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A dimensional versus a categorical approach to diagnosis: Anxiety and depression in the HUNT 2 study

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Abstract

The aim of this study was to compare a dimensional and a categorical approach to diagnosis, using as an illustration co-occurring symptoms of anxiety and depression concerning description, associations and predictive power. We analysed data from 60 869 individuals with valid ratings on the Hospital Anxiety and Depression Scale (HADS) and on mental impairment in the age range of 20 to 89 years of the cross-sectional Nord-Trøndelag Health Study 1995–1997. There was a wide variation of the dimensional symptom level (subscale scores) within both diagnostic categories (cut-offs ≥8 on both subscales), as is usually true with categorical and dimensional diagnosis. The dimensional (Spearman) correlation coefficients between anxiety and depression was 0.51 compared to 0.38 for the categorical. The power to predict impairment was weaker with the categorical than with the dimensional approach of the HADS, showing fewer statistically significant coefficients in the logistic regression models and lower area under curve (0.82 versus 0.87). This is an example illustrating the impact use of dimensional diagnoses would have on research and clinical practice.

Introduction

The classification of mental disorders may be done by either a dimensional or a categorical approach depending on the purpose (Kraemer *et al.*, 2004). The categorical classification identifies individuals suffering from a mental disorder, which is important for clinical planning of treatment and for estimation of service needs from a public health perspective. Researchers frequently use the categorical approach in order to reliably describe their samples, to have easily understandable outcome measures (Goldberg, 2000), and to consider eligibility for clinical trials. A problem with the categorical approach, however, is the need to define clear-cut thresholds between presence and absence of disorders. Studies have shown, for example, that conditions below cut-off thresholds of both depression and of anxiety disorders have significant clinical relevance in terms of functional impairment, mortality, treatment, and prognosis (Angst *et al.*, 1997; Angst *et al.*, 2000; Broadhead *et al.*, 1990; Johnson *et al.*, 1992; Maier *et al.*, 1997; Rapaport and Judd, 1998). Thus, experts have suggested that anxiety and depression are best described with dimensional symptom measures (Shear *et al.*, 2007; Andrews *et al.*, 2007), which have been proposed as valid alternatives to categorical diagnoses for anxiety and depression research (Goldberg, 2000).

Research has shown that mental disorders such as anxiety and depression frequently co-exist. High prevalence of such co-morbid conditions has been reported both in the general population (Alonso *et al.*, 2004; Kessler *et al.*, 2005), in primary care (Sartorius *et al.*, 1996), as well as in clinical settings (Belzer and Schneier, 2004). Co-morbidity of anxiety disorder and depression is associated with reduced treatment response to antidepressants, impaired recovery rate from depression, increased time to recovery, decreased time to relapse as well as increased risk for alcohol dependence and suicide (Belzer and Schneier, 2004; Angst, 1993; Coryell *et al.*, 1992; Trivedi *et al.*, 2006; Bruce *et al.*, 2005).

The costs of dichotomizing continuous variables are considerable, including loss of information with reduced power to detect a relation between the variable and an outcome measure, underestimation of the outcome variation between groups, concealment of non-linearity in relations between variables, and incomplete adjustment when the variable is treated as a confounder (Altmann and Royston, 2006). These costs would most probably also influence studies of dichotomized categorical co-morbid anxiety and depression as well. However, the quantity of such costs has, to our knowledge, not been demonstrated in studies of co-morbid anxiety and depression or other disorders, and it seems to be assumed that the costs are likely to be relatively trivial.

Therefore, we aimed to quantify the differences achieved by comparing a dimensional by a categorical approach to co-occurring anxiety and depression. Having access to a large population sample with self-rated anxiety and depression symptoms based on the Hospital Anxiety and Depression Rating Scale (HADS), we had the opportunity to make such a comparison. More precisely, the aims of our study were to compare a dimensional with a categorical approach to anxiety and depression regarding (1) description of the co-occurring symptoms; (2) associations between the co-occurring symptoms; and (3) predictive power and values of the co-occurring symptoms on an outcome measure such as mental impairment. This was done, not particularly to change our view of depression or anxiety, but to illustrate the effects of dichotomization on any dimensional diagnosis on the results of clinical research and decision-making.

Methods

Study population

Based on updated information from the National People Registry of Norway all inhabitants aged ≥20 years were invited to take part in the Nord-Trøndelag Health Study 1995–1997 (The HUNT 2 Study) (Holmen *et al.*, 2003; HUNT, 2008). Nord-Trøndelag County encompasses 3% of the Norwegian population, and except for a somewhat lower mean level of education, the County is representative of Norway as a whole. Among the eligible 93 183 inhabitants between 20 and 89 years 64 686 (69.4%) participated in the HUNT study by returning a mailed questionnaire containing the HADS and the item that self-rated subjective impairment due to mental health problems. Among the participants 3817 (5.9%) subjects had non-valid scores on either HADS-A (anxiety subscale) or HADS-D (depression subscale) or the variable indicating mental impairment. Compared to the completers (N = 60 869) the non-completers were older [67.7 years (standard deviation, SD = 14.8) versus 48.8 years (SD = 16.6)], more often women (60.2% versus 52.7%), and with a lower level of education [1.41 (SD = 0.86) versus 2.24 (1.27) on a scale from 1 (primary school) to 5 (university or college ≥4 years)].

Assessment of anxiety and depression

The HADS is a self-administered questionnaire consisting of 14 items, seven for anxiety (HADS-A subscale)

and seven for depression (HADS-D subscale), each scored from 0 (not present) to 3 (highly present) on a scale formulated in a readily understandable language (Bjelland *et al.*, 2002; Zigmond and Snaith, 1983). The HADS concerns symptoms during the last week before the survey. The HADS-A contains items mainly concerned with restlessness and worry plus one item on panic attacks, while the HADS-D focuses mainly on the reduced pleasure response aspect (anhedonia) of depression, as well as psychomotor retardation and depressed mood. The bidimensionality of the HADS has been demonstrated by several factor analytic studies (Bjelland *et al.*, 2002), as well as in the HUNT 2 population where the factors were identical with the subscales (Mykletun *et al.*, 2001). Valid ratings of the anxiety and depression subscales were defined as at least five completed items on HADS-A and HADS-D, respectively. The score of those who filled in five or six items was based on the sum of completed items multiplied with 7/5 or 7/6, respectively.

When one of the HADS subscale ratings (dimensional approach) is compared to an unrelated categorical approach (e.g. DSM-IV major depressive disorder or generalized anxiety disorder), it is impossible to tell how much of the differences that are due to non-shared components, and how much simply due to the fact that one measure is dimensional while the other is categorical (Kraemer *et al.*, 2004). Hence, we considered it appropriate to use the HADS for both the dimensional and the categorical approach. We thus in this study defined the dimensional measure as the continuous scores of the HADS-subscales, and the categorical as the dichotomies of the same subscales. A cut-off threshold of ≥8 on both the HADS subscales was chosen for categorical measures. This cut-off has demonstrated reasonable screening properties in identifying anxiety disorders and major depressive disorder, yielding sensitivities and specificities of approximately 0.8 (Bjelland *et al.*, 2002). The same cut-off was recently confirmed in a study of the HADS in Norwegian primary care (Olsson *et al.*, 2005). For the descriptive purpose the sample was divided into four groups: none-cases (both HADS-A and HADS-D < 8); pure anxiety (HADS-A ≥ 8 and HADS-D < 8); pure depression (HADS-D ≥ 8 and HADS-A < 8); and co-morbid anxiety and depression (both HADS-A and HADS-D ≥ 8). To allow for correlations and interactions between anxiety and depression in the statistical analyses, the groups could not be mutually exclusive. Hence, for these purposes they were defined simply by HADS-A ≥ 8 and HADS-D ≥ 8) for the anxiety group and the depression group, respectively.

Assessment of mental impairment

The HUNT questionnaire contained an item in which the participants were asked whether they had any chronic (at least for one year) mental problem that impaired their daily life functioning. Subjects responding moderate or much were defined as impaired, while no or little was defined as not impaired.

Statistics

While the dimensional distribution of symptom levels was represented by a (fuzzy) scatterplot, the categorical distribution was represented by proportions of participants defined as cases or non-cases by the cut-off thresholds. However, since the properties of the categorical measure differ by the chosen cut-off value (Brenner, 1996), additional analyses were done by a variety of cut-offs (from ≥4 to ≥11 on either HADS subscale) and their various combinations.

Odds ratios with confidence intervals are frequently used as a measure of co-morbidity, and are excellent indicators of non-random associations, but are questionable measures of effect sizes (Kraemer, 2004; Newcombe, 2006). Odds ratios are, for example, not comparable with a dimensional effect size, such as standardized mean difference or a correlation coefficient. We therefore used another measure of association for 2 × 2 contingency tables, namely the phi coefficient, which is the Spearman's rank correlation coefficient applied to two binary random variables. Spearman's rank correlation coefficient (r_s) was also used for the dimensional measures of co-occurrence because the usually assumptions underlying the product moment correlation coefficient are not here necessarily satisfied. In both cases, 95% confidence intervals were calculated using bootstrapping (1000 replications).

To compare the predictive power of the dimensional and categorical approach we applied logistic regression models predicting mental impairment (dependent variable) by symptoms of anxiety (HADS-A), depression (HADS-D) and their interaction (independent variables) (see Frame 1 in Appendix). Since the scaling of the HADS dimensions ('0' to '21') was fundamentally different from that of the HADS categories ('0' or '1'), effect measures, such as odds ratios or regression coefficients, of the separate independent variables could not be compared directly. However, the chi-square critical values (Wald) and the corresponding significance levels (p-values) of the independent variables were object to comparisons, which is the focus of interest in hypothesis testing.

For each individual it is also possible to calculate a probability, or risk score, for having subjective

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impairment, based on his/her HADS subscale scores (see Frame 1 in the Appendix). Such a risk score will relate to either a continuous scale (based on HADS dimensional scores) or a three point scale [based on HADS categories: values 0 (non-case of both anxiety and depression), 1 (only anxiety or depression), and 3 (both anxiety disorder and depression)], respectively. Then, an indirect way of comparing effect sizes of predictive values is to examine differences between the dimensional and the categorical risk scores in their ability to identify subjective impairment by use of receiver operating characteristics (ROC) analyses, including the area under the curve (AUC) measure.

The analyses were all conducted on both the total sample and on sub-populations stratified by 10 years age groups and gender.

A two-sided p-value <0.05 was chosen to indicate statistical significance. The statistical analyses were conducted using the software package of SPSS 11.5 and S-Plus 6.1.

Ethics

HUNT 2 was approved by the Norwegian Data Inspectorate and Regional Committee for Medical Research Ethics in Health Region IV of Norway. After complete description of the study to the subjects, written informed consent was obtained from all participants.

Results

Descriptive features

The fuzzy scatterplot (Figure 1) demonstrates the dimensional nature of the co-occurring anxiety and depression visualizing the problems of the categorical approach, namely the wide variation of dimensional symptom levels within each of the four anxiety and depression groups (non-cases; pure anxiety; pure depression; and co-morbid anxiety and depression), variation likely to be of clinical significance. By definition, the categorical approach could only distinguish between cases and non-cases, resulting in 79.6% non-cases, 9.6% pure anxiety cases, 4.9% pure depression cases, and 5.9% co-morbid anxiety and depression cases.

Co-morbidity measures

The categorical association between anxiety and depression (phi) was considerably lower (0.38, 95% confidence interval 0.37–0.39) than the dimensional (r_s) (0.51, 95% confidence interval 0.50–0.51) (Table 1). By exploring a variety of combinations of cut-offs of HADS-A and HADS-D the obtained maximum value of phi was 0.39 (cut-offs HADS-A ≥ 7; HADS-D ≥ 8). Differences were seen for all the age-gender sub-populations where the categorical phi was in the range 0.30–0.43 and the dimensional r_s 0.47–0.59 (Table 1).

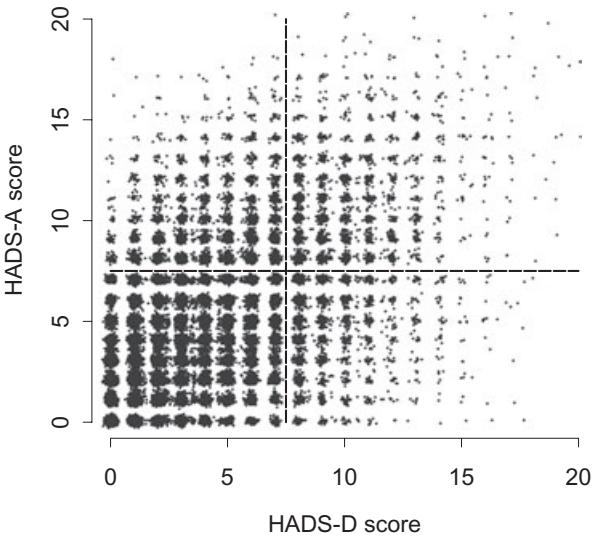

Figure 1 The distribution of HADS-A and HADS-D scores (fuzzy scatterplot). Categories: lower left, non-cases; lower right, 'pure' depression'; upper left, 'pure' anxiety; upper right, 'co-morbid' anxiety disorder and depression. The HUNT 2 study. $N = 60\,869$.

Predictive power and values

The Wald statistics [displaying the critical chi-square (χ^2) values] and the corresponding p-values showed in general markedly higher and lower values, respectively, in the dimensional model compared with the categorical model (Table 2). Moreover, these differences between the dimensional and the categorical models were seen in the sub-populations based on age and gender as well. In half of the sub-populations one or more of the coefficients that were statistically significant ($p < 0.05$) in the dimensional model, were not so in the categorical one. Statistical significance, however, only indicates some deviation from random associations (appropriate for hypothesis testing). The difference in effect sizes between the two models is better shown in the comparative ROC-curves (Figure 2). The AUC was somewhat better for the dimensional (0.87) than the categorical (0.82) risk score, without overlapping 95% confidence intervals (Table 3). The dimensional risk score showed especially higher sensitivity when the

Table 1 Co-occurrence of anxiety[a] and depression[a] symptoms measured by the Spearman correlation coefficient[b] (r_s), the phi coefficient[c] (phi). The HUNT 2 study. $N = 60\,869$

	Age (years)	*N* (%)	Dimensional r_s (95% confidence interval)	Categorical phi (95% confidence interval)
All		60 869 (100)	0.51 (0.50–0.51)	0.38 (0.37–0.39)
Men	20–29	3867 (6.4)	0.47 (0.44–0.50)	0.32 (0.26–0.37)
	30–39	5322 (8.7)	0.53 (0.51–0.55)	0.38 (0.35–0.43)
	40–49	6377 (10.5)	0.55 (0.54–0.57)	0.42 (0.39–0.46)
	50–59	5235 (8.6)	0.56 (0.53–0.57)	0.43 (0.40–0.47)
	60–69	4033 (6.6)	0.54 (0.51–0.56)	0.37 (0.33–0.41)
	70–79	3158 (5.2)	0.50 (0.47–0.53)	0.34 (0.29–0.38)
	80–89	816 (1.3)	0.48 (0.42–0.53)	0.30 (0.22–0.39)
Women	20–29	4661 (7.7)	0.52 (0.50–0.55)	0.34 (0.30–0.38)
	30–39	6042 (9.9)	0.59 (0.57–0.60)	0.41 (0.37–0.44)
	40–49	6915 (11.4)	0.58 (0.57–0.60)	0.42 (0.39–0.44)
	50–59	5546 (9.1)	0.58 (0.57–0.60)	0.43 (0.40–0.46)
	60–69	4279 (7.0)	0.56 (0.54–0.58)	0.42 (0.38–0.45)
	70–79	3474 (5.7)	0.55 (0.53–0.58)	0.38 (0.33–0.41)
	80–89	1144 (1.9)	0.51 (0.46–0.55)	0.33 (0.26–0.40)

[a] Measured by the Hospital Anxiety and Depression Scale (HADS), anxiety and depression subscales, respectively.
[b] The correlation between the continuous scores of HADS-A and HADS-D.
[c] Phi is a measure of the correlation between categorical measures of HADS-A and HADS-D (for both subscales cut-off values ≥8).

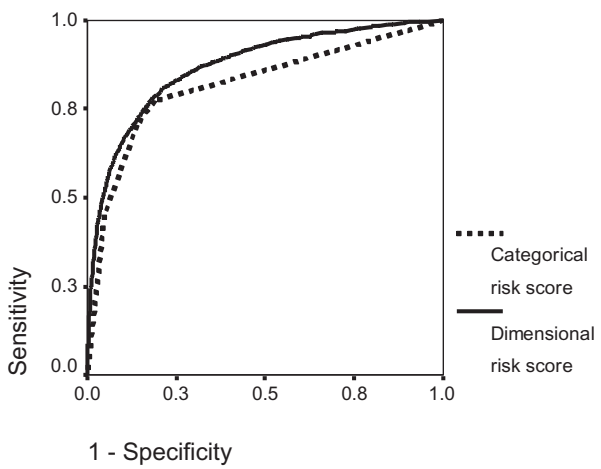

Figure 2 Receiver operating characteristics (ROC) curves of risk scores predicting subjective impairment. The HUNT 2 study. $N = 60\,869$. (Note: Risk scores were obtained from logistic regression models predicting subjective impairment with anxiety and depression subscores of the HADS, and their product (interaction term). In the categorical analyses HADS scores were dichotomized for both subscales at cut-off values ≥8, and in the dimensional analyses HADS subscale scores were used as continuous variables.)

specificity was falling (the right part of the curves) than the categorical risk score. Similar differences were seen for most of the age-gender sub-populations (curves not shown).

By exploring various combinations of cut-offs of HADS-A and HADS-D the maximum AUC obtained for the categorical risk score was 0.83 (the other data not shown). Again, for all the subgroups the dimensional AUCs values were higher than the categorical ones (Table 3).

Discussion

In this population-based cross-sectional study of self-rated anxiety and depression based on the HADS, we found a wide variation of dimensional symptom level within each of the anxiety and depression categories defined by cut-off ≥8 on both the HADS subscales. The dimensional measures of co-occurrence between anxiety and depression showed a considerably stronger association ($r_s = 0.51$) than the categorical (phi = 0.38). The power to predict subjective mental impairment was stronger with the dimensional approach than the categorical, demonstrated by substantially higher levels of statistical significance of the coefficients in the logistic regression

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Table 2 Significance levels (p) and chi-square critical values (χ^2 ,Wald statistics) of the regression coefficients from the multiple logistic regression models where anxiety[a] and depression[a] predict subjective impairment due to mental problems. The HUNT 2 study. $N = 60869$

		Dimensional						Categorical					
		Anxiety		Depression		Anxiety × depression		Anxiety		Depression		Anxiety × depression	
	Age (years)	p	χ^2	p	χ^2	p	χ^2	p	χ^2	p	χ^2	p	χ^2
All		<0.001	692.86	<0.001	194.08	<0.001	38.76	<0.001	225.36	<0.001	76.20	0.002	9.35
Men	20–29	<0.001	21.39	0.173	1.85	0.957	0.00	0.015	5.88	0.361	0.84	0.800	0.06
	30–39	<0.001	46.90	0.196	1.67	0.801	0.06	0.997	0.00	0.996	0.00	0.996	0.00
	40–49	<0.001	84.17	<0.001	27.60	0.002	9.73	<0.001	19.36	0.002	10.05	0.346	0.89
	50–59	<0.001	72.67	<0.001	18.66	0.025	5.04	<0.001	16.99	0.037	4.36	0.783	0.08
	60–69	<0.001	40.41	<0.001	17.76	0.082	3.02	0.005	7.92	0.133	2.26	0.869	0.03
	70–79	<0.001	43.94	<0.001	12.83	0.009	6.86	<0.001	28.56	<0.001	15.18	0.008	7.12
	80–89	0.316	1.01	0.977	0.00	0.394	0.73	0.563	0.33	0.825	0.05	0.549	0.36
Women	20–29	<0.001	66.58	<0.001	21.08	<0.001	12.67	<0.001	37.96	<0.001	18.66	<0.001	12.27
	30–39	<0.001	98.27	0.001	11.77	0.013	6.16	<0.001	22.22	0.008	7.02	0.149	2.08
	40–49	<0.001	56.81	0.010	6.59	0.992	0.00	<0.001	30.64	<0.001	13.31	0.083	3.00
	50–59	<0.001	92.33	0.004	8.37	0.084	2.98	0.036	4.39	0.814	0.06	0.184	1.77
	60–69	<0.001	63.16	0.014	6.01	0.427	0.63	<0.001	24.73	0.007	7.37	0.235	1.41
	70–79	<0.001	13.13	0.002	8.48	0.972	0.00	0.235	1.41	0.537	0.38	0.342	0.91
	80–89	0.006	7.57	0.005	7.81	0.292	1.11	0.005	7.97	0.010	6.66	0.096	2.78

[a]Measured by the HADS, anxiety and depression subscales, respectively. In the categorical models HADS scores were dichotomized for both subscales at cut-off values ≥8, and in the dimensional models HADS subscale scores were used as continuous variables, respectively.

Table 3 Receiver operating characteristics (ROC) analyses of risk scores[a] predicting subjective impairment. The HUNT 2 study. $N = 60\,869$

	Age (years)	Dimensional AUC[b] (95% confidence interval)	Categorical AUC[b] (95% confidence interval)
All		0.87 (0.86–0.88)	0.82 (0.81–0.83)
Men	20–29	0.87 (0.80–0.93)	0.84 (0.77–0.91)
	30–39	0.90 (0.86–0.94)	0.84 (0.79–0.89)
	40–49	0.89 (0.87–0.92)	0.83 (0.80–0.87)
	50–59	0.90 (0.87–0.92)	0.84 (0.80–0.87)
	60–69	0.85 (0.81–0.88)	0.76 (0.71–0.81)
	70–79	0.85 (0.81–0.89)	0.79 (0.73–0.85)
	80–89	0.68 (0.58–0.78)	0.67 (0.55–0.78)
Women	20–29	0.91 (0.87–0.94)	0.89 (0.85–0.93)
	30–39	0.91 (0.89–0.94)	0.85 (0.81–0.89)
	40–49	0.88 (0.85–0.90)	0.83 (0.80–0.87)
	50–59	0.87 (0.84–0.89)	0.82 (0.78–0.85)
	60–69	0.86 (0.83–0.89)	0.82 (0.78–0.85)
	70–79	0.83 (0.79–0.88)	0.77 (0.71–0.83)
	80–89	0.79 (0.72–0.85)	0.72 (0.64–0.81)

[a] Risk scores were obtained from logistic regression models predicting subjective impairment with anxiety and depression subscores of the HADS, and their product (interaction term). In the categorical analyses HADS scores were dichotomized for both subscales at cut-off values ≥8, and in the dimensional analyses HADS subscale scores were used as continuous variables.
[b] AUC, area under the curve.

models and somewhat larger AUC values in the ROC-analyses. These are the types of results that would be expected when within those with and without the categorical diagnosis, there is clinically meaningful variation in the corresponding dimensional diagnosis. Loss of power to detect association, for example between genotype and disorder, or in comparing treatments in randomized clinical trials, is the likely result of focus only on categorical diagnoses. Attenuated effect sizes, even those statistically significant, is also the predictable outcome. In short, many of the problems that have slowed progress in understanding of mental disorders, may be resolved in part by addition of dimensional diagnoses to categorical diagnosis.

The stronger association of anxiety and depression symptoms by the dimensional approach indicates an extensive co-occurrence of these symptoms in the 'pure' anxiety and depression groups, displayed by the density of observations near the corner of the cut-off lines in these categories (Figure 1). Generally, the loss of information induced by categorization will have the strongest impact for scores just below or above the cut-off values, and the cut-off values may themselves have been arbitrarily set. In categorical terms this corresponds to anxiety with co-occurring sub-syndromal depression, and *vice versa*. Patients not fulfilling the diagnostic criteria for either disorder might very well be still substantially impaired from their symptoms (Angst and Merikangas, 2001) and in need of treatment (Angst *et al.*, 1997). Allowing for graded symptom levels, adding a dimensional measure in cases with co-occurring anxiety and depression will most probably increase sensitivity to other clinical features, such as decisions on appropriate level of care and degree of improvement due to treatment.

The extensive occurrence of co-morbidity of mental disorders in epidemiologic studies (Alonso *et al.*, 2004; Kessler *et al.*, 2005) questions the validity of the present categorical classification. Are all the described syndromes really nosological entities, or may some of them instead fallaciously be based on artificial cut-off thresholds of one-dimensional psychopathology? If the latter is the case, broader clinical syndromes should be defined allowing more heterogeneous symptom pictures. For example, a mixed anxiety-depression syndrome, including co-occurring symptoms both above and below the categorical thresholds, would be a natural candidate for such a

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classification and is indeed defined in the ICD-10 as F41.2 – however with a somewhat artificial definition. Hence, such a syndrome would be much broader than F41.2 which excludes symptoms above threshold for both an anxiety and depressive disorder.

Our data show a stronger predictive power of the dimensional approach concerning mental impairment, which may also have relevance for research. In hypothesis testing 'non-significant' results may (erroneously) be interpreted as the proof of no association ('type II error') if there is a true association. The fewer the observations and the weaker the association, the greater is the probability for a non-significant result. Compared to the dimensional models, the categorical logistic regression models showed substantially more non-significant regression coefficients in relation to mental impairment. Thus, compared with the dimensional approach the categorical resulted in a marked loss of predictive power and a widespread occurrence of type II errors. Type-I errors (erroneously rejections of the null-hypothesis) are more a matter of where to define the significance level, which is not affected by these differences between the dimensional and categorical approaches.

Clinically, the results from the ROC analyses have some implications. In general, the somewhat larger AUC values achieved by the dimensional approach imply a more precise description of the combined anxiety and depression symptom levels and thus more accurate identification of individuals with mental impairment. More specifically, the reduced AUC values in the 'sensitivity part' of the ROC curve of the categorical risk score indicate an increased chance of missing impaired individuals since they are classified as non-cases.

The major strength of this study is the large sample from the general population, covering a wide age range that made sub-population analyses possible. Compared to the completers the non-completers were older, more often women, and with a lower level of education, which might indicate higher symptom levels of anxiety and depression and mental impairment among them. If this were an epidemiological study of the association of depression and anxiety, the issue of sampling bias would be paramount. However, the purpose here was to illustrate the impact of moving from categorical to dimensional diagnoses, whatever the sample.

The validity of the self-rated mental impairment could be questioned, but what is seen here is what would be expected with any ordinal outcome measure.

Similarly, the HADS might not be the best choice for measuring depression and anxiety, but these are demonstrated reliable and valid measures. Use of any other measures of dimensional diagnoses are likely to generate results paralleling these, for the issue is not the measure *per se*, but the heterogeneity within the categorical diagnostic groups of clinically relevant heterogeneity in the dimensional measure.

From one point of view our comparison of the categorical with the dimensional approach to diagnosis should have been performed with well accepted gold standard categorical and dimensional measures of anxiety and depression. However, such gold standards do not exist, at least not for dimensional diagnoses, and hardly for categorical diagnoses. Moreover, such a comparison would have introduced non-shared variation between the two measures, which would have biased the results. The principle difference between a categorical and a dimensional diagnosis is the use of a threshold versus a graded scale when describing a problem. By dichotomizing the HADS subscales that difference could be studied without introducing non-shared variation. Taking into account the possible measurement bias induced by such a dichotomizing, different combinations of cut-offs of HADS-A and HADS-D, respectively, were used in the analyses.

All measures have some degree of measurement error. When one dichotomizes a dimensional measure, errors of measurement are simply carried over. What is lost in the categorization is real information, the heterogeneity in the dimensional measures within each category. This then deflates the reliability of the categorical measure. Exactly how much the deflation is depends on whether the cut-point for the categorization is in the middle or in the extremes of the distribution. However, even optimally dichotomized in the middle of the distribution, the reliability coefficient of a categorical diagnosis is less than the corresponding dimensional diagnosis. This, in fact, is one of the reasons that methodologists have long claimed that use of categorical measures is associated with loss of power and attenuated effect size. What was done here was simply to demonstrate how great and where the loss might be.

We acknowledge that it takes more information than a symptom score from a questionnaire to establish a diagnosis of a mental disorder. Information on onset, course, persistence of symptoms, and functional impairment may also be needed in order to obtain valid and reliable categorical diagnoses, but these too are dimensional measures likely to be heterogeneous within any categorical diagnosis. Hence, we consider our findings as relevant arguments in the discussion addressing the issue of a dimensional adjunct to the present categorical classification systems (Kraemer, 2007).

In our study based on HADS-ratings we found that the dimensional approach added clinically important information to the categorical one both by describing the co-occurrence of anxiety and depression, and by identifying cases with mental impairment. Hence, our findings suggest that the dimensional approach should be a useful supplement to the categorical one, which has held a predominant position in psychiatry due to the categorical nature of the current classification systems. A major challenge is, however, to identify and operationalize the most characteristic symptom dimensions of anxiety and depression in order to achieve common, officially accepted dimensional measures of these prevalent conditions. Such dimensions have recently been suggested in this journal (Shear *et al.*, 2007; Andrews *et al.*, 2007).

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Declaration of interests statement

The authors report no competing interests.

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Appendix

Frame 1

Prediction formulas derived from the multiple logistic regression models estimating impairment from anxiety and depression symptoms.

Dimensional (using continuous HADS-scores [HADS-A cont and HADS-D cont]):

$$\text{Logit}(p) = c + b_1(\text{HADS-A cont}) + b_2(\text{HADS-D cont}) + b_3[(\text{HADS-A cont}) \times (\text{HADS-D cont})]$$

Categorical (using categorical HADS-scores, i.e. categorical variables after HADS scores were dichotomized for both subscales cut-off values ≥8 [HADS-A cat and HADS-D cat]):

$$\text{Logit}(p) = c + b_1(\text{HADS-A cat}) + b_2(\text{HADS-D cat}) + b_3[(\text{HADS-A cat}) \times (\text{HADS-D cat})]$$

where p, probability ('risk score') for having impairment; c, constant; $b_{1–3}$, coefficients for the terms in the equations; HADS-A, the Hospital Anxiety and Depression Scale, anxiety subscale; HADS-D, the Hospital Anxiety and Depression Scale, depression subscale.