore, BDI is thought to be suitable to compare the distributions of severity of depression, whereas the difference in the frequency distributions of TQI would be negligible. Finally, effect of socio-economical and clinical factors which are considered to be associated with depression (e.g., alcohol intake) were not included in the analysis.

We conclude that combined application of BDI and TQI is an efficient way to identify not only workers who are depressed but also those who are likely to be depressed in the workplace. Although further investigations using larger samples are needed, the BDI and TQI combination is a useful screening tool, especially for big companies that have many employees.

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Competing interests

None

Ethic approval

This study was approved under the guidelines for epidemiological studies by the Nagoya University Graduate School of Medicine and Nagoya University Hospital Ethics Review Committee and was conducted in accordance with the Helsinki Declaration. Written informed consent was obtained from each subject before the start of the study.

Contributorship Statement

YA, BA, KY, NO substantial contributed to conception and design, acquisition of data, or analysis and interpretation of data. YA, BA, RN, TS, KY, YO and NO drafted the article or revising it critically for important intellectual content. YA, BA, RN, TS, KY, YO and NO provided final approval of the version to be published

Data sharing statement

There is no additional data available.

REFERENCES

1 Greenberg PE, Kessler RC, Birnbaum HG, et al. The economic burden of depression in the United States: how did it change between 1990 and 2000? J Clin Psychiatry 2003;**64**:1465-75.

2 Kessler RC, Berglund P, Demler O, et al. The epidemiology of major depressive disorder: results from the National Comorbidity Survey Replication (NCS-R). JAMA 2003;**289**:3095-105.

3 Sobocki P, Jonsson B, Angst J, et al. Cost of depression in Europe. J Ment Health Policy Econ 2006;**9**:87-98.

4 Kawakami N, Takeshima T, Ono Y, et al. Twelve-month prevalence, severity, and treatment of common mental disorders in communities in Japan: preliminary finding from the World Mental Health Japan Survey 2002-2003. Psychiatry Clin Neurosci 2005;**59**:441-52.

5 Tokuyama M, Nakao K, Seto M, et al. Predictors of first-onset major depressive episodes among white-collar workers. Psychiatry Clin Neurosci 2003;**57**:523-31.

6 Ministry of Health Labour and Welfare. The annual societal cost of suicide and depression. 2010; http://www.mhlw.go.jp/stf/houdou/2r9852000000qvsy.html.

7 World Health Organization. Information on Mental Health Disorders Management: Depression. 2006; hrrp://www.who.int/mental_health/management/depression/definition/en..

8 Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med 2006;**3**:e442.

9 Patten SB, Wang JL, Williams JV, et al. Descriptive epidemiology of major depression in Canada. Can J Psychiatry 2006;**51**:84-90.

10 Kessler RC, Barber C, Birnbaum HG, et al. Depression in the workplace: effects on short-term disability. Health Aff (Millwood) 1999;**18**:163-71.

11 Alonso J, Angermeyer MC, Bernert S, et al. Disability and quality of life impact of mental disorders in Europe: results from the European Study of the Epidemiology of Mental Disorders

(ESEMeD) project. Acta Psychiatr Scand. 2004;**109**(Suppl 420):38-46.

12 Druss BG, Schlesinger M, Allen HM, Jr. Depressive symptoms, satisfaction with health care, and 2-year work outcomes in an employed population. Am J Psychiatry 2001;**158**:731-4.

13 Stewart WF, Ricci JA, Chee E, et al. Cost of lost productive work time among US workers with depression. JAMA 2003;**289**:3135-44.

14 Kessler RC, Akiskal HS, Ames M, et al. Prevalence and effects of mood disorders on work performance in a nationally representative sample of U.S. workers. Am J Psychiatry 2006;**163**:1561-8.

15 Goldman HH, Drake RE. Mood disorders and workplace performance: half a loaf. Am J Psychiatry 2006;**163**:1490-1.

16 Wang PS, Lane M, Olfson M, et al. Twelve-month use of mental health services in the United States: results from the National Comorbidity Survey Replication. Arch Gen Psychiatry 2005;**62**:629-40.

17 Young AS, Klap R, Sherbourne CD, et al. The quality of care for depressive and anxiety disorders in the United States. Arch Gen Psychiatry 2001;**58**:55-61.

18 Shapiro RW, Keller MB. Initial 6-month follow-up of patients with major depressive disorder. A preliminary report from the NIMH collaborative study of the psychobiology of depression. J Affect Disord 1981;**3**:205-20.

19 Ionescu R, Popescu C, Jipescu I. Predictors of outcome in depression. Rom J Neurol Psychiatry 1994;**32**:153-73.

20 Hirschfeld RM, Russell JM, Delgado PL, et al. Predictors of response to acute treatment of chronic and double depression with sertraline or imipramine. J Clin Psychiatry 1998;**59**:669-75.

21 de Diego-Adelino J, Portella MJ, Puigdemont D, et al. A short duration of untreated illness (DUI) improves response outcomes in first-depressive episodes. J Affect Disord 2010;**120**:221-5.

22 Okuda A, Suzuki T, Kishi T, et al. Duration of untreated illness and antidepressant

fluvoxamine response in major depressive disorder. Psychiatry Clin Neurosci 2010;**64**:268-73.

23 Suzuki T, Nobata A, Kim N, et al. Evaluation of Questionnaires (Two-question case-finding instrument and Beck Depression Inventory) as a Tool for Screening and Intervention of Depression in Work Place. Seishinigaku 2003;**45**:699-708.

24 Beck AT, Beamesderfer A. Assessment of depression: the depression inventory. Mod Probl Pharmacopsychiatry 1974;**7**:151-69.

25 Hazama N. Validation of the Japanese version of Beck Depression Investory (BDI). The Kyushu Neuro-psychiatry 1989;**35**:28-32.

26 Whooley MA, Avins AL, Miranda J, et al. Case-finding instruments for depression. Two questions are as good as many. J Gen Intern Med 1997;**12**:439-45.

27 Spitzer RL, Williams JB, Kroenke K, et al. Utility of a new procedure for diagnosing mental disorders in primary care. The PRIME-MD 1000 study. JAMA 1994;**272**:1749-56.

28 Sheehan DV, Lecrubier Y, Sheehan KH, et al. The Mini-International Neuropsychiatric Interview (M.I.N.I.): the development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. J Clin Psychiatry 1998;**59**(Suppl 20):22-33.

29 Greiner M, Pfeiffer D, Smith RD. Principles and practical application of the receiver-operating characteristic analysis for diagnostic tests. Prev Vet Med 2000;**45**:23-41.

30 Youden WJ. Index for rating diagnostic tests. Cancer 1950;**3**:32-5.

31 Ahola K, Honkonen T, Kivimaki M, et al. Contribution of burnout to the association between job strain and depression: the health 2000 study. J Occup Environ Med 2006;**48**:1023-30.

32 Aben I, Verhey F, Lousberg R, et al. Validity of the beck depression inventory, hospital anxiety and depression scale, SCL-90, and hamilton depression rating scale as screening instruments for depression in stroke patients. Psychosomatics 2002;**43**:386-93.

33 Lasa L, Ayuso-Mateos JL, Vazquez-Barquero JL, et al. The use of the Beck Depression Inventory to screen for depression in the general population: a preliminary analysis. J Affect Disord 2000;**57**:261-5.

Supplementary material

Combination Use of Beck Depression Inventory and Two-Question Case-Finding Instrument as a Screening Tool for Depression in the Workplace

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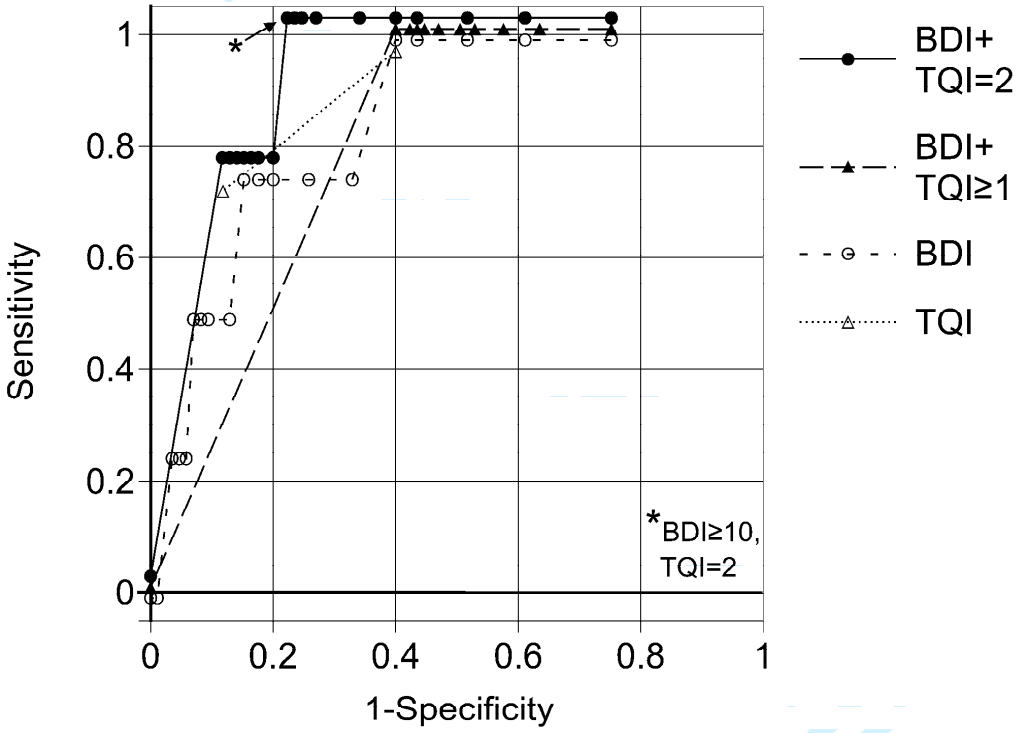
Supplementary table 1.

Demographic data of participants

	Group1 (N=89)		Group 2 (N=1500)	
	N	%	N	%
Sex				
Male	81	91.0	1408	93.9
Female	8	9.0	92	6.1
Age				
-19	0	0	0	0
20-29	7	7.9	54	3.6
30-39	44	49.4	655	43.7
40-49	32	36.0	573	38.2
50-59	6	6.7	213	14.2
60-	0	0	5	0.3

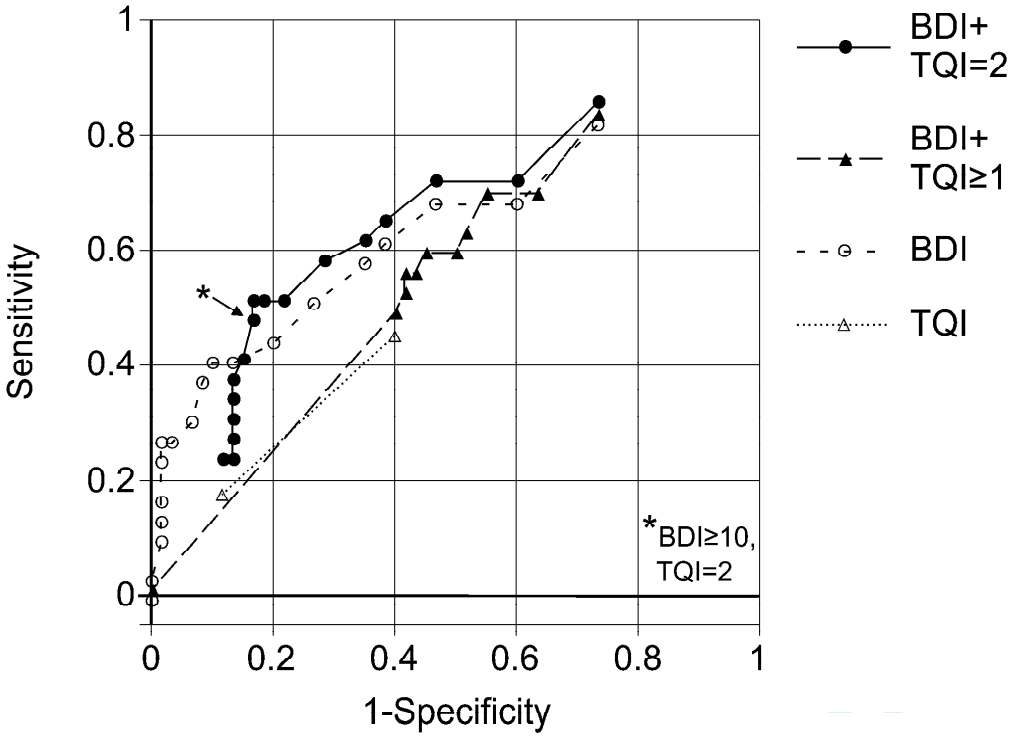
Supplementary figure 1.

Receiver Operation Characteristic curves for all possible cutoff scores of Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores of BDI and TQI to identify workers who were diagnosed as having major depressive disorder. The points and corresponding lines in this figure are shifted to avoid overlapping by adding 0.03, 0.01, -0.01 and -0.03 to the sensitivity values of the groups of BDI + TQI = 2, BDI + TQI ≥ 1, BDI and TQI, respectively.



Supplementary figure 2.

Receiver Operation Characteristic curves for all possible cutoff scores of Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores of BDI and TQI to identify both workers who were diagnosed as having major depressive disorder (MDD) and those who were not diagnosed as having MDD but having other psychiatric disorders frequently comorbid with MDD. The points and corresponding lines in this figure are shifted to avoid overlapping by adding 0.03, 0.01, -0.01 and -0.03 to the sensitivity values of the groups of BDI + TQI = 2, BDI + TQI ≥ 1, BDI and TQI, respectively.



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Diagnostic test study: Combination Use of Beck Depression Inventory and Two-Question Case-Finding Instrument as a Screening Tool for Depression in the Workplace

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Combination Use of Beck Depression Inventory and Two-Question Case-Finding Instrument as a Screening Tool for Depression in the Workplace

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ABSTRACT

Background

Depression is associated with enormous economic burden, especially in high-income countries. The social cost of depression is attributed to the functional impairment of employees via absenteeism and decreased work productivity. The present study aimed to validate screening tools that could be used to identify depression among workers.

Methods

The Beck Depression Inventory (BDI) and a two-question case-finding instrument (TQI) were administered to 89 workers (81 males and 8 females with a mean age of 38.4 ± 6.6 yrs) and Mini-International Neuropsychiatric Interview (MINI) was conducted to verify the diagnosis of depression. A second group of 1500 workers (1408 males and 92 females with a mean age of 40.9 ± 7.2 yrs) completed the BDI and TQI to detect possible sample bias for the distribution of depression. Specificity, sensitivity and PPV were calculated in order to obtain the optimal cutoff scores for BDI and TQI and receiver operating characteristic curves (ROC) and Youden index were applied to further refine the optimal cutoff scores.

Results

When paired together, BDI score ≥ 10 and TQI score of 2 adequately identified workers who had major depressive disorder (MDD) and those who had other psychiatric disorders that are frequently comorbid with MDD.

Conclusions

The combination of BDI score ≥ 10 and TQI score of 2 can adequately screen for current and potential cases of depression among workers. Furthermore, BDI and TQI offer the

advantage of being relatively easy to administer to a large number of workers. Early detection of depression could improve treatment outcomes and decrease economic burden.

SUMMARY

Article focus:

Depression is associated with enormous economic burden and the social cost of depression is attributed to the functional impairment of employees.

Even though the magnitude of productivity loss from depression is substantial, a large number of depressed workers are untreated or inadequately treated.

An efficient screening tool for depression among workers is needed because it is difficult to interview and evaluate all employees.

Key messages:

The combination use of the Beck Depression Inventory (BDI) and a two-question case-finding instrument (TQI) adequately identified workers who had major depressive disorder (MDD). Furthermore, it adequately identified workers who had other psychiatric disorders that are frequently comorbid with MDD.

Strength and limitations of this study:

This study presents an effective way to screen for current and potential cases of depression in the workplace, which is easy to administer to a large number of workers.

The limitations are as follows: the sample size was relatively small, the Japanese version of TQI has not been validated, not all participants were diagnosed using the diagnostic interview, and effect of socio-economical factors and clinical factors were not included in the analysis.

INTRODUCTION

Depression is a highly prevalent disorder that is associated with enormous economic costs. Major depressive disorder (MDD) was estimated to affect 18.1 million people living in United States in 2000, and to have lifetime prevalence of 16.2% and an annual prevalence of 6.6%.[1, 2] The total economic burden (both direct and indirect costs) of depression was estimated to be more than 83 billion U.S. dollars and 118 billion euros in the United States and Europe, respectively.[1, 3] In Japan, MDD was estimated to have an annual prevalence of 2.2% and 7.0% of white collar workers were reported to meet the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria for major depressive episode and score more than 40 points (depressive range) on the self-rating depression scale (SDS).[4, 5] The annual societal cost of depression and suicide was estimated at 2.7 trillion yen.[6] Based on the epidemiological trends, depression will become the second-leading cause of global disease burden by 2020,[7] and is expected to rank first in disease burden in high-income countries by the 2030.[8]

The economic burden of depression is attributed to functional impairment of employees due to physical and cognitive symptoms. Moreover, the prevalence of depression is highest in the age group of 15-64 years, which corresponds to the typical working age.[9] Indeed, it was reported that depressed workers in the United States have 1.5-3.2 times more short-term work-disability days per month than people who were not depressed.[10] Furthermore, the European ESEMeD study revealed that depressed workers had 3-4 times more work-loss days per month compared to workers without depression.[11] In addition to the cost of depression-related absenteeism, presenteeism, the state in which depressed workers stay at work but have reduced productivity as a result of their condition, needs to be considered.

Even though the magnitude of productivity loss from depression is substantial, a large number of depressed workers are untreated or inadequately treated.[2, 12, 13] The increasing

duration of untreated illness (DUI) may be associated with worse treatment outcomes of depression.[14] Many studies have reported that DUI is a predictive factor for treatment outcome.[15-17] In addition, early treatment of the first depressive episode is important because our previous study showed that a shorter DUI implied better remission outcomes in patients with the first MDD.[18] Therefore, early identification of depressed workers is crucial in order to improve treatment outcomes and reduce cost.[2, 12] Moreover, since it is difficult to interview and evaluate all employees, an efficient screening tool for depression among workers is needed.

The aim of the present study was to establish an efficient way to identify workers who were diagnosed as having MDD (= workers with depression) and those who were not diagnosed as having MDD but had other psychiatric disorders that are frequently comorbid with MDD (= workers with comorbid disorders). We identified workers with depression using Mini-International Neuropsychiatric Interview (M.I.N.I.) and investigated an optimal pair of cutoff scores using a combination of Beck Depression Inventory (BDI) and a two-question case-finding instrument (TQI) for depression screening. Afterwards, we examined the specificity and sensitivity of the screening procedure for identification of both workers with depression and those with comorbid disorders. The current study is a continuation of the preliminary research conducted in 2003.[19] In addition to the larger sample size used in the current study, we evaluated the receiver operating characteristic (ROC) curves and Youden Indices in order to calculate the optimal cutoff point for depression in the workplace.

MATERIALS AND METHODS

Participants

We selected two groups of participants. Group 1 was established in order to investigate the optimal pair of cutoff scores of BDI and TQI for screening of depression. Participants in Group 1 answered both BDI and TQI and their diagnosis was confirmed using the M.I.N.I.[20] The M.I.N.I. Japanese version was used as a diagnostic standard for identifying cases. Recruitment occurred between January 2001 and February 2004, and it included 90 workers in a company who agreed to participate. One (1.1%) participant did not complete the questionnaires; 89 (98.8%) took part in the study. The mean age of them was 38.4 (SD, 6.6) and 81 (91.0%) were male.

Group 2 was established in order to investigate the sampling bias in the distribution of depression severity among Group 1, which was a relatively small sample size. In Group 2, a large number of subjects were necessary; therefore, only BDI and TQI were performed and the M.I.N.I. assessment was omitted. Recruitment occurred between July 2000 and February 2004 and 1591 workers from three companies agreed to participate. All the employees in the companies were invited to participate in the study. Ninety-one (5.7%) participants did not complete the questionnaire; 1500 (94.2%) took part in the study. The mean age of them was 40.9 (SD, 7.2) and 1408 (93.9%) were male. Demographic data of participants in each group are shown in Supplementary table 1.

Measurements

Beck Depression Inventory (BDI)

The BDI, developed by Beck et al., is one of the most widely used self-rating questionnaires for measuring the severity of depression.[21] The BDI-I is a 21-item scale (range 0-60). We used the Japanese version of BDI-I, which has been validated and is widely used in Japan.[22]

Two-question case-finding instrument (TQI)

A two-question depression-screening tool developed by Whooley et al. was extracted from the Primary Care Evaluation of Mental Disorders (PRIME-MD) questionnaire.[23, 24] It includes two questions about depressed mood and anhedonia: (1) “During the past month, have you often been bothered by feeling down, depressed, or hopeless?” and (2) “During the past month, have you often been bothered by little interest or pleasure in doing things?” The TQI operates in the range of many other validated depression-screening tools, and it eases the burden of administration by being succinct. For the two-question instrument, a “yes” answer to either of the two questions was considered to indicate a positive result.

After obtaining consent from the author of the original work, the original TQI was carefully translated into Japanese. The semantic fidelity of the Japanese version of TQI was ascertained by means of back translation, whereby the first Japanese version was translated back into English by an independent researcher blind to the original English version, and any discrepancies between the original and the re-translations were corrected until the two were semantically equivalent.

Criterion Standard

The M.I.N.I. is a short structured diagnostic interview, developed jointly by psychiatrists and clinicians in the United States and Europe, for DSM-IV and International

Classification of Diseases, Tenth Edition (ICD-10) psychiatric disorders.[20] With an administration time of approximately 15 minutes, M.I.N.I. was designed to meet the need for a short but accurate structured psychiatric interview for multicenter clinical trials and epidemiology studies and to be used as a first step in outcome tracking in non-research clinical settings. Trained psychiatrists and clinical psychologists performed the Japanese version of M.I.N.I. structured interview, and the results were used to validate the optimal pair of cutoff scores of BDI and TQI.

Study Design and Procedure

In Group 1, participants were assessed by BDI and TQI and then they were additionally diagnosed using the M.I.N.I. In Group 2, only BDI and TQI assessments were performed. Subsequently, we investigated the frequency distributions of BDI and TQI in two groups and compared them to confirm that there were no significant differences between the two experimental groups. After confirming that Group 1 was not a biased sample, we explored the optimal pair of cutoff scores of BDI and TQI for identifying workers with depression.

The frequency distributions of BDI and TQI were compared using Mann-Whitney U test ($p < 0.05$) to examine whether there were statistical significant differences between the two groups. The sensitivity (Se), specificity (Sp), and positive predictive value (PPV) were calculated for all possible cutoff scores for BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI to identify workers with depression in Group 1. Sensitivity refers to the proportion of correctly identified cases and specificity to the proportion of correctly identified non-cases. PPV is the probability that depressed workers identified using the optimal cutoff score are cases according to the M.I.N.I.

To determine the optimal cutoff point, the receiver operating characteristic (ROC) curve was created for all possible cutoff scores of BDI, TQI, and all possible pairs of cutoff

scores of BDI and TQI. The Youden Indices were calculated, concurrently. The ROC curve is a popular graphical method of displaying the discriminatory accuracy of a diagnostic test for distinguishing between two populations. The ROC curve is a plot of Se and 1 - Sp for all possible cutoff scores of the test. To evaluate the discriminatory ability of a diagnostic test, it is common to summarize the information of the ROC curve into a single global value or index.[25] The Youden Index is the easiest to apply and frequently used in practice. This index can be defined as {Se + Sp - 1} and provides a criterion for the "optimal" threshold value; the threshold value for which Se + Sp -1 is maximized.[26]

Furthermore, we applied the screening thresholds to identify workers with comorbid disorders in additions to those with depression. The Se, Sp, and PPV were calculated for all possible cutoff scores for BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI to identify both workers with depression and those with comorbid disorders. Subsequently, the ROC curve was created and the Youden Indices were calculated.

RESULTS

The frequency distributions of BDI and TQI in each group are presented in Figure 1 and Table 1, respectively. Mann-Whitney U test revealed that there was no significant difference in the frequency distribution of BDI between the two groups. However, significant difference was found in the frequency distributions of TQI between two groups (p = .003). The diagnoses of the participants in Group 1 based on M.I.N.I. are listed in Table 2.

Table 1

Frequency distributions of two-question case-finding instrument

Number of 'yes' answers	Group 1		Group 2	
	N	%	N	%
0	51	57.3	1097	73.1
1	25	28.1	229	15.3
2	13	14.6	174	11.6

Table 2

The diagnoses of participants in Group 1 according to Mini-International Neuropsychiatric Interview

Diagnosis	N	%
No diagnosis	60	67.4
Substance use disorder	16	17.9
Anxiety disorder	6	6.7
Major depressive disorder	3	3.3
Bipolar disorder	1	1.1
Dysthymia	1	1.1
Bipolar disorder + Substance use disorder	1	1.1
Major depressive disorder + Substance use disorder + Anxiety disorder	1	1.1

The sensitivity, specificity, and PPV for all possible cutoff scores of BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI to identify workers with depression are listed in Table 3. The ROC curves are showed in Supplementary figure 1 and the Youden Indices are listed in Table 3. The maximum value of the Youden Index was derived from neither BDI nor TQI alone but the combination of the BDI and TQI: 0.776 at the point of BDI score ≥ 10 and TQI score = 2. The pair of scores of BDI ≥ 10 and TQI = 2 was considered to be optimal to identify workers with depression; both those whose BDI score was ≥10 and those whose TQI score was = 2 were defined as "cases".

Table 3

The sensitivity, specificity, positive predictive value (PPV), and Youden Indices for all possible cutoff scores for Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores of BDI and TQI to identify workers who were diagnosed with major depressive disorder.

	Sensitivity	Specificity	PPV	Youden Index
BDI cutoff score				
4	100	56.4	9.7	0.564
5	100	60.0	10.5	0.600
6	75.0	67.0	9.6	0.420
7	75.0	74.1	12.0	0.491
8	75.0	80.0	15.0	0.550
9	75.0	82.3	16.6	0.573
10	75.0	84.7	18.7	0.597
11	50.0	87.0	15.3	0.370
12	50.0	90.5	20.0	0.405
13	50.0	91.7	22.2	0.417
14	50.0	92.9	25.0	0.429
15	50.0	92.9	25.0	0.429

16		25.0	94.1	16.6	0.191
17		25.0	95.2	20.0	0.202
18		0	98.8	25.0	0.214
TQI cutoff score					
1		100	60.0	10.5	0.600
2		75.0	88.2	23.0	0.632
Pairs of cutoff scores					
BDI	TQI				
4	2	100	56.4	9.7	0.564
5	2	100	60.0	10.5	0.600
6	2	100	65.8	12.1	0.658
7	2	100	72.9	14.8	0.729
8	2	100	75.2	16.0	0.752
9	2	100	76.4	16.6	0.764
10	2	100	77.6	17.3	0.776
11	2	75.0	80.0	15.0	0.550
12	2	75.0	82.3	16.6	0.573
13	2	75.0	82.3	16.6	0.573
14	2	75.0	83.5	17.6	0.585
15	2	75.0	83.5	17.6	0.585
16	2	75.0	84.7	18.7	0.597
17	2	75.0	85.8	20.0	0.608
18	2	75.0	87.0	21.4	0.620
4	1	100	47.0	8.1	0.470
5	1	100	49.4	8.5	0.491
6	1	100	52.9	9.0	0.529
7	1	100	55.2	9.5	0.552
8	1	100	56.4	9.7	0.564
9	1	100	56.4	9.7	0.564
10	1	100	56.4	10.0	0.576
11	1	100	57.6	10.0	0.576
12	1	100	57.6	10.5	0.600

13	1	100	60.0	10.5	0.600
14	1	100	60.0	10.5	0.600
15	1	100	60.0	10.5	0.600
16	1	100	60.0	10.5	0.600
17	1	100	60.0	10.5	0.600
18	1	100	60.0	10.5	0.600

The sensitivity, specificity, and PPV at all possible cutoff scores for BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI to identify both workers with depression and those with comorbid disorders are listed in Table 4. The ROC curves are showed in Supplementary figure 2 and the Youden Indices are listed in Table 4. The maximum value of the Youden Index was derived from neither BDI nor TQI alone but from the combination of BDI and TQI: 0.316 at the point of BDI score ≥ 9 and TQI = 2. The combination of BDI ≥ 10 and TQI = 2, which was considered to be optimal to identify workers with depression, showed the Youden Index of 0.281 to identify both workers with depression and those with comorbid disorders. There was little difference in the Youden Index between the two points, and the primary purpose of this screening was to identify workers with depression; therefore, the pair of scores of BDI ≥ 10 and TQI = 2 would be adequate to identify both workers with depression and those with comorbid disorders.

Table 4

The sensitivity, specificity, positive predictive value (PPV), and Youden Indices for all possible cutoff scores for Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores BDI and TQI to identify both workers who were diagnosed as having major depressive disorder (MDD) and those who were not diagnosed as having MDD but had other psychiatric disorders frequently comorbid with MDD.

		Sensitivity	Specificity	PPV	Youden Index
BDI cutoff score					
4		62.0	61.6	43.9	0.237
5		58.6	65.0	44.7	0.236
6		51.7	73.3	48.3	0.250
7		44.8	80.0	52.0	0.248
8		41.3	86.6	60.0	0.280
9		41.3	90.0	66.6	0.313
10		37.9	91.6	68.7	0.295
11		31.0	93.3	69.2	0.243
12		27.5	96.6	80.0	0.242
13		27.5	98.3	88.8	0.259
14		24.1	98.3	87.5	0.224
15		24.1	98.3	87.5	0.224
16		17.2	98.3	83.3	0.155
17		13.7	98.3	80.0	0.121
18		10.3	98.3	75.0	0.086
TQI cutoff score					
1		48.2	60.0	36.8	0.082
2		20.2	88.3	46.1	0.090
Pairs of cutoff scores					
BDI	TQI				
4	2	62.0	61.6	43.9	0.237
5	2	58.6	65.0	44.7	0.236
6	2	55.1	71.6	48.4	0.268
7	2	48.2	78.3	51.8	0.266
8	2	48.2	81.6	56.0	0.299
9	2	48.2	83.3	58.3	0.316
10	2	44.8	83.3	56.5	0.281
11	2	37.9	85.0	55.0	0.229
12	2	34.4	86.6	55.5	0.211
13	2	34.4	86.6	55.5	0.211

14	2	31.0	86.6	52.9	0.177
15	2	31.0	86.6	52.9	0.177
16	2	27.5	86.6	50.0	0.142
17	2	24.1	86.6	46.6	0.108
18	2	20.6	86.6	42.8	0.073
4	1	62.0	48.3	36.7	0.104
5	1	58.6	50.0	36.1	0.086
6	1	58.6	55.0	38.6	0.136
7	1	55.1	56.6	38.0	0.118
8	1	55.1	58.3	39.0	0.135
9	1	55.1	58.3	39.0	0.135
10	1	51.7	58.3	37.5	0.100
11	1	48.2	58.3	37.5	0.100
12	1	48.2	60.0	36.8	0.082
13	1	48.2	60.0	36.8	0.082
14	1	48.2	60.0	36.8	0.082
15	1	48.2	60.0	36.8	0.082
16	1	48.2	60.0	36.8	0.082
17	1	48.2	60.0	36.8	0.082
18	1	48.2	60.0	36.8	0.082

DISCUSSION

The present study revealed that combined implementation of BDI and TQI is useful to screen for depressed workers and the optimal pair of cutoff scores is a BDI score ≥ 10 and a TQI score =2. Furthermore, all diagnosed workers in our sample were considered to be depressed because substance use disorder and anxiety disorder are frequently comorbid with depression and patients with bipolar disorder and dysthymia often experience depression. Our results also suggest that it is also possible to identify workers who are likely to be depressed using two instruments with the cutoff scores; therefore, the combination use is considered to be effective as a screening tool in the workplace.

Several studies have investigated the cutoff point of BDI in general populations and failed to get consistent results.[13, 21] Furthermore, there has been no study that investigated optimal cutoff scores of BDI and TQI in the workplace. Beck suggested that a total score of less than 10 is not associated with depressive disorders; scores between 10 and 18 indicate mild to moderate depression; scores between 19 and 29 correlate with moderate and severe depression; and scores of more than 30 indicate severe depression. Indeed, a BDI score ≥ 10 has been selected as a cutoff in many studies.[27-29] However, Lasa et al. reported that a BDI score ≥ 13 had high sensitivity and specificity for detecting depression and was an optimal cutoff in a general population.[29] We speculate that the difference between the cutoff detected in our study and that reported in the previous study is related to differences between the two study populations. Specifically, almost half of participants in the Lasa study were females (50.16%) and a high BDI score (≥13) was more common among females than males. However, as the majority of participants in the current study were males, difference in terms of gender composition might have contributed to the low cutoff score of BDI in this study as compared to that in the Lasa study. In our study, better sensitivity and specificity was achieved by an additional use of TQI. TQI is less time-consuming; therefore, the combination use of BDI and

TQI as a screening tool in the workplace is considered to be reasonable, especially for companies with large numbers of employees.

Several important limitations of our study design should be considered when interpreting the results. In particular, a relatively small sample size may affect the precision of calculated estimates based on the data presented in our study. Other Methodological problems are as follows: the Japanese version of TQI has not been validated, and the MINI interview was not performed in the larger group. Validation of the Japanese version of TQI would have contributed to improve accuracy of the present results. Performing the diagnostic interview even in shorter versions of MINI in the larger group would have contributed to increase the number of subjects for analysis. Moreover, a statistically significant difference was found in the frequency distribution of TQI between Group 1 and 2, although there was no significant difference in BDI between the two groups. The score range of BDI is wide (0-60), and it has been proved that BDI can be used as a measure of depression symptom severity. On the other hand, the score range of TQI is 0 – 2, and TQI is considered to be a tool that can help to make the diagnosis of depression, but not to evaluate symptom severity. Therefore, BDI is thought to be suitable to compare the distributions of severity of depression, whereas the difference in the frequency distributions of TQI would be negligible. Finally, effect of socio-economical and clinical factors which are considered to be associated with depression (e.g., alcohol intake) were not included in the analysis.

We conclude that combined application of BDI and TQI is an efficient way to identify not only workers who are depressed but also those who are likely to be depressed in the workplace. Although further investigations using larger samples are needed, the BDI and TQI combination is a useful screening tool, especially for big companies that have many employees.

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Competing interests

None

Ethic approval

This study was approved under the guidelines for epidemiological studies by the Nagoya University Graduate School of Medicine and Nagoya University Hospital Ethics Review Committee and was conducted in accordance with the Helsinki Declaration. Written informed consent was obtained from each subject before the start of the study.

Data sharing

There is no additional data available.

Contributorship

YA, BA, KY, NO substantial contributed to conception and design, acquisition of data, or analysis and interpretation of data. YA, BA, RN, TS, KY, YO and NO drafted the article or revising it critically for important intellectual content. YA, BA, RN, TS, KY, YO and NO provided final approval of the version to be published.

REFERENCES

1 Greenberg PE, Kessler RC, Birnbaum HG, et al. The economic burden of depression in the United States: how did it change between 1990 and 2000? J Clin Psychiatry 2003;**64**:1465-75.

2 Kessler RC, Berglund P, Demler O, et al. The epidemiology of major depressive disorder: results from the National Comorbidity Survey Replication (NCS-R). JAMA 2003;**289**:3095-105.

3 Sobocki P, Jonsson B, Angst J, et al. Cost of depression in Europe. J Ment Health Policy Econ 2006;**9**:87-98.

4 Kawakami N, Takeshima T, Ono Y, et al. Twelve-month prevalence, severity, and treatment of common mental disorders in communities in Japan: preliminary finding from the World Mental Health Japan Survey 2002-2003. Psychiatry Clin Neurosci 2005;**59**:441-52.

5 Tokuyama M, Nakao K, Seto M, et al. Predictors of first-onset major depressive episodes among white-collar workers. Psychiatry Clin Neurosci 2003;**57**:523-31.

6 Ministry of Health Labour and Welfare. The annual societal cost of suicide and depression. 2010; http://www.mhlw.go.jp/stf/houdou/2r9852000000qvsy.html.

7 World Health Organization. Information on Mental Health Disorders Management: Depression. 2006; hrrp://www.who.int/mental_health/management/depression/definition/en..

8 Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med 2006;**3**:e442.

9 Patten SB, Wang JL, Williams JV, et al. Descriptive epidemiology of major depression in Canada. Can J Psychiatry 2006;**51**:84-90.

10 Kessler RC, Barber C, Birnbaum HG, et al. Depression in the workplace: effects on short-term disability. Health Aff (Millwood) 1999;**18**:163-71.

11 Alonso J, Angermeyer MC, Bernert S, et al. Disability and quality of life impact of mental

disorders in Europe: results from the European Study of the Epidemiology of Mental Disorders (ESEMeD) project. Acta Psychiatr Scand. 2004;**109**(Suppl 420):38-46.

12 Wang PS, Lane M, Olfson M, et al. Twelve-month use of mental health services in the United States: results from the National Comorbidity Survey Replication. Arch Gen Psychiatry 2005;**62**:629-40.

13 Young AS, Klap R, Sherbourne CD, et al. The quality of care for depressive and anxiety disorders in the United States. Arch Gen Psychiatry 2001;**58**:55-61.

14 Shapiro RW, Keller MB. Initial 6-month follow-up of patients with major depressive disorder. A preliminary report from the NIMH collaborative study of the psychobiology of depression. J Affect Disord 1981;**3**:205-20.

15 Ionescu R, Popescu C, Jipescu I. Predictors of outcome in depression. Rom J Neurol Psychiatry 1994;**32**:153-73.

16 Hirschfeld RM, Russell JM, Delgado PL, et al. Predictors of response to acute treatment of chronic and double depression with sertraline or imipramine. J Clin Psychiatry 1998;**59**:669-75.

17 de Diego-Adelino J, Portella MJ, Puigdemont D, et al. A short duration of untreated illness (DUI) improves response outcomes in first-depressive episodes. J Affect Disord 2010;**120**:221-5.

18 Okuda A, Suzuki T, Kishi T, et al. Duration of untreated illness and antidepressant fluvoxamine response in major depressive disorder. Psychiatry Clin Neurosci 2010;**64**:268-73.

19 Suzuki T, Nobata A, Kim N, et al. Evaluation of Questionnaires (Two-question case-finding instrument and Beck Depression Inventory) as a Tool for Screening and Intervention of Depression in Work Place. Seishinigaku 2003;**45**:699-708.

20 Sheehan DV, Lecrubier Y, Sheehan KH, et al. The Mini-International Neuropsychiatric Interview (M.I.N.I.): the development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. J Clin Psychiatry 1998;**59**(Suppl 20):22-33.

21 Beck AT, Beamesderfer A. Assessment of depression: the depression inventory. Mod Probl

Pharmacopsychiatry 1974;**7**:151-69.

22 Hazama N. Validation of the Japanese version of Beck Depression Investory (BDI). The Kyushu Neuro-psychiatry 1989;**35**:28-32.

23 Whooley MA, Avins AL, Miranda J, et al. Case-finding instruments for depression. Two questions are as good as many. J Gen Intern Med 1997;**12**:439-45.

24 Spitzer RL, Williams JB, Kroenke K, et al. Utility of a new procedure for diagnosing mental disorders in primary care. The PRIME-MD 1000 study. JAMA 1994;**272**:1749-56.

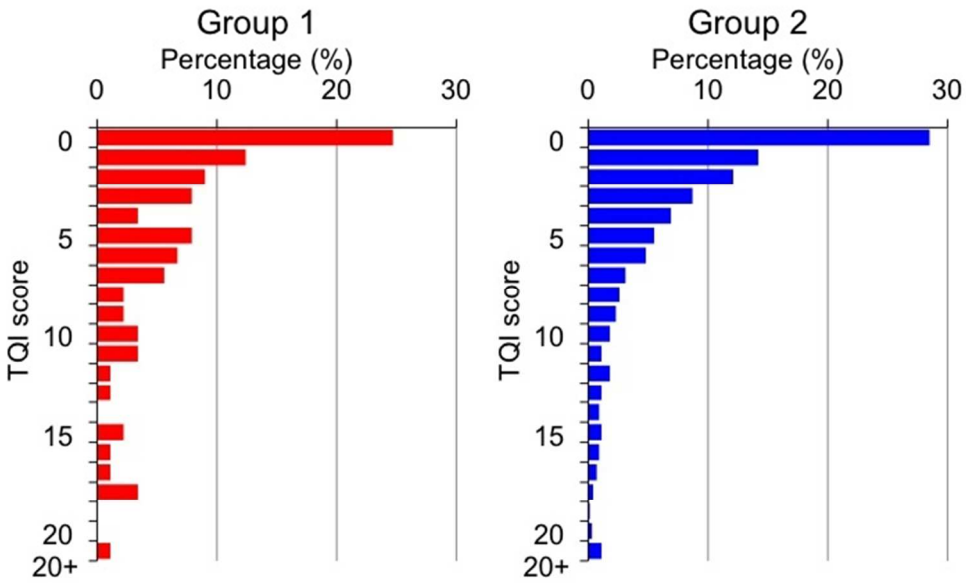
25 Greiner M, Pfeiffer D, Smith RD. Principles and practical application of the receiver-operating characteristic analysis for diagnostic tests. Prev Vet Med 2000;**45**:23-41.

26 Youden WJ. Index for rating diagnostic tests. Cancer 1950;**3**:32-5.

27 Ahola K, Honkonen T, Kivimaki M, et al. Contribution of burnout to the association between job strain and depression: the health 2000 study. J Occup Environ Med 2006;**48**:1023-30.

28 Aben I, Verhey F, Lousberg R, et al. Validity of the beck depression inventory, hospital anxiety and depression scale, SCL-90, and hamilton depression rating scale as screening instruments for depression in stroke patients. Psychosomatics 2002;**43**:386-93.

29 Lasa L, Ayuso-Mateos JL, Vazquez-Barquero JL, et al. The use of the Beck Depression Inventory to screen for depression in the general population: a preliminary analysis. J Affect Disord 2000;**57**:261-5.



254x160mm (72 x 72 DPI)

Supplementary material

Combination Use of Beck Depression Inventory and Two-Question Case-Finding Instrument as a Screening Tool for Depression in the Workplace

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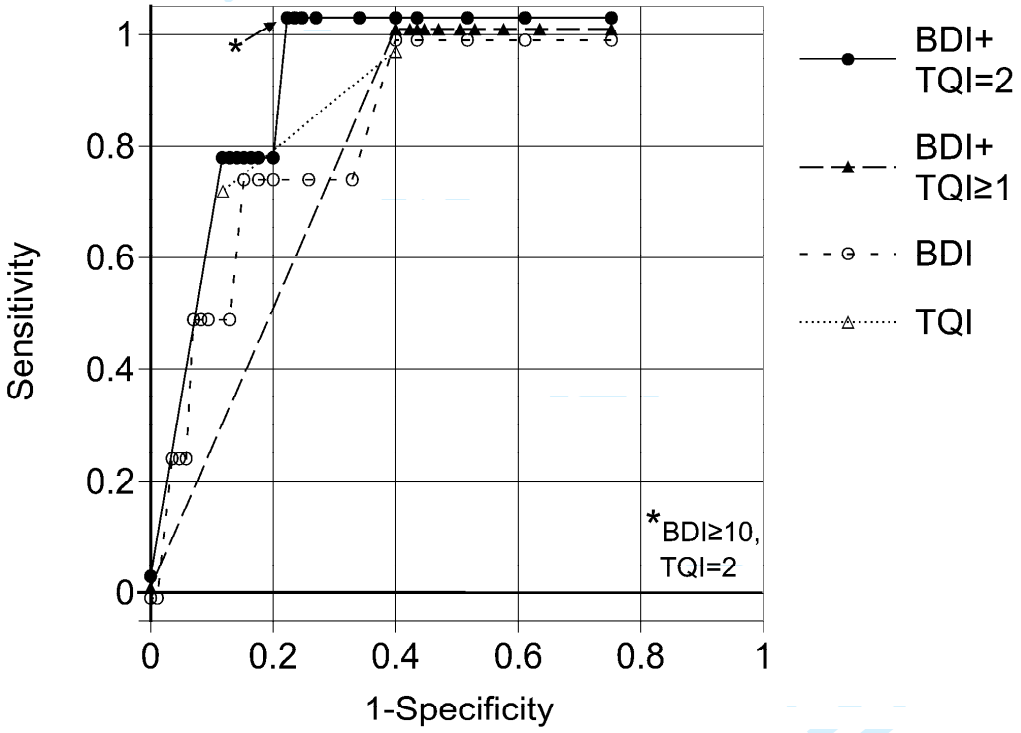
Supplementary table 1.

Demographic data of participants

	Group1 (N=89)		Group 2 (N=1500)	
	N	%	N	%
Sex				
Male	81	91.0	1408	93.9
Female	8	9.0	92	6.1
Age				
-19	0	0	0	0
20-29	7	7.9	54	3.6
30-39	44	49.4	655	43.7
40-49	32	36.0	573	38.2
50-59	6	6.7	213	14.2
60-	0	0	5	0.3

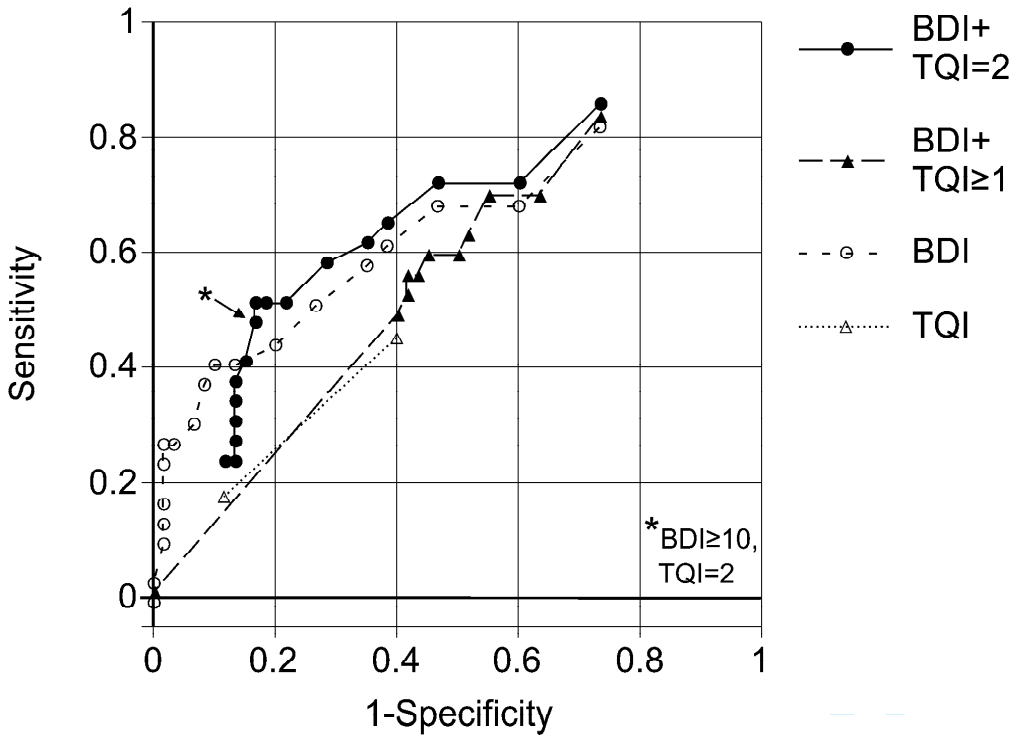
Supplementary figure 1.

Receiver Operation Characteristic curves for all possible cutoff scores of Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores of BDI and TQI to identify workers who were diagnosed as having major depressive disorder. The points and corresponding lines in this figure are shifted to avoid overlapping by adding 0.03, 0.01, -0.01 and -0.03 to the sensitivity values of the groups of BDI + TQI = 2, BDI + TQI ≥ 1, BDI and TQI, respectively.



Supplementary figure 2.

Receiver Operation Characteristic curves for all possible cutoff scores of Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores of BDI and TQI to identify both workers who were diagnosed as having major depressive disorder (MDD) and those who were not diagnosed as having MDD but having other psychiatric disorders frequently comorbid with MDD. The points and corresponding lines in this figure are shifted to avoid overlapping by adding 0.03, 0.01, -0.01 and -0.03 to the sensitivity values of the groups of BDI + TQI = 2, BDI + TQI ≥ 1, BDI and TQI, respectively.



Diagnostic test study: Combination Use of Beck Depression Inventory and Two-Question Case-Finding Instrument as a Screening Tool for Depression in the Workplace

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Combination Use of Beck Depression Inventory and Two-Question Case-Finding Instrument as a Screening Tool for Depression in the Workplace

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ABSTRACT

Objectives: The present study aimed to validate screening tools that could be used to identify depression among workers.

Design: Diagnostic test study.

Settings: Workers from three Japanese companies agreed to participate.

Participants: Recruitment for the group 1 occurred between January 2001 and February 2004, and 89 participants (81 males and 8 females with a mean age of 38.4 ± 6.6 yrs) (98.8%) took part in the study. Recruitment for the group 2 occurred between July 2000 and February 2004 and 1500 participants (1408 males and 92 females with a mean age of 40.9 ± 7.2 yrs) (94.2%) took part in the study. Demographic data are shown in Supplementary table 1.

Interventions: -

Primary and secondary outcome measures: The Beck Depression Inventory (BDI) and a two-question case-finding instrument (TQI) were administered to 89 workers and Mini-International Neuropsychiatric Interview was conducted to verify the diagnosis of depression. A second group of 1500 workers completed the BDI and TQI to detect possible sample bias for the distribution of depression. Specificity, sensitivity and PPV were calculated in order to obtain the optimal cutoff scores for BDI and TQI and receiver operating characteristic curves (ROC) and Youden index were applied to further refine the optimal cutoff scores.

Results: When paired together, BDI score ≥ 10 and TQI score of 2 adequately identified workers who had major depressive disorder (MDD) and those who had other psychiatric disorders that are frequently comorbid with MDD.

Conclusions: The combination of BDI score ≥ 10 and TQI score of 2 can adequately screen for current and potential cases of depression among workers. Furthermore, BDI and TQI offer the advantage of being relatively easy to administer to a large number of workers. Early

detection of depression could improve treatment outcomes and decrease economic burden.

Trail registration:-

INTRODUCTION

Depression is a highly prevalent disorder that is associated with enormous economic costs. Major depressive disorder (MDD) was estimated to affect 18.1 million people living in United States in 2000, and to have lifetime prevalence of 16.2% and an annual prevalence of 6.6%.[1, 2] The total economic burden (both direct and indirect costs) of depression was estimated to be more than 83 billion U.S. dollars and 118 billion euros in the United States and Europe, respectively.[1, 3] In Japan, MDD was estimated to have an annual prevalence of 2.2% and 7.0% of white collar workers were reported to meet the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) criteria for major depressive episode and score more than 40 points (depressive range) on the self-rating depression scale (SDS).[4, 5] The annual societal cost of depression and suicide was estimated at 2.7 trillion yen.[6] Based on the epidemiological trends, depression will become the second-leading cause of global disease burden by 2020,[7] and is expected to rank first in disease burden in high-income countries by the 2030.[8]

The economic burden of depression is attributed to functional impairment of employees due to physical and cognitive symptoms. Moreover, the prevalence of depression is highest in the age group of 15-64 years, which corresponds to the typical working age.[9] Indeed, it was reported that depressed workers in the United States have 1.5-3.2 times more short-term work-disability days per month than people who were not depressed.[10] Furthermore, the European ESEMeD study revealed that depressed workers had 3-4 times more work-loss days per month compared to workers without depression.[11] In addition to the cost of depression-related absenteeism, presenteeism, the state in which depressed workers stay at work but have reduced productivity as a result of their condition, needs to be considered.

Even though the magnitude of productivity loss from depression is substantial, a large number of depressed workers are untreated or inadequately treated.[2, 12, 13] The increasing

duration of untreated illness (DUI) may be associated with worse treatment outcomes of depression.[14] Many studies have reported that DUI is a predictive factor for treatment outcome.[15-17] In addition, early treatment of the first depressive episode is important because our previous study showed that a shorter DUI implied better remission outcomes in patients with the first MDD.[18] Therefore, early identification of depressed workers is crucial in order to improve treatment outcomes and reduce cost.[2, 12] Moreover, since it is difficult to interview and evaluate all employees, an efficient screening tool for depression among workers is needed.

The aim of the present study was to establish an efficient way to identify workers who were diagnosed as having MDD (= workers with depression) and those who were not diagnosed as having MDD but had other psychiatric disorders that are frequently comorbid with MDD (= workers with comorbid disorders). We identified workers with depression using Mini-International Neuropsychiatric Interview (M.I.N.I.) and investigated an optimal pair of cutoff scores using a combination of Beck Depression Inventory (BDI) and a two-question case-finding instrument (TQI) for depression screening. Afterwards, we examined the specificity and sensitivity of the screening procedure for identification of both workers with depression and those with comorbid disorders. The current study is a continuation of the preliminary research conducted in 2003.[19] In addition to the larger sample size used in the current study, we evaluated the receiver operating characteristic (ROC) curves and Youden Indices in order to calculate the optimal cutoff point for depression in the workplace.

MATERIALS AND METHODS

Participants

We selected two groups of participants. Group 1 was established in order to investigate the optimal pair of cutoff scores of BDI and TQI for screening of depression. Participants in Group 1 answered both BDI and TQI and their diagnosis was confirmed using the M.I.N.I.[20] The M.I.N.I. Japanese version was used as a diagnostic standard for identifying cases. Recruitment occurred between January 2001 and February 2004, and it included 90 workers in a company who agreed to participate. One (1.1%) participant did not complete the questionnaires; 89 (98.8%) took part in the study. The mean age of them was 38.4 (SD, 6.6) and 81 (91.0%) were male.

Group 2 was established in order to investigate the sampling bias in the distribution of depression severity among Group 1, which was a relatively small sample size. In Group 2, a large number of subjects were necessary; therefore, only BDI and TQI were performed and the M.I.N.I. assessment was omitted. Recruitment occurred between July 2000 and February 2004 and 1591 workers from three companies agreed to participate. All the employees in the companies were invited to participate in the study. Ninety-one (5.7%) participants did not complete the questionnaire; 1500 (94.2%) took part in the study. The mean age of them was 40.9 (SD, 7.2) and 1408 (93.9%) were male. Demographic data of participants in each group are shown in Supplementary table 1.

Measurements

Beck Depression Inventory (BDI)

The BDI, developed by Beck et al., is one of the most widely used self-rating questionnaires for measuring the severity of depression.[21] The BDI-I is a 21-item scale (range 0-60). We used the Japanese version of BDI-I, which has been validated and is widely used in Japan.[22]

Two-question case-finding instrument (TQI)

A two-question depression-screening tool developed by Whooley et al. was extracted from the Primary Care Evaluation of Mental Disorders (PRIME-MD) questionnaire.[23, 24] It includes two questions about depressed mood and anhedonia: (1) “During the past month, have you often been bothered by feeling down, depressed, or hopeless?” and (2) “During the past month, have you often been bothered by little interest or pleasure in doing things?” The TQI operates in the range of many other validated depression-screening tools, and it eases the burden of administration by being succinct. For the two-question instrument, a “yes” answer to either of the two questions was considered to indicate a positive result.

After obtaining consent from the author of the original work, the original TQI was carefully translated into Japanese. The semantic fidelity of the Japanese version of TQI was ascertained by means of back translation, whereby the first Japanese version was translated back into English by an independent researcher blind to the original English version, and any discrepancies between the original and the re-translations were corrected until the two were semantically equivalent.

Criterion Standard

The M.I.N.I. is a short structured diagnostic interview, developed jointly by psychiatrists and clinicians in the United States and Europe, for DSM-IV and International

Classification of Diseases, Tenth Edition (ICD-10) psychiatric disorders.[20] With an administration time of approximately 15 minutes, M.I.N.I. was designed to meet the need for a short but accurate structured psychiatric interview for multicenter clinical trials and epidemiology studies and to be used as a first step in outcome tracking in non-research clinical settings. Trained psychiatrists and clinical psychologists performed the Japanese version of M.I.N.I. structured interview, and the results were used to validate the optimal pair of cutoff scores of BDI and TQI.

Study Design and Procedure

In Group 1, participants were assessed by BDI and TQI and then they were additionally diagnosed using the M.I.N.I. In Group 2, only BDI and TQI assessments were performed. Subsequently, we investigated the frequency distributions of BDI and TQI in two groups and compared them to confirm that there were no significant differences between the two experimental groups. After confirming that Group 1 was not a biased sample, we explored the optimal pair of cutoff scores of BDI and TQI for identifying workers with depression.

The frequency distributions of BDI and TQI were compared using Mann-Whitney U test ($p < 0.05$) to examine whether there were statistical significant differences between the two groups. The sensitivity (Se), specificity (Sp), and positive predictive value (PPV) were calculated for all possible cutoff scores for BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI to identify workers with depression in Group 1. Sensitivity refers to the proportion of correctly identified cases and specificity to the proportion of correctly identified non-cases. PPV is the probability that depressed workers identified using the optimal cutoff score are cases according to the M.I.N.I.

To determine the optimal cutoff point, the receiver operating characteristic (ROC) curve was created for all possible cutoff scores of BDI, TQI, and all possible pairs of cutoff

scores of BDI and TQI. The Youden Indices were calculated, concurrently. The ROC curve is a popular graphical method of displaying the discriminatory accuracy of a diagnostic test for distinguishing between two populations. The ROC curve is a plot of Se and 1 - Sp for all possible cutoff scores of the test. To evaluate the discriminatory ability of a diagnostic test, it is common to summarize the information of the ROC curve into a single global value or index.[25] The Youden Index is the easiest to apply and frequently used in practice. This index can be defined as {Se + Sp - 1} and provides a criterion for the "optimal" threshold value; the threshold value for which Se + Sp -1 is maximized.[26]

Furthermore, we applied the screening thresholds to identify workers with comorbid disorders in additions to those with depression. The Se, Sp, and PPV were calculated for all possible cutoff scores for BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI to identify both workers with depression and those with comorbid disorders. Subsequently, the ROC curve was created and the Youden Indices were calculated.

RESULTS

The frequency distributions of BDI and TQI in each group are presented in Figure 1 and Table 1, respectively. Mann-Whitney U test revealed that there was no significant difference in the frequency distribution of BDI between the two groups. However, significant difference was found in the frequency distributions of TQI between two groups (p = .003). The diagnoses of the participants in Group 1 based on M.I.N.I. are listed in Table 2.

Table 1

Frequency distributions of two-question case-finding instrument

Number of 'yes' answers	Group 1		Group 2	
	N	%	N	%
0	51	57.3	1097	73.1
1	25	28.1	229	15.3
2	13	14.6	174	11.6

Table 2

The diagnoses of participants in Group 1 according to Mini-International Neuropsychiatric Interview

Diagnosis	N	%
No diagnosis	60	67.4
Substance use disorder	16	17.9
Anxiety disorder	6	6.7
Major depressive disorder	3	3.3
Bipolar disorder	1	1.1
Dysthymia	1	1.1
Bipolar disorder + Substance use disorder	1	1.1
Major depressive disorder + Substance use disorder + Anxiety disorder	1	1.1

The sensitivity, specificity, and PPV for all possible cutoff scores of BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI to identify workers with depression are listed in Table 3. The ROC curves are showed in Supplementary figure 1 and the Youden Indices are listed in Table 3. The maximum value of the Youden Index was derived from neither BDI nor TQI alone but the combination of the BDI and TQI: 0.776 at the point of BDI score ≥ 10 and TQI score = 2. The pair of scores of BDI ≥ 10 and TQI = 2 was considered to be optimal to identify workers with depression; both those whose BDI score was ≥10 and those whose TQI score was = 2 were defined as "cases".

Table 3

The sensitivity, specificity, positive predictive value (PPV), and Youden Indices for all possible cutoff scores for Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores of BDI and TQI to identify workers who were diagnosed with major depressive disorder.

	Sensitivity	Specificity	PPV	Youden Index
BDI cutoff score				
4	100	56.4	9.7	0.564
5	100	60.0	10.5	0.600
6	75.0	67.0	9.6	0.420
7	75.0	74.1	12.0	0.491
8	75.0	80.0	15.0	0.550
9	75.0	82.3	16.6	0.573
10	75.0	84.7	18.7	0.597
11	50.0	87.0	15.3	0.370
12	50.0	90.5	20.0	0.405
13	50.0	91.7	22.2	0.417
14	50.0	92.9	25.0	0.429
15	50.0	92.9	25.0	0.429

16		25.0	94.1	16.6	0.191
17		25.0	95.2	20.0	0.202
18		0	98.8	25.0	0.214
TQI cutoff score					
1		100	60.0	10.5	0.600
2		75.0	88.2	23.0	0.632
Pairs of cutoff scores					
BDI	TQI				
4	2	100	56.4	9.7	0.564
5	2	100	60.0	10.5	0.600
6	2	100	65.8	12.1	0.658
7	2	100	72.9	14.8	0.729
8	2	100	75.2	16.0	0.752
9	2	100	76.4	16.6	0.764
10	2	100	77.6	17.3	0.776
11	2	75.0	80.0	15.0	0.550
12	2	75.0	82.3	16.6	0.573
13	2	75.0	82.3	16.6	0.573
14	2	75.0	83.5	17.6	0.585
15	2	75.0	83.5	17.6	0.585
16	2	75.0	84.7	18.7	0.597
17	2	75.0	85.8	20.0	0.608
18	2	75.0	87.0	21.4	0.620
4	1	100	47.0	8.1	0.470
5	1	100	49.4	8.5	0.491
6	1	100	52.9	9.0	0.529
7	1	100	55.2	9.5	0.552
8	1	100	56.4	9.7	0.564
9	1	100	56.4	9.7	0.564
10	1	100	56.4	10.0	0.576
11	1	100	57.6	10.0	0.576
12	1	100	57.6	10.5	0.600

13	1	100	60.0	10.5	0.600
14	1	100	60.0	10.5	0.600
15	1	100	60.0	10.5	0.600
16	1	100	60.0	10.5	0.600
17	1	100	60.0	10.5	0.600
18	1	100	60.0	10.5	0.600

The sensitivity, specificity, and PPV at all possible cutoff scores for BDI, TQI, and all possible pairs of cutoff scores of BDI and TQI to identify both workers with depression and those with comorbid disorders are listed in Table 4. The ROC curves are showed in Supplementary figure 2 and the Youden Indices are listed in Table 4. The maximum value of the Youden Index was derived from neither BDI nor TQI alone but from the combination of BDI and TQI: 0.316 at the point of BDI score ≥ 9 and TQI = 2. The combination of BDI ≥ 10 and TQI = 2, which was considered to be optimal to identify workers with depression, showed the Youden Index of 0.281 to identify both workers with depression and those with comorbid disorders. There was little difference in the Youden Index between the two points, and the primary purpose of this screening was to identify workers with depression; therefore, the pair of scores of BDI ≥ 10 and TQI = 2 would be adequate to identify both workers with depression and those with comorbid disorders.

Table 4

The sensitivity, specificity, positive predictive value (PPV), and Youden Indices for all possible cutoff scores for Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores BDI and TQI to identify both workers who were diagnosed as having major depressive disorder (MDD) and those who were not diagnosed as having MDD but had other psychiatric disorders frequently comorbid with MDD.

		Sensitivity	Specificity	PPV	Youden Index
BDI cutoff score					
4		62.0	61.6	43.9	0.237
5		58.6	65.0	44.7	0.236
6		51.7	73.3	48.3	0.250
7		44.8	80.0	52.0	0.248
8		41.3	86.6	60.0	0.280
9		41.3	90.0	66.6	0.313
10		37.9	91.6	68.7	0.295
11		31.0	93.3	69.2	0.243
12		27.5	96.6	80.0	0.242
13		27.5	98.3	88.8	0.259
14		24.1	98.3	87.5	0.224
15		24.1	98.3	87.5	0.224
16		17.2	98.3	83.3	0.155
17		13.7	98.3	80.0	0.121
18		10.3	98.3	75.0	0.086
TQI cutoff score					
1		48.2	60.0	36.8	0.082
2		20.2	88.3	46.1	0.090
Pairs of cutoff scores					
BDI	TQI				
4	2	62.0	61.6	43.9	0.237
5	2	58.6	65.0	44.7	0.236
6	2	55.1	71.6	48.4	0.268
7	2	48.2	78.3	51.8	0.266
8	2	48.2	81.6	56.0	0.299
9	2	48.2	83.3	58.3	0.316
10	2	44.8	83.3	56.5	0.281
11	2	37.9	85.0	55.0	0.229
12	2	34.4	86.6	55.5	0.211
13	2	34.4	86.6	55.5	0.211

14	2	31.0	86.6	52.9	0.177
15	2	31.0	86.6	52.9	0.177
16	2	27.5	86.6	50.0	0.142
17	2	24.1	86.6	46.6	0.108
18	2	20.6	86.6	42.8	0.073
4	1	62.0	48.3	36.7	0.104
5	1	58.6	50.0	36.1	0.086
6	1	58.6	55.0	38.6	0.136
7	1	55.1	56.6	38.0	0.118
8	1	55.1	58.3	39.0	0.135
9	1	55.1	58.3	39.0	0.135
10	1	51.7	58.3	37.5	0.100
11	1	48.2	58.3	37.5	0.100
12	1	48.2	60.0	36.8	0.082
13	1	48.2	60.0	36.8	0.082
14	1	48.2	60.0	36.8	0.082
15	1	48.2	60.0	36.8	0.082
16	1	48.2	60.0	36.8	0.082
17	1	48.2	60.0	36.8	0.082
18	1	48.2	60.0	36.8	0.082

DISCUSSION

The present study revealed that combined implementation of BDI and TQI is useful to screen for depressed workers and the optimal pair of cutoff scores is a BDI score ≥ 10 and a TQI score =2. Furthermore, all diagnosed workers in our sample were considered to be depressed because substance use disorder and anxiety disorder are frequently comorbid with depression and patients with bipolar disorder and dysthymia often experience depression. Our results also suggest that it is also possible to identify workers who are likely to be depressed using two instruments with the cutoff scores; therefore, the combination use is considered to be effective as a screening tool in the workplace.

Several studies have investigated the cutoff point of BDI in general populations and failed to get consistent results.[13, 21] Furthermore, there has been no study that investigated optimal cutoff scores of BDI and TQI in the workplace. Beck suggested that a total score of less than 10 is not associated with depressive disorders; scores between 10 and 18 indicate mild to moderate depression; scores between 19 and 29 correlate with moderate and severe depression; and scores of more than 30 indicate severe depression. Indeed, a BDI score ≥ 10 has been selected as a cutoff in many studies.[27-29] However, Lasa et al. reported that a BDI score ≥ 13 had high sensitivity and specificity for detecting depression and was an optimal cutoff in a general population.[29] We speculate that the difference between the cutoff detected in our study and that reported in the previous study is related to differences between the two study populations. Specifically, almost half of participants in the Lasa study were females (50.16%) and a high BDI score (≥13) was more common among females than males. However, as the majority of participants in the current study were males, difference in terms of gender composition might have contributed to the low cutoff score of BDI in this study as compared to that in the Lasa study. In our study, better sensitivity and specificity was achieved by an additional use of TQI. TQI is less time-consuming; therefore, the combination use of BDI and

TQI as a screening tool in the workplace is considered to be reasonable, especially for companies with large numbers of employees.

Several important limitations of our study design should be considered when interpreting the results. In particular, the facts that our sample size was relatively small and the vast majority of the participants were men may affect the precision of calculated estimates based on the data presented in our study. We conducted additional analyses in the male only sample and presented the results in the supplementary materials (Supplementary tables 2, 3, 4 and 5; Supplementary figures 3, 4 and 5). Other Methodological problems are as follows: the Japanese version of TQI has not been validated, and the MINI interview was not performed in the larger group. Validation of the Japanese version of TQI would have contributed to improve accuracy of the present results. Performing the diagnostic interview even in shorter versions of MINI in the larger group would have contributed to increase the number of subjects for analysis. Moreover, a statistically significant difference was found in the frequency distribution of TQI between Group 1 and 2, although there was no significant difference in BDI between the two groups. The score range of BDI is wide (0-60), and it has been proved that BDI can be used as a measure of depression symptom severity. On the other hand, the score range of TQI is 0 – 2, and TQI is considered to be a tool that can help to make the diagnosis of depression, but not to evaluate symptom severity. Therefore, BDI is thought to be suitable to compare the distributions of severity of depression, whereas the difference in the frequency distributions of TQI would be negligible. Finally, no data of the socio-economical status was collected in this study, therefore, effect of socio-economical factors were not included in the analyses.

We conclude that combined application of BDI and TQI is an efficient way to identify not only workers who are depressed but also those who are likely to be depressed in the workplace. Although further investigations using larger samples are needed, the BDI and TQI combination is a useful screening tool, especially for big companies that have many employees.

Funding

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Competing interests

None

Ethic approval

This study was approved under the guidelines for epidemiological studies by the Nagoya University Graduate School of Medicine and Nagoya University Hospital Ethics Review Committee and was conducted in accordance with the Helsinki Declaration. Written informed consent was obtained from each subject before the start of the study.

Contributorship Statement

YA, BA, KY, NO substantial contributed to conception and design, acquisition of data, or analysis and interpretation of data. YA, BA, RN, TS, KY, YO and NO drafted the article or revising it critically for important intellectual content. YA, BA, RN, TS, KY, YO and NO provided final approval of the version to be published.

REFERENCES

1 Greenberg PE, Kessler RC, Birnbaum HG, et al. The economic burden of depression in the United States: how did it change between 1990 and 2000? J Clin Psychiatry 2003;**64**:1465-75.

2 Kessler RC, Berglund P, Demler O, et al. The epidemiology of major depressive disorder: results from the National Comorbidity Survey Replication (NCS-R). JAMA 2003;**289**:3095-105.

3 Sobocki P, Jonsson B, Angst J, et al. Cost of depression in Europe. J Ment Health Policy Econ 2006;**9**:87-98.

4 Kawakami N, Takeshima T, Ono Y, et al. Twelve-month prevalence, severity, and treatment of common mental disorders in communities in Japan: preliminary finding from the World Mental Health Japan Survey 2002-2003. Psychiatry Clin Neurosci 2005;**59**:441-52.

5 Tokuyama M, Nakao K, Seto M, et al. Predictors of first-onset major depressive episodes among white-collar workers. Psychiatry Clin Neurosci 2003;**57**:523-31.

6 Ministry of Health Labour and Welfare. The annual societal cost of suicide and depression. 2010; http://www.mhlw.go.jp/stf/houdou/2r9852000000qvsy.html.

7 World Health Organization. Information on Mental Health Disorders Management: Depression. 2006; hrrp://www.who.int/mental_health/management/depression/definition/en..

8 Mathers CD, Loncar D. Projections of global mortality and burden of disease from 2002 to 2030. PLoS Med 2006;**3**:e442.

9 Patten SB, Wang JL, Williams JV, et al. Descriptive epidemiology of major depression in Canada. Can J Psychiatry 2006;**51**:84-90.

10 Kessler RC, Barber C, Birnbaum HG, et al. Depression in the workplace: effects on short-term disability. Health Aff (Millwood) 1999;**18**:163-71.

11 Alonso J, Angermeyer MC, Bernert S, et al. Disability and quality of life impact of mental

disorders in Europe: results from the European Study of the Epidemiology of Mental Disorders (ESEMeD) project. Acta Psychiatr Scand. 2004;**109**(Suppl 420):38-46.

12 Wang PS, Lane M, Olfson M, et al. Twelve-month use of mental health services in the United States: results from the National Comorbidity Survey Replication. Arch Gen Psychiatry 2005;**62**:629-40.

13 Young AS, Klap R, Sherbourne CD, et al. The quality of care for depressive and anxiety disorders in the United States. Arch Gen Psychiatry 2001;**58**:55-61.

14 Shapiro RW, Keller MB. Initial 6-month follow-up of patients with major depressive disorder. A preliminary report from the NIMH collaborative study of the psychobiology of depression. J Affect Disord 1981;**3**:205-20.

15 Ionescu R, Popescu C, Jipescu I. Predictors of outcome in depression. Rom J Neurol Psychiatry 1994;**32**:153-73.

16 Hirschfeld RM, Russell JM, Delgado PL, et al. Predictors of response to acute treatment of chronic and double depression with sertraline or imipramine. J Clin Psychiatry 1998;**59**:669-75.

17 de Diego-Adelino J, Portella MJ, Puigdemont D, et al. A short duration of untreated illness (DUI) improves response outcomes in first-depressive episodes. J Affect Disord 2010;**120**:221-5.

18 Okuda A, Suzuki T, Kishi T, et al. Duration of untreated illness and antidepressant fluvoxamine response in major depressive disorder. Psychiatry Clin Neurosci 2010;**64**:268-73.

19 Suzuki T, Nobata A, Kim N, et al. Evaluation of Questionnaires (Two-question case-finding instrument and Beck Depression Inventory) as a Tool for Screening and Intervention of Depression in Work Place. Seishinigaku 2003;**45**:699-708.

20 Sheehan DV, Lecrubier Y, Sheehan KH, et al. The Mini-International Neuropsychiatric Interview (M.I.N.I.): the development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. J Clin Psychiatry 1998;**59**(Suppl 20):22-33.

21 Beck AT, Beamesderfer A. Assessment of depression: the depression inventory. Mod Probl

Pharmacopsychiatry 1974;**7**:151-69.

22 Hazama N. Validation of the Japanese version of Beck Depression Investory (BDI). The Kyushu Neuro-psychiatry 1989;**35**:28-32.

23 Whooley MA, Avins AL, Miranda J, et al. Case-finding instruments for depression. Two questions are as good as many. J Gen Intern Med 1997;**12**:439-45.

24 Spitzer RL, Williams JB, Kroenke K, et al. Utility of a new procedure for diagnosing mental disorders in primary care. The PRIME-MD 1000 study. JAMA 1994;**272**:1749-56.

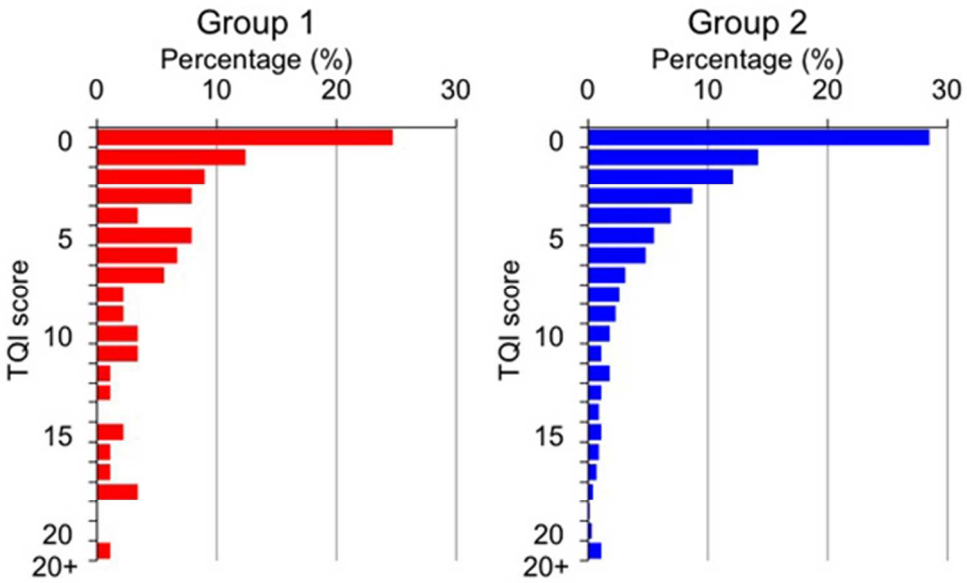
25 Greiner M, Pfeiffer D, Smith RD. Principles and practical application of the receiver-operating characteristic analysis for diagnostic tests. Prev Vet Med 2000;**45**:23-41.

26 Youden WJ. Index for rating diagnostic tests. Cancer 1950;**3**:32-5.

27 Ahola K, Honkonen T, Kivimaki M, et al. Contribution of burnout to the association between job strain and depression: the health 2000 study. J Occup Environ Med 2006;**48**:1023-30.

28 Aben I, Verhey F, Lousberg R, et al. Validity of the beck depression inventory, hospital anxiety and depression scale, SCL-90, and hamilton depression rating scale as screening instruments for depression in stroke patients. Psychosomatics 2002;**43**:386-93.

29 Lasa L, Ayuso-Mateos JL, Vazquez-Barquero JL, et al. The use of the Beck Depression Inventory to screen for depression in the general population: a preliminary analysis. J Affect Disord 2000;**57**:261-5.



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Supplementary material

Combination Use of Beck Depression Inventory and Two-Question Case-Finding Instrument as a Screening Tool for Depression in the Workplace

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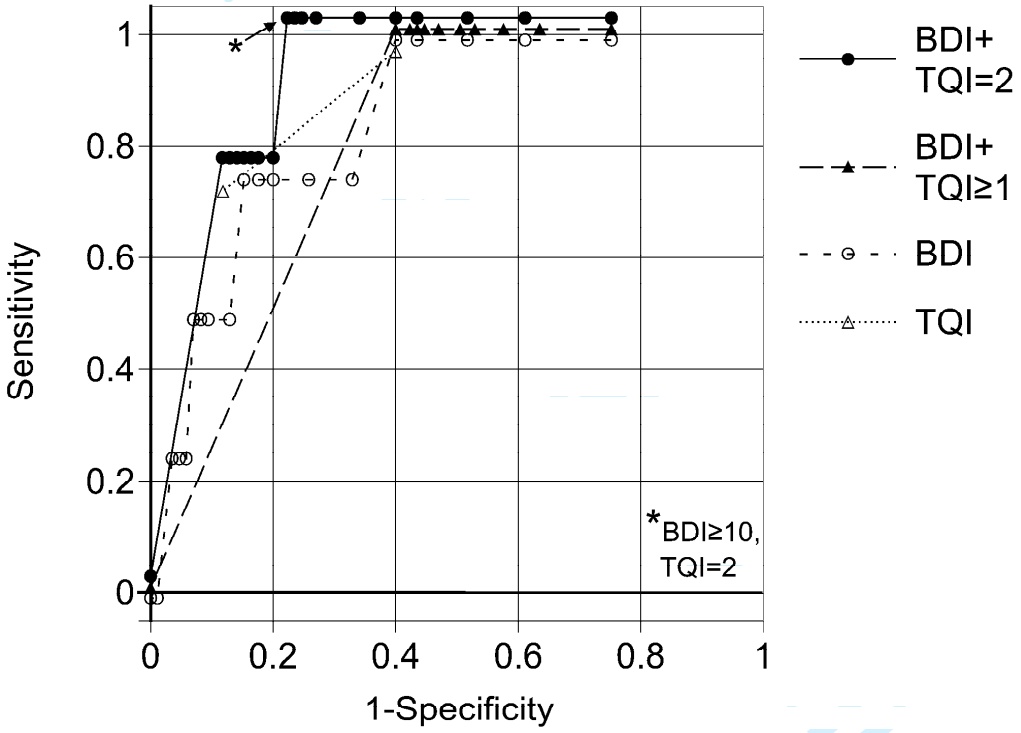
Supplementary table 1.

Demographic data of participants

	Group1 (N=89)		Group 2 (N=1500)	
	N	%	N	%
Sex				
Male	81	91.0	1408	93.9
Female	8	9.0	92	6.1
Age				
-19	0	0	0	0
20-29	7	7.9	54	3.6
30-39	44	49.4	655	43.7
40-49	32	36.0	573	38.2
50-59	6	6.7	213	14.2
60-	0	0	5	0.3

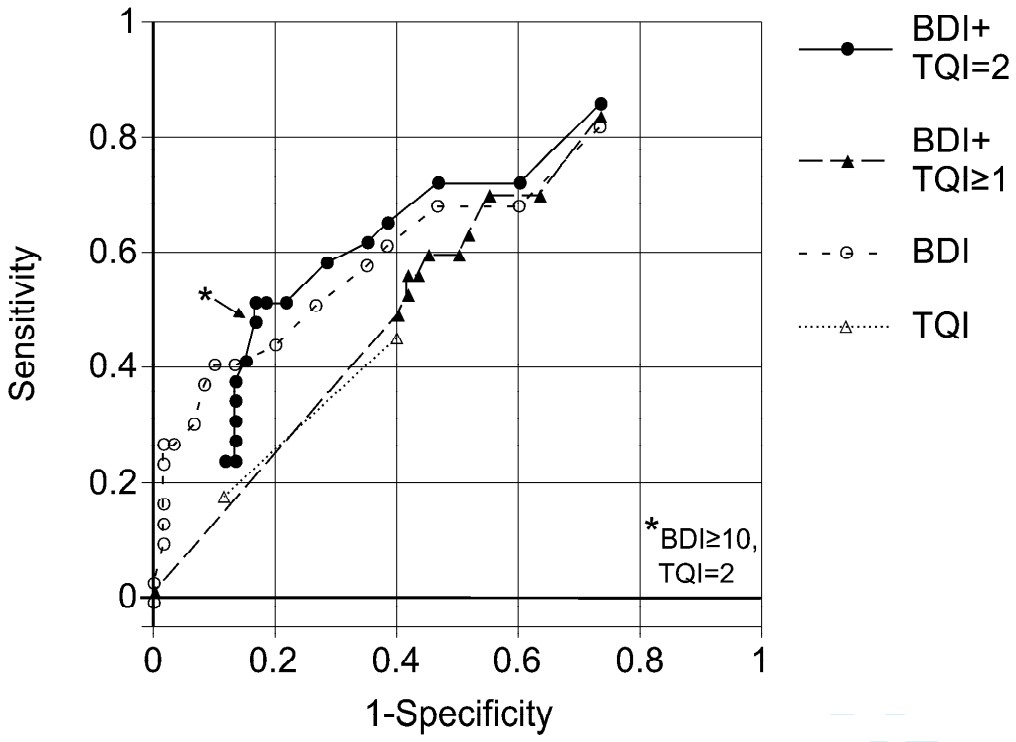
Supplementary figure 1.

Receiver Operation Characteristic curves for all possible cutoff scores of Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores of BDI and TQI to identify workers who were diagnosed as having major depressive disorder. The points and corresponding lines in this figure are shifted to avoid overlapping by adding 0.03, 0.01, -0.01 and -0.03 to the sensitivity values of the groups of BDI + TQI = 2, BDI + TQI ≥ 1, BDI and TQI, respectively.



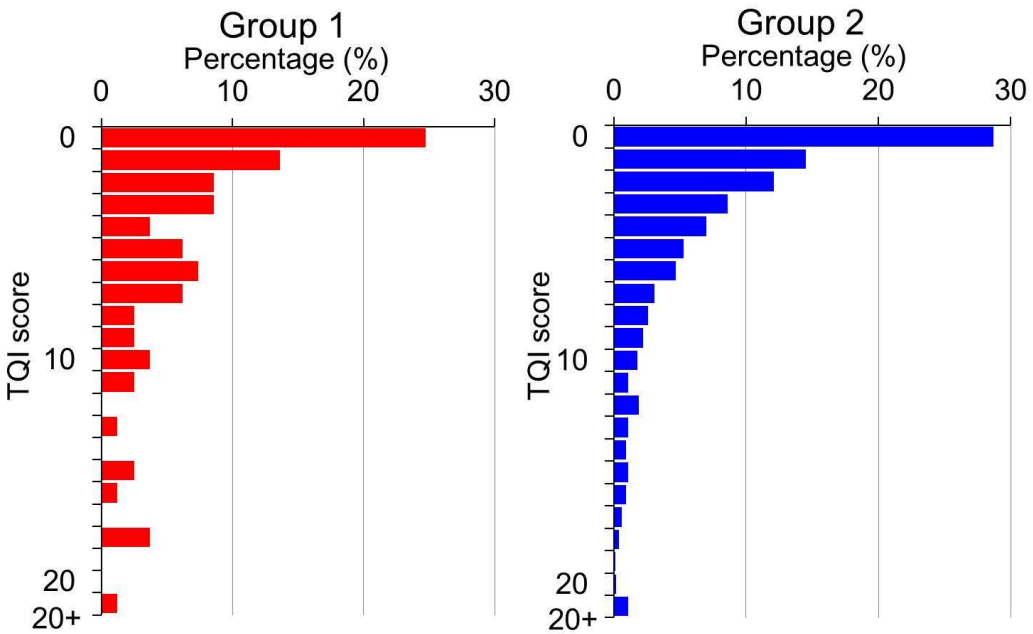
Supplementary figure 2.

Receiver Operation Characteristic curves for all possible cutoff scores of Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores of BDI and TQI to identify both workers who were diagnosed as having major depressive disorder (MDD) and those who were not diagnosed as having MDD but having other psychiatric disorders frequently comorbid with MDD. The points and corresponding lines in this figure are shifted to avoid overlapping by adding 0.03, 0.01, -0.01 and -0.03 to the sensitivity values of the groups of BDI + TQI = 2, BDI + TQI ≥ 1, BDI and TQI, respectively.



Supplementary figure 3.

Frequency distributions of Beck Depression Inventory in the male only sample



Supplementary table 2

Frequency distributions of two-question case-finding instrument in the male only sample

Number of 'yes' answers	Group 1		Group 2	
	N	%	N	%
0	47	58.0	1033	73.4
1	23	28.4	213	15.1
2	11	13.6	162	11.5

Supplementary table 3

The diagnoses of male participants in Group 1 according to Mini-International Neuropsychiatric Interview

Diagnosis	N	%
No diagnosis	54	66.7
Substance use disorder	16	19.8
Anxiety disorder	5	6.2
Major depressive disorder	2	2.5
Bipolar disorder	1	1.2
Dysthymia	1	1.2
Bipolar disorder + Substance use disorder	1	1.2
Major depressive disorder + Substance use disorder + Anxiety disorder	1	1.2

Supplementary table 4

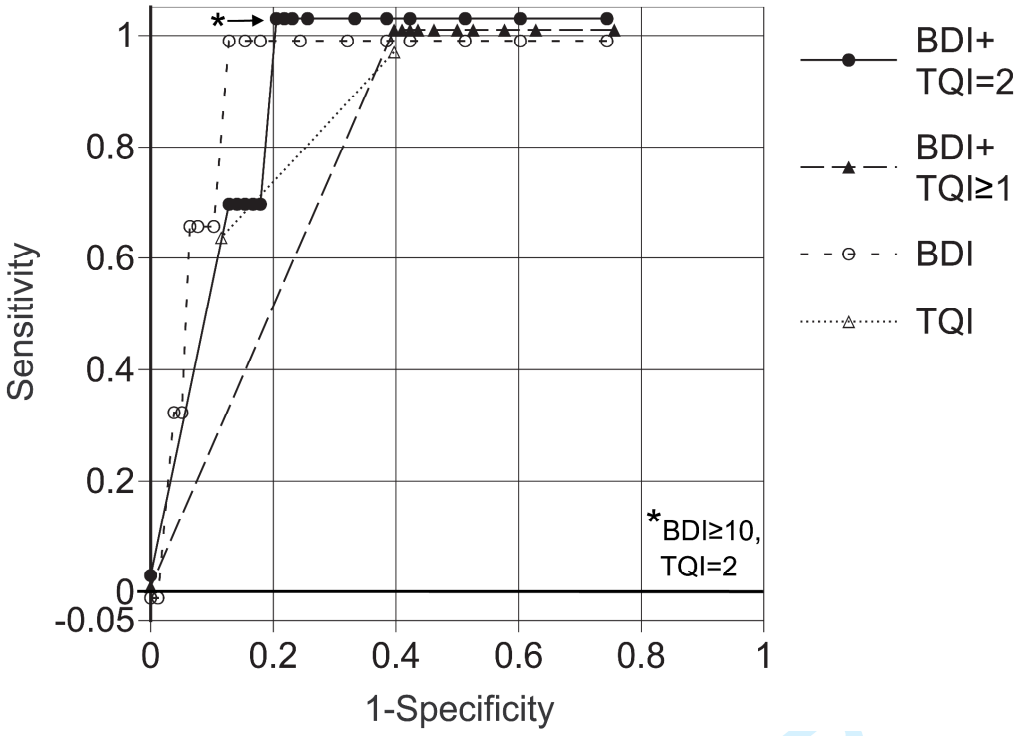
The sensitivity, specificity, positive predictive value (PPV), and Youden Indices for all possible cutoff scores for Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores of BDI and TQI to identify workers who were diagnosed with major depressive disorder in the male only sample.

		Sensitivity	Specificity	PPV	Youden Index
BDI cutoff score					
4		100	57.7	8.3	0.577
5		100	61.5	9.1	0.615
6		100	67.9	10.7	0.679
7		100	75.6	13.6	0.756
8		100	82.1	17.6	0.821
9		100	84.6	20.0	0.846
10		100	87.2	23.1	0.872
11		66.7	89.7	20.0	0.564
12		66.7	92.3	25.0	0.590
13		66.7	92.3	25.0	0.590
14		66.7	93.5	28.6	0.603
15		66.7	93.5	28.6	0.603
16		33.3	94.9	20.0	0.282
17		33.3	96.2	25.0	0.295
18		33.3	96.2	25.0	0.295
TQI cutoff score					
1		100	60.3	8.8	0.603
2		66.7	88.5	18.2	0.551
Pairs of cutoff scores					
BDI	TQI				
4	2	100	57.7	8.3	0.577
5	2	100	61.5	9.1	0.615
6	2	100	66.7	10.3	0.667
7	2	100	74.4	13.0	0.744
8	2	100	76.9	14.3	0.769
9	2	100	78.2	15.0	0.782
10	2	100	79.5	15.8	0.795
11	2	66.7	82.1	12.5	0.487
12	2	66.7	83.3	13.3	0.500
13	2	66.7	83.3	13.3	0.500
14	2	66.7	84.6	14.3	0.513
15	2	66.7	84.6	14.3	0.513
16	2	66.7	85.9	15.4	0.526
17	2	66.7	87.2	16.7	0.538
18	2	66.7	87.2	16.7	0.538
4	1	100	47.4	6.8	0.474
5	1	100	50.0	7.1	0.500
6	1	100	53.8	7.7	0.538
7	1	100	56.4	8.1	0.564
8	1	100	57.7	8.3	0.577
9	1	100	57.7	8.3	0.577

10	1	100	59.0	8.6	0.590
11	1	100	59.0	8.6	0.590
12	1	100	60.3	8.8	0.603
13	1	100	60.3	8.8	0.603
14	1	100	60.3	8.8	0.603
15	1	100	60.3	8.8	0.603
16	1	100	60.3	8.8	0.603
17	1	100	60.3	8.8	0.603
18	1	100	60.3	8.8	0.603

Supplementary figure 4.

Receiver Operation Characteristic curves for all possible cutoff scores of Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores of BDI and TQI to identify workers who were diagnosed as having major depressive disorder in the male only sample. The points and corresponding lines in this figure are shifted to avoid overlapping by adding 0.03, 0.01, -0.01 and -0.03 to the sensitivity values of the groups of BDI + TQI = 2, BDI + TQI ≥ 1, BDI and TQI, respectively.



Supplementary table 5

The sensitivity, specificity, positive predictive value (PPV), and Youden Indices for all possible cutoff scores for Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores BDI and TQI to identify both workers who were diagnosed as having major depressive disorder (MDD) and those who were not diagnosed as having MDD but had other psychiatric disorders frequently comorbid with MDD in the male only sample.

		Sensitivity	Specificity	PPV	Youden Index
BDI cutoff score					
4		59.3	63.0	44.4	0.222
5		55.6	66.7	45.5	0.222
6		51.9	74.1	50.0	0.259
7		44.4	81.5	54.5	0.259
8		40.7	88.9	64.7	0.296
9		40.7	92.6	73.3	0.333
10		37.0	94.4	76.9	0.315
11		29.6	96.3	80.0	0.259
12		25.9	98.1	87.5	0.259
13		25.9	98.1	87.5	0.201
14		22.2	98.1	85.7	0.201
15		22.2	98.1	85.7	0.224
16		14.8	98.1	80.0	0.130
17		11.1	98.1	75.0	0.093
18		11.1	98.1	75.0	0.093
TQI cutoff score					
1		44.4	59.3	35.3	0.037
2		18.5	88.9	45.5	0.074
Pairs of cutoff scores					
BDI	TQI				
4	2	59.3	63.0	44.4	0.222
5	2	55.6	66.7	45.5	0.222
6	2	51.9	72.2	48.3	0.241
7	2	44.4	79.6	52.2	0.241
8	2	44.4	83.3	57.1	0.278
9	2	44.4	85.2	60.0	0.296
10	2	44.8	85.2	57.9	0.259
11	2	33.3	87.0	56.3	0.204
12	2	29.6	87.0	53.3	0.167
13	2	29.6	87.0	53.3	0.167
14	2	25.9	87.0	50.0	0.130
15	2	25.9	87.0	50.0	0.130
16	2	22.2	87.0	46.2	0.093
17	2	18.5	87.0	41.7	0.056
18	2	18.5	87.0	41.7	0.056
4	1	59.3	48.1	36.4	0.074
5	1	55.6	50.0	35.7	0.056
6	1	55.6	55.6	38.5	0.111

7	1	51.9	57.4	37.8	0.093
8	1	51.9	59.3	38.9	0.111
9	1	51.9	59.3	38.9	0.111
10	1	48.1	59.3	37.1	0.074
11	1	48.1	59.3	37.1	0.074
12	1	44.4	59.3	35.2	0.037
13	1	44.4	59.3	35.2	0.037
14	1	44.4	59.3	35.2	0.037
15	1	44.4	59.3	35.2	0.037
16	1	44.4	59.3	35.2	0.037
17	1	44.4	59.3	35.2	0.037
18	1	44.4	59.3	35.2	0.037

Supplementary figure 5.

Receiver Operation Characteristic curves for all possible cutoff scores of Beck Depression Inventory (BDI), two-question case-finding instrument (TQI), and all possible pairs of cutoff scores of BDI and TQI to identify both workers who were diagnosed as having major depressive disorder (MDD) and those who were not diagnosed as having MDD but having other psychiatric disorders frequently comorbid with MDD in the male only sample. The points and corresponding lines in this figure are shifted to avoid overlapping by adding 0.03, 0.01, -0.01 and -0.03 to the sensitivity values of the groups of BDI + TQI = 2, BDI + TQI ≥ 1, BDI and TQI, respectively.