Title page

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Title:

Are we overestimating the prevalence of depression in chronic illness using questionnaires?: meta-analytic evidence in Obstructive Sleep Apnoea.

Running head:

OSA and depression

Abstract

Introduction

Depression is common in chronic illness, albeit prevalence can be highly variable. This variability may be a function of symptom overlap between depression and chronic illness. Using Obstructive Sleep Apnoea (OSA) as an exemplar, this meta-analysis explored whether the proportion of overlapping symptoms between OSA and depression, within different depression questionnaires, moderates prevalence estimates.

Methods

A systematic search identified 13 studies meeting eligibility criteria.

Results

Based on depression questionnaires, the prevalence of depression in OSA ranged from 8% – 68%, reflecting marked heterogeneity. Prevalence estimates based on questionnaires with greater symptom overlap between OSA and depression were higher, whilst questionnaires with a higher proportion of anhedonia symptoms were associated with lower prevalence estimates.

Discussion

Overall, these data suggest that when using depression questionnaires to assess the prevalence of depression in OSA, questionnaires that have a lower proportion of symptom overlap between OSA and depression, as well as a higher proportion of anhedonia symptoms, reduce the likelihood of overestimating the prevalence of depression in OSA. This study has implications for other chronic illnesses with symptom overlap with depression, for example diabetes, chronic kidney disease or heart disease, as well as suggesting that depression questionnaires are not equally appropriate for assessing depression symptomatology in chronic illness populations.

Keywords

Obstructive Sleep Apnoea; sleep apnea; prevalence; depression; chronic illness

Are we overestimating the prevalence of depression in chronic illness using questionnaires?: meta-analytic evidence in Obstructive Sleep Apnoea.

Depression is a common, debilitating disorder characterised by loss of energy, anhedonia, poor concentration, decreased libido, and feelings of sadness and hopelessness (American Psychiatric Association, 2013). Evidence suggests greater incidence of comorbid depression or more severe depression symptoms in individuals with chronic medical illness, such as diabetes mellitus (Anderson, Freedland, Clouse, & Lustman, 2001), sleep disorders (Vandeputte & de Weerd, 2003), and heart disease (Rutledge, Reis, Linke, Greenberg, & Mills, 2006). The relationship is bidirectional, such that depression increases risk of developing chronic illness, and chronic illness increases risk of depression (Katon, 2003). Combined depression with chronic illness is associated with increased symptom burden and functional impairment, non-compliance with treatment, and poorer health and quality of life (Katon, 2003).

A growing number of meta-analyses has examined the prevalence of depression in different chronic illness, including heart failure (Rutledge et al., 2006), chronic kidney disease (Palmer et al., 2013) and diabetes mellitus (Anderson et al., 2001). All find that depression prevalence estimates vary widely, attributing this to the methodologies used and individual characteristics, such as the type of depression assessment, type of sample, gender, age, and chronic illness severity. Although these are all plausible explanations for differing prevalence estimates, no research to date has examined whether depression prevalence estimates in individuals with chronic illnesses, are also moderated by the proportion of symptom overlap between the chronic illness and depression, within the assessment tools used to assess depression symptomatology.

Stringent identification of depression relies on structured diagnostic interviews applied against criteria, such as those from the Diagnostic and Statistical Manual of Mental Disorders, DSM-5 (American Psychiatric Association, 2013), e.g., the Structured Interview

for Clinical Disorders (SCID; First, Spitzer, Gibbon, & Williams, 2012). However, structured interviews are rarely used in epidemiological and case-control studies (Coyne, Thompson, Klinkman, & Nease Jr, 2002). Instead, validated psychometric questionnaires are used to assess self-reported depressive symptomatology (Coyne, Thompson, Klinkman, & Nease Jr, 2002), from which prevalence estimates are estimated (Harris, Glozier, Ratnavadivel, & Grunstein, 2009). A number of depression questionnaires are used to assess depression symptomatology, e.g. the Geriatric Depression Scale (15 items scale; Yesavage & Sheikh, 1986), Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961), and the Zung Self Rating Depression Scale (Zung, 1965). Each questionnaire consists of a different number of items assessing symptoms of depression. However, many are also symptoms commonly reported by individuals with a particular chronic medical illness, such as fatigue, sleep disturbance, and weight/appetite changes (Benton, Staab, & Evans, 2007). Given this symptom overlap, assessing depression, per se, becomes difficult, as there is an increased risk of overestimating the prevalence of depression in chronic illness. To overcome this, researchers/clinicians (e.g. Peppard, Szklo-Coxe, Hla, & Young, 2006) have eliminated crossover symptoms when assessing depression, as endorsement of these symptoms may not necessarily indicate depression but, rather, the chronic illness.

Obstructive Sleep Apnoea (OSA) is a chronic medical condition for which there is considerable controversy regarding the prevalence of comorbid depression and high levels of symptom overlap (Harris et al., 2009). Epidemiological studies show that between 2-4% of middle-aged men, 1-2% of women (Young et al., 1993), and 11-62% of older adults (>60 years old; Janssens, Pautex, Hilleret, & Michel, 2000) are diagnosed with OSA. Diagnosis of OSA is by polysomnograph (PSG), and severity is usually based on the average number of times per hour an individual's upper airway partially (hypopnea) or completely (apnoea) blocks due to upper airway collapse (Peppard et al., 2006).

Prevalence of mild or more severe depression in an OSA population ranges from 7-63% (Saunamaki & Jehkonen, 2007) compared to 6 - 7% in the general adult population (Kessler et al., 2003). However, assessment of depression in OSA is confounded by overlap in symptoms, such as insomnia, irritability, decreased libido, fatigue and poor concentration, all of which are included in many of the depression questionnaires used to assess prevalence estimates in the OSA literature (Harris et al., 2009).

Therefore, this study sought to determine if the prevalence of depression in OSA is moderated by the degree of overlap between OSA and depressive symptoms within the depression questionnaires used. We addressed three questions: 1) What is the range of prevalence estimates of depression in OSA, when using depression questionnaires? 2) Is the prevalence of depression in OSA moderated by the proportion of symptoms shared between OSA and depression within the depression questionnaire used? 2) Are these effects moderated by age, OSA severity, BMI, sample type, or gender?

Method

Search strategy

A scoping search failed to find sources prior to 1980 that met quality criteria. Thus, data for this meta-analysis consisted of articles published in peer-reviewed journals, non-published articles, and conference abstracts between January 1980 and July 2013. Procedural details of the methodology employed in this meta-analysis are outlined in Fig 1.

The terms ‘apnoea OR apnea OR sleep-disordered breathing’ were combined with ‘depression OR major depressive disorder OR depressive disorder OR dysthymic disorder’. The terms chosen covered a wide range of terms to capture studies that have explored the relationship between depression and OSA. An extensive, computer-assisted, systematic literature search was conducted using electronic databases (Keyword and MeSH explode) for published articles and conference abstracts (Medline R, PsychInfo, PubMed, EMBASE,

CINAHL, CCTR), grey literature (SIGLE), dissertations and theses (Proquest Dissertations and Theses) and via handsearching (references of the included articles). Authors of conference abstracts who reported the prevalence of depression with OSA were contacted to ask for further information regarding their study, and for any unpublished studies relevant to the field of OSA and depression. Additionally, relevant articles were retrieved from the reference lists of studies that were included in the final analysis. This search methodology produced 11,226 papers/conference proceedings.

Study selection criteria and quality assessment

Abstracts retrieved from the databases and subsequent papers were examined for suitability (outlined in Fig 1). This meta-analysis included group-based empirical studies that assessed the prevalence of depression in adults with OSA. In all instances, studies were excluded if OSA participants were not diagnosed with OSA using an overnight sleep study (PSG), split night PSG, in-home PSG, or portable ambulatory diagnosis. However, an exception to this was for Reyes-Zúñiga et al., (2012) where some participants were administered a simplified, respiratory polygraph instead of a PSG. Simplified respiratory polygraphs have been found to be a sensitive and accurate method for diagnosing OSA (Ballester et al., 2000). As the present focus was on OSA, studies where it was clear that individuals had central sleep apnoea (CSA) were excluded. Research demonstrates that the epidemiology, pathophysiology, and clinical characteristics of CSA and OSA are distinct (Young, Peppard, & Gottlieb, 2002). Studies that assessed individuals under the category of sleep apnoea or sleep disordered breathing (SDB) were included, as CSA events are only prevalent in 9-10 % of individuals with SDB (Young et al., 2002).

This paper considered only studies with adult participants (≥ 18 years). For articles where the age range or inclusion criteria for age were not stated, 95% confidence intervals using the provided mean and SD of the age were calculated. Studies were excluded if the

lower confidence interval fell below 18, reducing the chance of including participants aged below 18. Only studies that assessed depression using validated questionnaires were included. Studies were also excluded if the authors failed to report the cut-off indicative of a depression. Although diagnostic and statistical interviews of clinical disorders (DSM-III and DSM-IV) are the gold standard for assessing depression, the focus of this study was exploring whether symptom overlap in depression questionnaires influenced prevalence estimates, therefore studies that used clinical interviews only were excluded. Studies were excluded if they did not include all individuals with depression at baseline. Studies that excluded individuals who may have had depression (e.g. individuals with current psychiatric illness, axis I diagnoses, currently taking antidepressants, past diagnosis of depression etc.) were excluded. Samples were also excluded if individuals were from special populations (e.g. individuals with traumatic brain injury, major depression, terminal illness, chronic kidney disease, Alzheimer's disease etc.). Studies were excluded if patients had engaged in any OSA treatment: Continuous Positive Airway Pressure (CPAP), oxygen therapy, weight loss, mandibular advancement splint and positional therapy, since the severity of depression symptomatology may decrease after OSA treatment (Wells, Freedland, Carney, Duntley, & Stepanski, 2007). As depressive symptomatology has been found to influence CPAP use, studies were excluded if they reported baseline depression prevalence only for individuals who engaged successfully with an OSA treatment (Wells et al., 2007). Studies were excluded if authors provided insufficient information regarding their sampling methodology. For studies where there was an overlap between the populations assessed, studies that had the earlier publishing date or largest N were selected; the remaining studies were excluded. If insufficient data were provided to calculate prevalence rates (percentages, frequencies, or odds ratios) and the authors could not be contacted, these studies were excluded.

Twenty-nine authors of conference abstracts that reported the prevalence of depression in individuals with OSA were contacted for further information, and for unpublished and published papers that were in the field of depression and OSA; seven replied. Five provided more information about their study, however these studies were later excluded due to failure to meet the inclusion criteria. Four provided full journal articles, but only one paper (Castro et al., 2013) was included, as the other studies were either articles that were already found in the systematic search or did not meet inclusion criteria. One author provided extra, but insufficient, information about their study, leading to exclusion. Additionally, 1 unpublished thesis could not be sourced. This left 13 studies to be included in the final analysis. The authors (SN, RSB, TS) independently reviewed 10% of the abstracts for abstract screening, 10% of the articles for the paper screening, and 10% of the articles for the paper quality assessment. The approach of assessing 10% of the articles within screening phases and data extraction has been commonly used (see Hartling et al., 2013; Chang, Connelly, & Geeza, 2012). Where there were disagreements the authors discussed and came to an agreement. The data for all included studies were extracted and coded by the first author. The second author extracted and coded the data for 5 randomly selected articles. There was 100% agreement on data extraction between the first and second author.

Categorisation of the items from the depression questionnaires

Table 1 reports the allocation of the items from each depression questionnaire (from studies in the final analysis) into the symptom categories and subcategories. The symptom categories were as follows:

- OSA: Symptoms that are considered symptoms of both OSA and depression
- Somatic/behavioural consequences of depression: Symptoms that are physical or behavioural manifestations of depression;
- Sleep disturbance: Symptoms that directly relate to sleep quality or quantity;

- Loss of energy or fatigue: Symptoms that reflect loss of energy or fatigue;
- Cognitive: Symptoms that relate to conscious mental activities;
- Negative affect: Symptoms that refer to the experience of an internal feeling or emotion;
- Cognition: Symptoms that reflect mental processes about oneself, e.g. 'I am a failure';
- Anhedonia: Symptoms that relate to the inability to experience pleasure from different experiences or activities;
- Anxiety: Somatic and cognition symptoms that are characteristic of anxiety;

The number of items in each symptom category was divided by the total number of items in the questionnaire to produce a proportion for the symptom category. Items that belonged to two or more symptom categories were counted separately for each symptom category. For example, changes in fatigue and appetite are symptoms of OSA as well as somatic/behavioural consequences of depression, thus they were counted in both symptom categories. The QUIDS contains 16 items, collapsed into 9 category scores (sleep, sadness, weight/appetite change, concentration/decision making, view of myself, suicidal ideation, general interest, energy changes, and psychomotor changes). Thus, the proportion for the QUIDS was based on 9 rather than 16 points. The categorization was conducted by the primary author, and checked independently by the other authors (RSB, TS). Any disagreements were discussed and resolved. Table 2 reports the proportions of symptoms by symptom category for each questionnaire.

Data Extraction and Analysis

Data extracted and coded from the final articles included author/s, publication status, year of publication, sample size, sample type (opportunity or population-based), participant details when available (gender, body mass index (BMI), age, AHI/RDI (Respiratory Desaturation Index), depression questionnaire used, and prevalence estimate of depression.

Opportunity samples were made up of participants with OSA, usually recruited from a hospital clinic or through medical records. Population-based studies were sampled using stringent sampling methodologies from a fixed population. Pooled mean and SDs for AHI/RDI, BMI and age that were not reported were calculated if sufficient data were provided, using the following formulae for pooled means $((x_1 * n_1 + x_2 * n_2) / (n_1 + n_2))$ and pooled standard deviations $(\sigma_{x_1-x_2} = \sqrt{\sigma^2_1 / n_1 + \sigma^2_2 / n_2})$. Individual study and participant characteristics are provided in Table 3.

Data processing and quantitative methodology

Comprehensive Meta-Analysis version 2.2.064 (Borenstein, Hedges, Higgins, & Rothstein, 2011) was used to synthesize data, calculate effect sizes, conduct moderator and meta-regression analyses, and create forest plots. All probability values that were less than .05 were deemed significant

Results

Data are reported from 2085 individuals with OSA (72% male; Mean Age, 52.69±9.83; Mean BMI, 31.77±5.32; Mean AHI, 40.45±24.91).

Calculation of pooled prevalence of depression in OSA

We computed prevalence point estimates and 95% confidence intervals using the formula: $\text{Logit Event Rate SE} = \sqrt{1 / (\text{Event Rate} \times \text{Total}) + 1 / [1 - \text{Event Rate}] \times \text{total}}$ (see Rutledge et al., 2006). A random effects model was used. The random effects model assumes that each study has a different underlying ‘true’ effect size due to differing sample demographic variables (Rosenthal, 1995). A random effects model accounts for these between-studies differences, as well as within-study participant differences (Rosenthal, 1995). In the present meta-analysis, samples differed in age, OSA severity, BMI, sample type, gender, and depression questionnaire used. Table 3 illustrates the prevalence estimates of depression among individuals with OSA reported for each of the 13 studies. The

prevalence estimates reported across these studies varied widely, from 7.59% to 68.33% (see Fig 2). The highest depression prevalence estimate was found using the CES-D (10 items), and the lowest were from the GDS and HADS-D. Rosenthal's Fail-safe N, which represents the number of studies needed to create an overall, non-significant effect, was 765.

Moderator analysis

Categorical moderator analyses were conducted to examine if age (Group 1 < 50 years old, Group 2 ≥ 50 years old), OSA severity (Group 1 = Severe (AHI/RDI ≥ 30), Group 2 = Mild-Moderate (AHI/RDI <30)), BMI (Group 1 = Overweight (BMI 25 – 29.99), Group 2 = Obese (BMI ≥ 30)), and sample type (Group 1 = opportunity sample, Group 2 = population-based study), contributed to the heterogeneity of the prevalence of depression in OSA. We had planned to explore depression questionnaire and publication status as moderators, but there were insufficient studies to do so statistically.

Age, OSA severity and BMI were not significant moderators ($p > .05$) of the prevalence of depression in OSA. Study type was a significant moderator of depression prevalence estimates ($Q(1) = 10.13, p < .05$), with prevalence estimates from population-based studies being lower ($N = 4$; 9.70%) than estimates from opportunity samples ($N = 9$; 38.60%). See online supplement (Fig S1) for the forest plot for the effect of study type on depression prevalence estimates.

Meta regression analysis

Meta regression analyses were conducted on the proportion of items for each of the different categories of items for each depression assessment. A mixed effects regression with unrestricted maximum likelihood analysis (UML) was used.

The proportion of items within the questionnaires for the cognition, cognitive, negative affect, anxiety, and somatic items were not significant predictors ($p > .05$) of depression prevalence estimates in OSA. By contrast, the proportion of OSA symptoms was a

significant predictor, with increasing proportion of OSA symptoms associated with increased prevalence rates, $Q(1) = 6.96, p < .05; T^2 = .71$. Likewise, the same positive association held for the proportion of sleep items, $Q(1) = 17.32, p < .05; T^2 = .44$, and for the proportion of loss of energy/fatigue items, $Q(1) = 18.18, p < .05; T^2 = .42$. The greatest proportion of symptom overlap with OSA was found for the QUIDS and the CESD-10, the lowest was for the HADS and GDS (see Table 2). The proportion of anhedonia items was also a significant predictor, $Q(1) = 11.11, p < .05; T^2 = .56$, except that the relationship with prevalence of depression was negative. That is, as the proportion of anhedonia items increased (greatest in the GDS), prevalence of depression decreased.

Finally, increasing proportion of males in a sample ($N = 12$ studies) was a significant predictor of increasing depression estimates, $Q(1) = 9.01, p < .05; T^2 = .58$. See online supplement for the moderated regression plots of the significant predictors (Fig S2 – Fig S6).

Discussion

The current paper builds on evidence surrounding the relationship between depression and chronic illness, with a focus on OSA. Prevalence estimates ranged from 7.59% – 68.33%. Exploration of this heterogeneity considered depression questionnaire characteristics (proportion of items that belong to the different symptom categories within each depression questionnaire), and study and participant characteristics (age, OSA severity, BMI, sample type, and gender).

Nature of the depression measure

Studies that utilised the HADS-D and GDS reported the lowest prevalence estimates (7.59%-9.80%), whilst the study that utilised the CES-D (10 items) reported the highest prevalence estimate (68.33%).

Proportion of items belonging to the somatic/behavioural, cognition, cognitive, anxiety, and negative affect categories did not moderate prevalence estimates. Proportion of

depression symptoms that were also symptoms of OSA moderated prevalence estimates of depression. The same was found for sleep and loss of energy/fatigue items (both symptoms characteristic of OSA). Interestingly, the higher the proportion of anhedonia items, the lower the prevalence of depression. Questionnaires with very few overlapping symptoms with OSA, and a higher proportion of anhedonia items, such as the HADS-D and GDS produced lower prevalence estimates (between 7.59%-9.80%).

Intriguingly, this prevalence estimate appears to be similar to that found in the general population (6%-7%) when a stringent diagnostic interview (Composite International Diagnostic Interview (CIDI; World Health Organization, 1990)) was used to assess the prevalence of depression (Kessler et al., 2003). Thus, all meta-regressions tell a consistent story: depression questionnaires that have a high proportion of shared symptomatology and a low proportion of anhedonia items are associated with higher prevalence estimates, and therefore may lead to an overestimation in the prevalence of depression in OSA.

Study characteristics

Studies created from opportunity samples (38.60%) were associated with higher depression prevalence estimates than population-based studies (9.70%). This may be due to differences in depression severity, biases in subject selection, quality of life, or comorbid disease in individuals with OSA in these two types of samples (Harris et al., 2009). Age and OSA severity were not significant moderators. These findings were consistent with previous research that investigated the relationship between age (e.g. Millman, Fogel, McNamara, & Carlisle, 1989), and OSA severity (e.g. Kripke et al., 1997), but inconsistent with research exploring the relationship between BMI and depression symptomatology (e.g. Aloia et al., 2005). Nonetheless, by assessing BMI, age, and AHI/RDI, using group averages, we may have obscured the effects. Therefore, further research addressing the effect of BMI, OSA severity, and age on the relationship between depression and OSA is warranted.

This study suggests that males have a higher rate of depression than females, which contrasts to findings from previous studies. However, as males generally have more severe OSA than females, they may endorse more symptoms on depression questionnaires due to OSA than females, which may account for this result (Wahner-Roedler et al., 2007). Studies reporting depressive symptoms by gender and OSA severity (AHI/RDI) are required to assess this intriguing idea.

Other factors, such as antidepressant use, presence of hypertension, and presence of other comorbid diseases (e.g. diabetes and heart failure), were not explored in this study, and therefore could not be considered for their effect on prevalence estimates (Benton et al., 2007). Nevertheless, this is the first, comprehensive study that has assessed whether the prevalence of depression in OSA is affected by the degree of symptom overlap between the two disorders, within different depression questionnaires.

Implications and future research

These results paint a compelling story regarding the influence of different depression questionnaires used to assess the prevalence and symptomatology of depression in OSA. These findings suggest that what is needed is the development of a questionnaire to measure depression in OSA. [At the most basic level, such a questionnaire could assess symptoms that do not overlap with OSA, albeit this might ignore important features of depression as a result.](#) Any new questionnaire will need validating against gold-standard diagnostic interview measures such as the SCID (First et al., 2012). Until such a questionnaire has been developed, however, and based on our findings, we would recommend the use of the GDS (15-item short form; Yesavage & Sheikh, 1986) or the HADS-D (Snaith & Zigmond, 1983), to assess depression symptomatology in individuals with OSA, when clinical interviews are unavailable in clinical or research settings.

The impact of depression questionnaires may have implications for the assessment of

CPAP outcomes. There has been contrasting evidence in the literature regarding whether CPAP diminishes depression symptomatology in individuals with OSA (Schröder et al., 2005). However, no study to date has examined if the proportion of overlapping symptoms in the different depression questionnaires used to examine CPAP outcomes, moderates the aggregated results regarding the efficacy and effectiveness of CPAP on depressive symptomatology in OSA. Additionally, comparing which symptoms within depression questionnaires change after OSA treatment will allow us to explore which groups of symptoms are more tractable with OSA treatment, and which (perhaps negative self beliefs, hopelessness, desire to self harm) are less amenable to OSA treatment. Together, these studies will help to shed more light on the phenomenon of depression in OSA.

These findings also have significant implications for other chronic illness populations in which depression is comorbid (e.g. diabetes, Anderson et al., 2001; chronic kidney disease, Palmer et al., 2013; and heart failure, Rutledge et al., 2006). Our findings suggest that not all depression questionnaires may be appropriate for assessing depressive symptomatology in chronic illness populations. Studies replicating this methodology in other chronic illnesses, such as diabetes, chronic kidney disease and heart failure are now warranted.

Declaration of conflicting interests

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Fig 1. Flow chart of search, retrieval and inclusion process

Fig 2. Forest plot of the event rates, 95% confidence intervals, Z- values (the standardized effect size), and P-values (the significance of the standardized effect, indicating if the standardized effect is significantly greater than zero) for each study, calculated using a random effects model.

Table 1

The categorization of the items (numbers under each depression questionnaire corresponds to the item number within the questionnaire) into symptom categories and subcategories.

Symptom categories (in bold) and subcategories	Depression questionnaire						
	BDI	HADS-D	CES-D	CES-D (10 items)	SDS	GDS	QUIDS
OSA items							
Increase in appetite ¹	18						7
Increase in irritability ²	11		1	1	15		
Weight gain ¹							9
Diurnal variation ²					2		
Psychomotor changes ³		8					15
Insomnia ⁴	16		11	7	4		1,2,3,4
Loss of energy ⁴					10	13	14
Tiredness or fatigue ⁴	17						
Cognitive difficulties (concentration and/or memory) ²			5	2	11	10	10
Loss of libido ⁵	21				6		
Somatic/behavioural consequence of depression items							
Loss of appetite	18 ⁶		2		5		6
Appetite gain	18 ⁶						7
Irritability	11		1	1	15		
Weight loss	19				7		8
Weight gain							9
Agitation					13		16
Diurnal variation					2		
Psychomotor retardation		8					15
Crying	10		17		3		
Talking			13				
Bowel changes					8		
Sleep disturbance items							
Insomnia	16		11	7	4		1,2,3,4
Loss of energy or fatigue items							
Loss of energy					10	13	14
Tiredness or fatigue	17						
Apathy	15		7, 20	4, 10	12		
Cognitive items							
Indecivness	13				16		10 ⁷
Concentration difficulty			5	2	11		10 ⁷
Memory issues						10	

Negative affect items							
Sad	1	6	18, 3, 6, 12	3, 8	1	5, 7	5
Lonely			14	9			
Pessimism and hope	2		8	5	14	14	
Guilt	5						
Cognition items							
Sense of humor		4					
Useless					17		
Bored						4	
Helpless						8	
Suicidal thoughts and ideation	9						12
Failure	3		9				
Worthless						12	
Punishment	6						
Self judgement	7, 8						11
Body image	14						
Interpersonal relationships			15, 19, 4		19	15	
Anhedonia items							
Full of life and satisfaction					18	3, 11, 1	
Loss of pleasure in activities once enjoyed	4	2			20		
Loss of interest in general	12	12	16			2, 9	13
Loss of interest in appearance		10					
Loss of interest in entertainment		14					
Loss of libido	21				6		
Anxiety items							
Somatic					9		
Cognition	20		10	6		6	

Note. BDI = Beck Depression Inventory (Beck et al., 1961); HADS-D = Hospital Anxiety and Depression Scale – Depression Scale (Snaith & Zigmond, 1983); CES-D = Center for Epidemiological Studies Depression Scale (Radloff, 1977); CES-D (10 items) = Center for Epidemiological Studies Depression Scale (10-item short form; Andresen, Malmgren, Carter, & Patrick, 1994); SDS = Zung Rating Scale for Depression (Zung, 1965); GDS = Geriatric Depression Scale (15-item short form; Yesavage & Sheikh, 1986); QUIDS = Quick Inventory for Depressive Symptoms (Rush et al., 2003). QUIDS score categories: Sleep (items 1-4), sadness (item 5), appetite/weight changes (items 6-9), concentration/decision-making (item 10), view of myself (item 11), suicide (item 12), general interest (item 13), energy level (item 14), and psychomotor retardation (items 15 and 16). For the OSA items, the superscript numbers represent the articles that indicate that the symptom that the item is assessing is also a symptom of OSA. ¹ Phillips, Kato, Narkiewicz, Choe, & Somers (2000); ² Schröder & O'Hara (2005); ³ Mathieu et al., (2008); ⁴ Chervin (2000); ⁵ Karacan & Karatas (1995); ⁶ The appetite item on the BDI asks about appetite change, which could be appetite gain or loss. Therefore, this symptom was only counted once for that symptom category. ⁷ The concentration/decision-making item on the QUIDS relates to two symptom subcategories within the cognitive category, concentration difficulty or indecisiveness. Therefore, this symptom was only counted once for that symptom category.

Table 2
Number (%) of items belonging to each symptom category for each depression questionnaire

Symptom Categories	Depression Questionnaire						
	BDI	HADS-D	CES-D	CES-D (10 items)	SDS	GDS	QUIDS
OSA items	5 (23.81)	1 (14.29)	3 (15.00)	3 (30.00)	6 (30.00)	2 (13.33)	5 (55.56)
Somatic/behavioural consequence of depression items	4 (19.05)	1 (14.29)	4 (20.00)	1 (10.00)	7 (35.00)	0	2 (22.22)
Sleep disturbance items	1 (4.76)	0	1 (5.00)	1 (10.00)	1 (5.00)	0	1 (11.00)
Loss of energy or fatigue items	2 (9.52)	0	2 (10.00)	2 (20.00)	2 (10.00)	1 (6.67)	1 (11.00)
Cognitive items	1 (4.76)	0	1 (5.00)	1 (10.00)	2 (10.00)	1 (6.67)	1 (11.00)
Negative affect items	3 (14.29)	1 (14.29)	6 (30.00)	4 (40.00)	2 (10.00)	3 (20.00)	1 (11.00)
Cognition items	6 (28.57)	1 (14.29)	4 (20.00)	0	2 (10.00)	4 (26.67)	2 (22.22)
Anhedonia items	3 (14.29)	4 (57.14)	1 (5.00)	0	3 (15.00)	5 (33.33)	1 (11.00)
Anxiety items	1 (4.76)	0	1 (5.00)	1 (10.00)	1 (5.00)	1 (6.67)	0

Note. BDI = Beck Depression Inventory; HADS = Hospital Anxiety and Depression Scale – Depression Scale; CES-D = Center for Epidemiological Studies Depression Scale; CES-D (10 items) = Center for Epidemiological Studies Depression Scale (10-item short form); SDS = Zung Rating Scale for Depression; GDS = Geriatric Depression Scale (15-item short form); QUIDS = Quick Inventory for Depressive Symptoms (16 items divided into 9 categories: proportions of symptom categories reported). 0.01 was added to each of the proportions in the categories (except the OSA item category) to prevent zero values on Comprehensive Meta analysis.

Table 3
Participant and study characteristics for each study

First author of paper	Year	Publication status	Sample Type	N	Age M (SD)	%Male	AHI (M/SD)	BMI (M/SD)	Depression measure	Prevalence of depression (%)
Castro	2013	P	P	354	xx	xx	xx	xx	BDI	9.28
Liu	2011	P	O	142	47.52 (10.62)	80.28	10 ^A	28.41 (3.82)	BDI	31.69
Hashmi	2006	P	O	98	53.20 (10.10)	100	43.50 (29.80)	35.40 (6.80)	BDI	35.70
McCall	2006	P	O	121	54.70 (14.10)	76.03	56.20 (27.20)	xx	BDI	44.60
Svaldi	2003	P	O	54	48.70 (9.20)	61.11	49.70 (31.00)	37.40 (7.00)	BDI	55.56
Stepnowsky	2011	P	O	240	57.00 (12.10)	96.67	37.50 (20.10)	33.40 (6.30)	CES-D (10 – items)	68.33
Kuo	2000	D	P	52	60.1 (9.00)	59.60	33.50 (7.40)	xx	CES-D	11.50
Bardwell	2001	P	O	64	49.30 (7.90)	84.38	51.50 (28.50)	29.80 (4.50)	CES-D	33.00
Yaffe	2011	P	P	105	82.60 (3.10)	0	xx	28.70 (5.30)	GDS	8.57
Kristiansen	2012	P	P	296	45.14	64.53	49.99	xx	HADS-D	9.80
Reyes-Zuniga	2012	P	O	382	50.80 (13.60)	61.78	54.18 (37.55)	32.00 (6.00)	HADS-D	7.59 ^B
Mysliwiec	2013	P	O	69	35.68 (7.64)	100	20.18 (17.56)	31.48 (3.86)	QUIDS	47.82
Ye	2008	P	O	108	47.60 (10.80)	80.56	38.70 (25.10)	27.30 (3.30)	SDS	42.60

Note. Articles are displayed alphabetically by type of depression measure used; ‘Publication status’ corresponds to the publication status of the study (P= peer reviewed published article; D= dissertation; ‘Study type’ indicates whether the study was an opportunity sample (O) or population-based study (P), xx indicates that these details were not provided in the study, ^A indicates that the median value was used as an AHI was not reported (see. Hozo, Djulbegovic, & Hozo, 2005). ^B indicates that only the individuals who were met the cut-off for the HADS-D were used, not the individuals who reported anxiety plus depression. BDI = Beck Depression Inventory; HADS-D = Hospital Anxiety and Depression Scale – Depression Scale; CES-D = Center for Epidemiological Studies Depression Scale; CES-D (10 items) = Center for Epidemiological Studies Depression Scale (10-item short form); SDS = Zung Rating Scale for Depression); GDS = Geriatric Depression Scale (15-item short form); QUIDS = Quick Inventory for Depressive Symptoms.