Prevalence of dyspnea in general adult populations: A systematic review and meta-analysis

Alexander Müller[1,2], Tobias Mraz[1,3], Emiel FM Wouters[1], Sander MJ van Kuijk[4], André FS Amaral[5,6], Robab Breyer-Kohansal[1,7], Marie-Kathrin Breyer[1,3], Sylvia Hartl[1], Daisy JA Janssen[8,9]

Affiliations

(1) Ludwig Boltzmann Institute for Lung Health, Sanatoriumstrasse 2, 1140 Vienna, Austria
(2) Care and Public Health Research Institute, Faculty of Health Medicine and Life Sciences, Maastricht University, Universiteitssingel 40, 6229 ER Maastricht, The Netherlands
(3) Department of Respiratory and Critical Care Medicine, Clinic Penzing, Vienna Healthcare Group, Sanatoriumstrasse 2, 1140 Vienna, Austria
(4) Department of Clinical Epidemiology and Medical Technology Assessment, Maastricht University Medical Centre, Peter Debyeplein 1, 6229 HA Maastricht, The Netherlands
(5) National Heart and Lung Institute, Imperial College London, 1B Manresa Road, London SW3 6LR, UK
(6) NIHR Imperial Biomedical Research Centre, The Bays, Entrance 2, South Wharf Road, St. Mary's Hospital, London W2 1NY, UK
(7) Department of Respiratory and Pulmonary Diseases, Clinic Hietzing, Vienna Healthcare Group, Wolkersbergenstrasse 1, 1130 Vienna, Austria
(8) Department of Health Services Research and Department of Family Medicine, Care and Public Health Research Institute, Faculty of Health Medicine and Life Sciences, Maastricht University, Universiteitssingel 40, 6229 ER Maastricht, The Netherlands
(9) Department of Research & Development, Ciro, Hornerheide 1, 6085 NM Horn, The Netherlands

Corresponding author:
Alexander Müller
Ludwig Boltzmann Institute for Lung Health, Sanatoriumstrasse 2, 1140 Vienna, Austria
alexander.mueller@leadstudy.at

Word count: 3,248 words
Key words: dyspnea, breathlessness, prevalence

Abstract

Introduction and objectives

Dyspnea is a commonly described symptom in various chronic and acute conditions. Despite its frequency, relatively little is known about the prevalence and assessment of dyspnea in general populations. The aims of this review were: 1) to estimate the prevalence of dyspnea in general adult populations; 2) to identify associated factors; and 3) to identify used methods for dyspnea assessment.

Methods

A systematic literature search was conducted using MEDLINE/PubMed, Embase, CINAHL and JAMA network. Records were screened by two independent reviewers and quality was assessed by using the Joanna Briggs Institute checklist for risk of bias in prevalence studies. Multi-level meta-analysis was performed to estimate pooled prevalence. The protocol was registered on PROSPERO (CRD42021275499).

Results

Twenty original articles, all from studies in high-income countries, met the criteria for inclusion. Overall, their quality was good. Pooled prevalence of dyspnea in general adult populations based on 11 studies was 10% (95% CI 7, 15), but heterogeneity across studies was high. The most frequently reported risk factors were increasing age, female sex, higher BMI and respiratory or cardiac disease. The MRC, or the modified MRC, scale was the most used tool to assess dyspnea in general populations.

Conclusions

Dyspnea is a common symptom in adults in high-income countries. However, the high heterogeneity across studies and the lack of data from low- and middle-income countries limit the generalizability of our findings. Therefore, more research is needed to unveil the prevalence of dyspnea and its main risk factors in general populations around the world.

Word count abstract: 253 words

Introduction

Dyspnea is a subjective and discomforting experience where a person feels an increased respiratory effort. [1] Other terms frequently used instead of dyspnea are *breathlessness* and *shortness of breath*. Dyspnea is a common symptom of a broad range of diseases. [2] Often, dyspnea can be explained by chronic cardiorespiratory disease, such as COPD, asthma, or chronic heart failure. It can also be associated with acute conditions such as myocardial infarction, pulmonary embolism, or pneumonia. [3] Chronic breathlessness is related to a reduction in both physical and mental quality of life and thereby seems to contribute to an increased burden of disease. [4] It is also one of the most frequent reasons for admission to hospitals and emergency departments and is linked to increased mortality. [5, 6] In addition, it has been shown that dyspnea can affect activities of daily life leading to higher-level care dependency. [7]

Despite this clinical importance, little is known about the prevalence of dyspnea among the general adult population. Van Mourik et al. conducted a systematic review to investigate the prevalence of dyspnea among people above the age of 65 years. They included 20 population-based studies and reported a pooled prevalence of 36% (95% confidence interval [CI]: 27, 47). [8] The studies they included used the modified Medical Research Council (mMRC) scale to identify dyspnea. The 5-item MRC scale uses everyday situations to quantify the severity of dyspnea, ranging from 1 ("breathlessness only on strenuous exercise") to 5 ("too breathless to leave the house, breathless when dressing/undressing"). The mMRC scale as a modified version uses the same items, but with a grading from 0 to 4 with 0 ("breathlessness only on strenuous exercise") being considered as normal. In a large prospective study, Mockel et al. found out that of all patients presenting at the emergency department, 7.4% do so because of dyspnea. Heart failure and obstructive lung disease were the most frequently reported underlying conditions in this group. [9] They also identified an in-hospital mortality of 9.4% among patients with dyspnea presenting at the emergency department. Knowing the prevalence of dyspnea and its associated factors is important, as it has been shown to be an early predictor of disease progression and mortality and can therefore guide therapeutic decision-making. [10, 11] This may help to improve effective management of underlying conditions.

Currently, there is no gold standard method for the assessment of dyspnea. [1] Various questionnaires exist to measure dyspnea, including short-term intensity tools and situational measures. [12] However, most of these questionnaires were designed for specific cohorts of patients (e.g. COPD, chronic heart failure). For the understanding of dyspnea prevalence, insight in the methods used to assess dyspnea is paramount.

The aims of this review were: to determine the prevalence of dyspnea in the general adult population; to identify factors associated with dyspnea; and to study commonly used methods for dyspnea assessment. We hypothesized in advance that the prevalence of dyspnea is lower in the general adult population than the prevalence found among older people (36%).

Methods

The protocol for this systematic review has been previously registered on PROSPERO (protocol nr.: CRD42021275499). The PRISMA reporting guideline was followed to prepare the manuscript.

Search strategy and selection process

We conducted a systematic literature search using the databases MEDLINE/PubMed, Embase, CINAHL, and JAMA Network. Databases were searched from database inception to June 1, 2022. Search terms used were “dyspnea”, “breathlessness”, “shortness of breath”, “prevalence”, “frequency”, “epidemiology” and “general population”. Medical subject headings (MeSH) “dyspnea” and “prevalence” were used in PubMed.

All study types, except review articles and case studies, were included. Studies focusing on pediatric populations (<18 years) or populations with specific diseases were excluded to reflect the general adult population. Publications not reporting the prevalence of dyspnea were also excluded. Records were screened by two independent reviewers (AM and TM) based on title and abstract. The same strategy was used for full text analyses. In cases of disagreement, a third reviewer (DJ or EW) was consulted. A complete overview of the literature search strategy and the study selection process can be found in the supplementary material. (supplementary material, S1-S5)

Quality assessment

The quality of studies was assessed independently by two reviewers (AM and TM). The *Joanna Briggs Institute (JBI) Checklist for Prevalence Studies* was used to evaluate risk of bias in publications. [13] In cases of disagreement, a third reviewer (DJ or EW) was included in the discussion. The JBI checklist comprises nine items. No cut-off values based on the JBI checklist were defined for study inclusion.

Data extraction

Data extraction forms were created using Microsoft Excel. Both reviewers (AM and TM) extracted data independently. Data were compared to check agreement. In cases of disagreement a third reviewer (DJ or EW) was included. Data was then summarized in one form by the first reviewer (AM) and re-checked by the second reviewer (TM). Data extracted included study design, country, characteristics of the study population (age, sex) prevalence of dyspnea as well as definition of dyspnea and method used for assessment.

Data synthesis

Random-effects meta-analysis was performed for dyspnea prevalence only. No other outcomes were considered for meta-analysis as the reporting of associated factors differed substantially across studies. The pooled prevalence estimate for dyspnea was calculated by using total sample size and number of cases. For studies where no absolute counts were reported, case numbers were calculated using percentages and total sample size. The pooled prevalence estimate was reported as proportion and 95% confidence interval. Multi-level analysis was used to account for similarities and potential overlap in samples. All analyses were performed using R (version 4.2.2) and R studio (version 2022.07.0, *R Foundation*).

Results

Results of literature search

Of the 711 records found, 68 were considered for full text analysis. Of these 68 studies, 20 were included in the systematic review. In cases where the full text was not available, authors were contacted to get access. An overview of the selection process is shown in Figure 1.

Additional information on the reasons of exclusion for each study can be found in the supplementary material (supplementary material, S6).

Study characteristics

Table 1 gives an overview of study characteristics. The study design was mainly cross-sectional, with only 3 studies [14, 23, 32] using a longitudinal approach. Studies were mainly performed in high-income countries (7 in Australia, 1 in the United States, 8 in Scandinavia, 1 in the Netherlands, 2 in the United Kingdom). One study [24] was a multinational analysis using data of 15 countries. The sample sizes showed a broad range from 1013 to 114,380 participants. Study participants of the included studies were adults, with 4 studies [15, 16, 20, 24] also including data of adolescents above the age of 15 or 16 years. The mean age of study participants ranged from 45 to 78 years. The percentage of female participants ranged from 22% to 62%.

Quality of studies

Overall quality of the included studies was very good, with 13 studies fulfilling all criteria of the JBI checklist for prevalence studies. Figure 2 provides a detailed overview of risk of bias assessment for all studies.

Prevalence of dyspnea

Table 1 gives an overview of prevalence estimates for all 20 studies included. Prevalence of dyspnea ranged from 2.4% [18] to 32.3%. [14, 26] Random-effects meta-analysis was used to calculate a pooled prevalence estimate for dyspnea (Figure 3). Six studies we included in the review explored general populations to evaluate dyspnea prevalence but with an a priori interest in specific conditions such as sleeping disorders, asthma, COPD or obesity. [16, 17, 20, 21, 28, 33] We excluded these studies from the meta-analysis based on methodological considerations. Three studies only reported dyspnea prevalence in an older age population. [14, 26, 32] These studies were also excluded from the meta-analysis as their inclusion might lead to over-estimation of the pooled prevalence-estimate. Some of the studies we included for statistical analysis drew their samples from the same populations and thus used overlapping data. [18, 19 / 22, 30] We therefore performed multi-level meta-analysis to account for similarities in populations. Pooled prevalence of dyspnea was 10% (95% CI 7, 15). Although we excluded studies based on the considerations mentioned above, heterogeneity among studies included in the meta-analysis was extremely high (I^2= 100%).

Factors related to dyspnea

An overview of all reported factors associated with dyspnea can also be found in Table 1.

Prevalence increased with increasing mean age of the study cohorts with substantially higher prevalence estimates in populations of higher age. [14, 26, 32] Females showed to have a higher prevalence of dyspnea compared to males in six studies. [14, 15, 19, 21, 22, 24] None of the included studies reported on a higher dyspnea prevalence in men.

Respiratory and cardiac disease or both [14, 22, 24, 26, 30, 32] as well as high BMI [15, 17, 21, 26, 30] were the most commonly described factors potentially increasing the risk for having dyspnea. Underweight was only mentioned in one study as being related to dyspnea. [21] Reduced lung function in absence of diagnosed lung disease showed an association with dyspnea in three

papers. [14, 22, 24] Associations between dyspnea and tobacco smoking, [15, 32] as well as lower socioeconomic status [15, 19, 32] were also reported.

Three studies reported on increased mortality in persons experiencing dyspnea. [14, 23, 25] A potential impact of dyspnea on reduced quality of life, psychological distress and reduced physical activity was frequently reported. [16, 18, 26, 29, 30, 32]

Method of dyspnea assessment

Of the 20 included studies, 16 used the MRC or mMRC scale for assessment of dyspnea. However, the cut-off values used for defining clinically relevant dyspnea differed. Ten studies used a cut-off of ≥1 on the mMRC scale, which is equal to a value of ≥2 on the original MRC scale. Six studies used a cut-off of ≥2 (mMRC) or ≥3 (MRC), respectively. Gulsvik et al. [25] used a specifically designed questionnaire on respiratory symptoms, which also used mMRC items for dyspnea evaluation. Three studies [20, 31, 32] used single-item dyspnea assessment tools. Only two studies [29, 31] asked for a specific period or timeframe in which symptoms occurred. An overview of assessment methods and dyspnea definitions can be found in Table 1.

Discussion

Key findings

The present systematic review showed a pooled prevalence estimate of 10% (95% CI 7, 15) with individual study estimates ranging from 2.4% to 32.3%. Older age, female sex and respiratory or cardiac disease were the most frequently described factors associated with dyspnea. The mMRC or MRC scale was the most commonly used questionnaire to measure dyspnea in general populations.

The highest prevalence of dyspnea was reported in studies by Ahmed et al. [14] and Ho et al. [26], both reporting a prevalence estimate of 32.3%. The data from these two studies derived from the same population of people ≥70 years and the findings were similar to the results of the systematic review by van Mourik et al. [8], which included both publications. However, increasing age has also been shown to be a risk factor for dyspnea in some of the included studies. There are several reasons why older people are more at risk for dyspnea. It has been shown that although total lung capacity seems to be stable over the lifespan, residual volume and functional residual capacity seem to increase. [34, 35] This is due to changes in airway resistance because of altered lung compliance and elastic recoil. These changes in respiratory mechanics lead to a decline in vital capacity and inspiratory capacity. [36] In addition to these mechanical changes, cardiovascular and respiratory conditions commonly related to dyspnea are more prevalent in older populations. [37] Therefore, it can be assumed that age is an influential factor on dyspnea and that both physiological and pathophysiological mechanisms can lead to higher dyspnea prevalence in older adults.

It has been reported earlier that dyspnea prevalence might be higher among females compared to males. [1] The results of our review seem to confirm this assumption. Gut-Gobert et al. identified physiological differences between men and women making women more prone to experiencing dyspnea. [38] Those factors include narrower airway diameters in relation to absolute lung size and thicker bronchial walls. These differences in respiratory mechanics called dysanapsis can especially explain why females seem to be more strongly affected by activity-induced dyspnea. [39] Smaller relative airway diameters lead to an increase in work of breathing as more force needs to be generated for the same amount of air to be

moved. Beside changes in respiratory mechanics, sex hormones, especially progesterone and estrogen, might influence respiration as receptors for these hormones in the respiratory system affect cellular lung defense and breathing control mechanisms. [40] Brown et al. have recently investigated the relationship between trait self-control regarding dyspnea and self-reported sensation of dyspnea in males and females using a CO_2-rebreathing. [41] They observed that breathlessness caused by hypercapnia was less well tolerated by females compared to males, however further research is needed to investigate the reasons for that. In addition to physiological differences, different ways of expressing symptoms like dyspnea based on societal expectations and psycho-emotional factors might also explain some of the possible differences in dyspnea prevalence between males and females. [42, 43, 44]

Seven studies reported on associations between dyspnea prevalence and high Body Mass Index (BMI). These findings are in accordance with previous publications indicating that overweight and obesity are associated risk factors for dyspnea whereby physical deconditioning and altered respiratory mechanics are the most frequently described explanations. [45, 46] It has also been discussed that adipose tissue plays a role in immune defense mechanisms in respiratory infections leading to a stronger reaction to irritants and airway inflammation which might also lead to an increase in symptom perception. [45] Only one study reported an association between dyspnea and low BMI (<20 kg/m2). [21] However, after adjusting for potential confounders, there was no evidence of such association.

Respiratory or cardiac disease or both have been reported to be the most common conditions associated with dyspnea based on our findings. This is not surprising, as dyspnea is considered to be a key symptom of many cardiorespiratory pathologies. [2] Interestingly, in some of the studies we included, reduced lung function without diagnosed pulmonary disease was associated with breathlessness. [22, 24] This leads to the conclusion that dyspnea might be a sign of early alterations in lung function, even before a respiratory disease can actually be diagnosed.

The MRC or mMRC scale was the most used method of dyspnea assessment in the included studies. The use of these situational measures is easy and time efficient and therefore suitable for epidemiological studies with large simple sizes. However, they have some limitations. First, dyspnea is a complex symptom comprising pathophysiological as well as psycho-emotional and social factors. [47, 48] Using one-dimensional scales like the mMRC/MRC scale does not account for this complexity and it is thus questionable whether these tools are reliable in identifying dyspnea. In addition, different cut-off values for the mMRC/MRC scale were used in the studies included in this review. Not only does this make the results less comparable, but it also leads to the question of how much dyspnea is “normal”. The mMRC/MRC scales were designed to assess dyspnea in patients with obstructive lung disease. [49] Although they are now widely used in research and clinical practice for a broader range of conditions, it is unclear whether they are useful for assessing dyspnea in overall healthy populations. It has to be assumed that a certain amount of breathlessness during physical activity is not related to any disease and therefore less clinically relevant. However, using different cut-off values on a unidimensional scale such as the mMRC/MRC scale makes it difficult to differentiate between physiological and pathological breathlessness. In addition, MRC grade 1 is highly subjective and can therefore be misleading as the definition of strenuous exercise can differ substantially, especially in individuals with disease. More complex tools like the Multidimensional Dyspnea Profile (MDP) might be useful in this case, as they also measure

the psychological and emotional dimensions of dyspnea. [50] However, the MDP might not be feasible for large population-based studies due to its complexity. The results of our review thereby highlight the need of a valid and easy to use gold-standard method of dyspnea assessment that can be applied to general populations.

Strengths and limitations

Using four comprehensive databases, we identified 20 studies for our review and overall study quality was good. We were also able to highlight some potential risk factors for dyspnea and identified the most used method for dyspnea assessment. This adds valuable information to the understanding of dyspnea from an epidemiological point of view and may be useful information to consider for further research.

However, our review also has some limitations. First, all the included studies were derived from populations from high-income countries. So, a lack of data from low- to middle-income countries limits the generalizability of this review's results. We were not able to perform statistical analyses of risk factors associated with dyspnea. This is due to the different ways of reporting those risk factors in individual studies. We calculated a pooled prevalence estimate by using multi-level meta-analysis. However, we had to exclude a considerable number of studies due to methodological considerations. Despite the exclusion of some studies, heterogeneity of the studies included in the meta-analysis was high, thus limiting its results. In addition, the use of different cut-off values to define dyspnea based on the mMRC/MRC scale in the individual studies may have influenced our pooled prevalence estimate. We assume that if all included studies used a cut-off value of mMRC ≥1, the pooled prevalence estimate would be higher. On the other hand, it would probably be lower if all studies used an mMRC cut-off of ≥2.

Some of the studies we included in the systematic review had overlapping data. Four studies drew its data from different years of the health survey. [16-19] We conferred with the authors about the sampling scheme. A resampling of participants might have been possible in these four publications, but the probability is low. We excluded 2 of these studies in the meta-analysis and accounted for potential overlap of the remaining two in our multi-level analysis. Two studies used the exact same data. [14, 26] These two studies also reported much higher prevalence as they included older participants only. We excluded them in our statistical analysis to make sure they do not bias our results.

Although we planned to exclude studies on pediatric populations, we decided to include 4 studies with participants above the age of 15 or 16 years. [15, 16, 20, 25] We did this, as these studies otherwise offered data from all adult age groups. We therefore thought it will be important to not exclude these studies from our review. One might assume, that the prevalence of dyspnea was lower in these studies due to their inclusion, however we did not observe this.

Conclusion

This review shows that the prevalence of dyspnea in adult general populations is around 10%. We were able to identify certain risk factors for developing dyspnea such as higher age, female sex, high BMI and cardiac or respiratory disease. This might be useful information to clinicians and researchers to identify patients and populations at risk. We have shown that a gold standard method for dyspnea assessment is needed to further investigate it in larger

population-based studies. Future research should also focus on dyspnea prevalence in low- to middle-income countries as data from these countries are currently missing.

Abbreviations

BMI: Body Mass Index; COPD: Chronic Obstructive Pulmonary Disease; CI: Confidence Interval; JBI: Joanna Briggs Institute;

Supplementary information

Acknowledgements

AM, EW and DJ planned the review. AM and TM conducted the title, abstract and full text screening. SVK conducted the statistical analyses. AM wrote the first draft of the manuscript. TM, EW, DJ, AFSA, RBK, MKB, SH commented on the manuscript.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declarations

Ethics Approval: Not applicable

Conflict of Interest: DJAJ reports non-personal lecture fees from Chiesi, AstraZeneca and Abbott within the previous three years outside the submitted work. All other authors report no conflicts of interest.

Use of generative AI: We declare that we did not use generative AI for the development of this manuscript.

References

[1] Parshall MB, Schwartzstein RM, Adams L, et al. An official American Thoracic Society statement: update on the mechanisms, assessment, and management of dyspnea. *Am J Respir Crit Care Med*. 2012;185(4):435-452. doi:10.1164/rccm.201111-2042ST

[2] Coccia CB, Palkowski GH, Schweitzer B, Motsohi T, Ntusi NA. Dyspnoea: Pathophysiology and a clinical approach. *S Afr Med J*. 2016;106(1):32-36. doi:10.7196/samj.2016.v106i1.10324

[3] Santus, P., Radovanovic, D., Saad, M., Zilianti, C., Coppola, S., Chiumello, D. A., & Pecchiari, M. (2023). Acute dyspnea in the emergency department: a clinical review. *Internal and emergency medicine*, 1–17. Advance online publication. https://doi.org/10.1007/s11739-023-03322-8

[4] Cristea L, Olsson M, Currow D, Johnson M, Sandberg J, Ekström M. Breathlessness dimensions association with physical and mental quality of life: the population based VASCOL study of elderly men. *BMJ Open Respir Res*. 2021;8(1):e000990. doi:10.1136/bmjresp-2021-000990

[5] Johnson MJ, Hutchinson A. Breathlessness in the emergency care setting. *Curr Opin Support Palliat Care*. 2018;12(3):232-236. doi:10.1097/SPC.0000000000000374

[6] Gruenberger JB, Vietri J, Keininger DL, Mahler DA. Greater dyspnea is associated with lower health-related quality of life among European patients with COPD. *Int J Chron Obstruct Pulmon Dis*. 2017;12:937-944. Published 2017 Mar 20. doi:10.2147/COPD.S123744

[7] Chen Y, Hayward R, Chew-Graham CA, et al. Prognostic value of first-recorded breathlessness for future chronic respiratory and heart disease: a cohort study using a UK national primary care database. *Br J Gen Pract*. 2020;70(693):e264-e273. Published 2020 Mar 26. doi:10.3399/bjgp20X708221

[8] van Mourik Y, Rutten FH, Moons KG, Bertens LC, Hoes AW, Reitsma JB. Prevalence and underlying causes of dyspnoea in older people: a systematic review. *Age Ageing*. 2014;43(3):319-326. doi:10.1093/ageing/afu001

[9] Mockel, M., Searle, J., Muller, R., Slagman, A., Storchmann, H., Oestereich, P., Wyrwich, W., Ale-Abaei, A., Vollert, J. O., Koch, M., & Somasundaram, R. (2013). Chief complaints in medical emergencies: do they relate to underlying disease and outcome? The Charité Emergency Medicine Study (CHARITEM). *Europ J Emerg Med.*, *20*(2), 103–108. https://doi.org/10.1097/MEJ.0b013e328351e609

[10] Banzett RB, O'Donnell CR. Should we measure dyspnoea in everyone?. *Eur Respir J*. 2014;43(6):1547-1550. doi:10.1183/09031936.00031114

[11] Pesola GR, Ahsan H. Dyspnea as an independent predictor of mortality. *Clin Respir J*. 2016;10(2):142-152. doi:10.1111/crj.12191

[12] Spruit MA, Singh SJ, Garvey C, et al. An official American Thoracic Society/European Respiratory Society statement: key concepts and advances in pulmonary rehabilitation [published correction appears in Am J Respir Crit Care Med. 2014 Jun 15;189(12):1570]. *Am J Respir Crit Care Med*. 2013;188(8):e13-e64. doi:10.1164/rccm.201309-1634ST

[13] http://joannabriggs.org/research/critical-appraisal-tools.html [accessed 12 July 2022]

[14] Ahmed T, Steward JA, O'Mahony MS. Dyspnoea and mortality in older people in the community: a 10-year follow-up. *Age Ageing*. 2012;41(4):545-549. doi:10.1093/ageing/afs049

[15] Bowden JA, To TH, Abernethy AP, Currow DC. Predictors of chronic breathlessness: a large population study. *BMC Public Health*. 2011;11:33. Published 2011 Jan 12. doi:10.1186/1471-2458-11-33

[16] Currow DC, Chang S, Ferreira D, et al. Chronic breathlessness and sleep problems: a population-based survey. *BMJ Open*. 2021;11(8):e046425. Published 2021 Aug 12. doi:10.1136/bmjopen-2020-046425

[17] Currow DC, Dal Grande E, Sidhu C, Ekström M, Johnson MJ. The independent association of overweight and obesity with breathlessness in adults: a cross-sectional, population-based study. *Eur Respir J*. 2017;50(3):1700558. Published 2017 Sep 27. doi:10.1183/13993003.00558-2017

[18] Currow DC, Chang S, Reddel HK, et al. Breathlessness, Anxiety, Depression, and Function-The BAD-F Study: A Cross-Sectional and Population Prevalence Study in Adults. *J Pain Symptom Manage*. 2020;59(2):197-205.e2. doi:10.1016/j.jpainsymman.2019.09.021

[19] Currow DC, Plummer JL, Crockett A, Abernethy AP. A community population survey of prevalence and severity of dyspnea in adults. *J Pain Symptom Manage*. 2009;38(4):533-545. doi:10.1016/j.jpainsymman.2009.01.006

[20] Ekerljung L, Bossios A, Lötvall J, et al. Multi-symptom asthma as an indication of disease severity in epidemiology. *Eur Respir J*. 2011;38(4):825-832. doi:10.1183/09031936.00143710

[21] Ekström MP, Blomberg A, Bergström G, et al. The association of body mass index, weight gain and central obesity with activity-related breathlessness: the Swedish Cardiopulmonary Bioimage Study. *Thorax*. 2019;74(10):958-964. doi:10.1136/thoraxjnl-2019-213349

[22] Ekström M, Sundh J, Schiöler L, et al. Absolute lung size and the sex difference in breathlessness in the general population. *PLoS One*. 2018;13(1):e0190876. Published 2018 Jan 5. doi:10.1371/journal.pone.0190876

[23] Figarska SM, Boezen HM, Vonk JM. Dyspnea severity, changes in dyspnea status and mortality in the general population: the Vlagtwedde/Vlaardingen study. *Eur J Epidemiol*. 2012;27(11):867-876. doi:10.1007/s10654-012-9736-0

[24] Grønseth R, Vollmer WM, Hardie JA, et al. Predictors of dyspnoea prevalence: results from the BOLD study. *Eur Respir J*. 2014;43(6):1610-1620. doi:10.1183/09031936.00036813 [25] Gulsvik A, Bakke PS, Brøgger J, Nielsen R, Stavem K. Respiratory symptoms and mortality in four general population cohorts over 45 years. Respir Med 2020;170:106060. PubMed PMID: 32843179.

[26] Ho SF, O'Mahony MS, Steward JA, Breay P, Buchalter M, Burr ML. Dyspnoea and quality of life in older people at home. *Age Ageing*. 2001;30(2):155-159. doi:10.1093/ageing/30.2.155

[27] Johnson MJ, Bowden JA, Abernethy AP, Currow DC. To what causes do people attribute their chronic breathlessness? A population survey. *J Palliat Med*. 2012;15(7):744-750. doi:10.1089/jpm.2011.0430

[28] Kainu A, Pallasaho P, Pietinalho A. No change in prevalence of symptoms of COPD between 1996 and 2006 in Finnish adults - a report from the FinEsS Helsinki Study. *Eur Clin Respir J*. 2016;3:31780. Published 2016 Aug 16. doi:10.3402/ecrj.v3.31780

[29] Kochovska S, Chang S, Morgan DD, et al. Activities Forgone because of Chronic Breathlessness: A Cross-Sectional Population Prevalence Study. *Palliat Med Rep*. 2020;1(1):166-170. Published 2020 Aug 18. doi:10.1089/pmr.2020.0083

[30] Sandberg J, Ekström M, Börjesson M, et al. Underlying contributing conditions to breathlessness among middle-aged individuals in the general population: a cross-sectional study. *BMJ Open Respir Res*. 2020;7(1):e000643. doi:10.1136/bmjresp-2020-000643

[31] Sele LM, Balasubramaniam K, Elnegaard S, Søndergaard J, Jarbøl DE. Lifestyle factors and experience of respiratory alarm symptoms in the general population. *BMJ Open Respir Res*. 2015;2(1):e000101. Published 2015 Sep 30. doi:10.1136/bmjresp-2015-000101

[32] Smith AK, Currow DC, Abernethy AP, et al. Prevalence and Outcomes of Breathlessness in Older Adults: A National Population Study. *J Am Geriatr Soc*. 2016;64(10):2035-2041. doi:10.1111/jgs.14313

[33] Toren K, Schiöler L, Lindberg A, et al. Chronic airflow limitation and its relation to respiratory symptoms among ever-smokers and never-smokers: a cross-sectional study. *BMJ Open Respir Res*. 2020;7(1):e000600. doi:10.1136/bmjresp-2020-000600

[34] Wang L, Green FH, Smiley-Jewell SM, Pinkerton KE. Susceptibility of the aging lung to environmental injury. *Semin Respir Crit Care Med*. 2010;31(5):539-553. doi:10.1055/s-0030-1265895

[35] Skloot GS. The Effects of Aging on Lung Structure and Function. *Clin Geriatr Med*. 2017;33(4):447-457. doi:10.1016/j.cger.2017.06.001

[36] Pride NB. Ageing and changes in lung mechanics. *Eur Respir J*. 2005;26(4):563-565. doi:10.1183/09031936.05.00079805

[37] Arnett DK, Blumenthal RS, Albert MA, et al. 2019 ACC/AHA Guideline on the Primary Prevention of Cardiovascular Disease: Executive Summary: A Report of the American College of Cardiology/American Heart Association Task Force on Clinical Practice Guidelines [published correction appears in Circulation. 2019 Sep 10;140(11):e647-e648] [published correction appears in Circulation. 2020 Jan 28;141(4):e59] [published correction appears in Circulation. 2020 Apr 21;141(16):e773]. *Circulation*. 2019;140(11):e563-e595. doi:10.1161/CIR.0000000000000677

[38] Gut-Gobert C, Cavaillès A, Dixmier A, et al. Women and COPD: do we need more evidence?. *Eur Respir Rev*. 2019;28(151):180055. Published 2019 Feb 27. doi:10.1183/16000617.0055-2018

[39] Sheel AW, Dominelli PB, Molgat-Seon Y. Revisiting dysanapsis: sex-based differences in airways and the mechanics of breathing during exercise. *Exp Physiol*. 2016;101(2):213-218. doi:10.1113/EP085366

[40] LoMauro A, Aliverti A. Sex and gender in respiratory physiology. *Eur Respir Rev*. 2021;30(162):210038. Published 2021 Nov 8. doi:10.1183/16000617.0038-2021

[41] Brown, J. C., Boat, R., Williams, N. C., Johnson, M. A., & Sharpe, G. R. (2022). The effect of trait self-control on dyspnoea and tolerance to a CO_2 rebreathing challenge in healthy males and females. *Physiology & behavior*, *255*, 113944. https://doi.org/10.1016/j.physbeh.2022.113944

[42] Raherison C, Tillie-Leblond I, Prudhomme A, et al. Clinical characteristics and quality of life in women with COPD: an observational study. *BMC Womens Health*. 2014;14(1):31. Published 2014 Feb 20. doi:10.1186/1472-6874-14-31

[43] Chhabra SK, Chhabra P. Gender differences in perception of dyspnea, assessment of control, and quality of life in asthma. *J Asthma*. 2011;48(6):609-615. doi:10.3109/02770903.2011.587577

[44] Nowobilski R, Furgał M, Polczyk R, de Barbaro B, Szczeklik A. Gender gap in psychogenic factors may affect perception of asthma symptoms. *J Investig Allergol Clin Immunol*. 2011;21(3):193-198.

[45] Dixon AE, Peters U. The effect of obesity on lung function. *Expert Rev Respir Med*. 2018;12(9):755-767. doi:10.1080/17476348.2018.1506331

[46] Shim YM, Burnette A, Lucas S, et al. Physical deconditioning as a cause of breathlessness among obese adolescents with a diagnosis of asthma. *PLoS One*. 2013;8(4):e61022. Published 2013 Apr 23. doi:10.1371/journal.pone.0061022

[47] Hayen A, Herigstad M, Pattinson KT. Understanding dyspnea as a complex individual experience. *Maturitas*. 2013;76(1):45-50. doi:10.1016/j.maturitas.2013.06.005

[48] Lansing RW, Gracely RH, Banzett RB. The multiple dimensions of dyspnea: review and hypotheses. *Respir Physiol Neurobiol*. 2009;167(1):53-60. doi:10.1016/j.resp.2008.07.012

[49] Williams N. The MRC breathlessness scale. *Occup Med (Lond)*. 2017;67(6):496-497. doi:10.1093/occmed/kqx086

[50] Banzett RB, O'Donnell CR, Guilfoyle TE, et al. Multidimensional Dyspnea Profile: an instrument for clinical and laboratory research. *Eur Respir J*. 2015;45(6):1681-1691. doi:10.1183/09031936.00038914

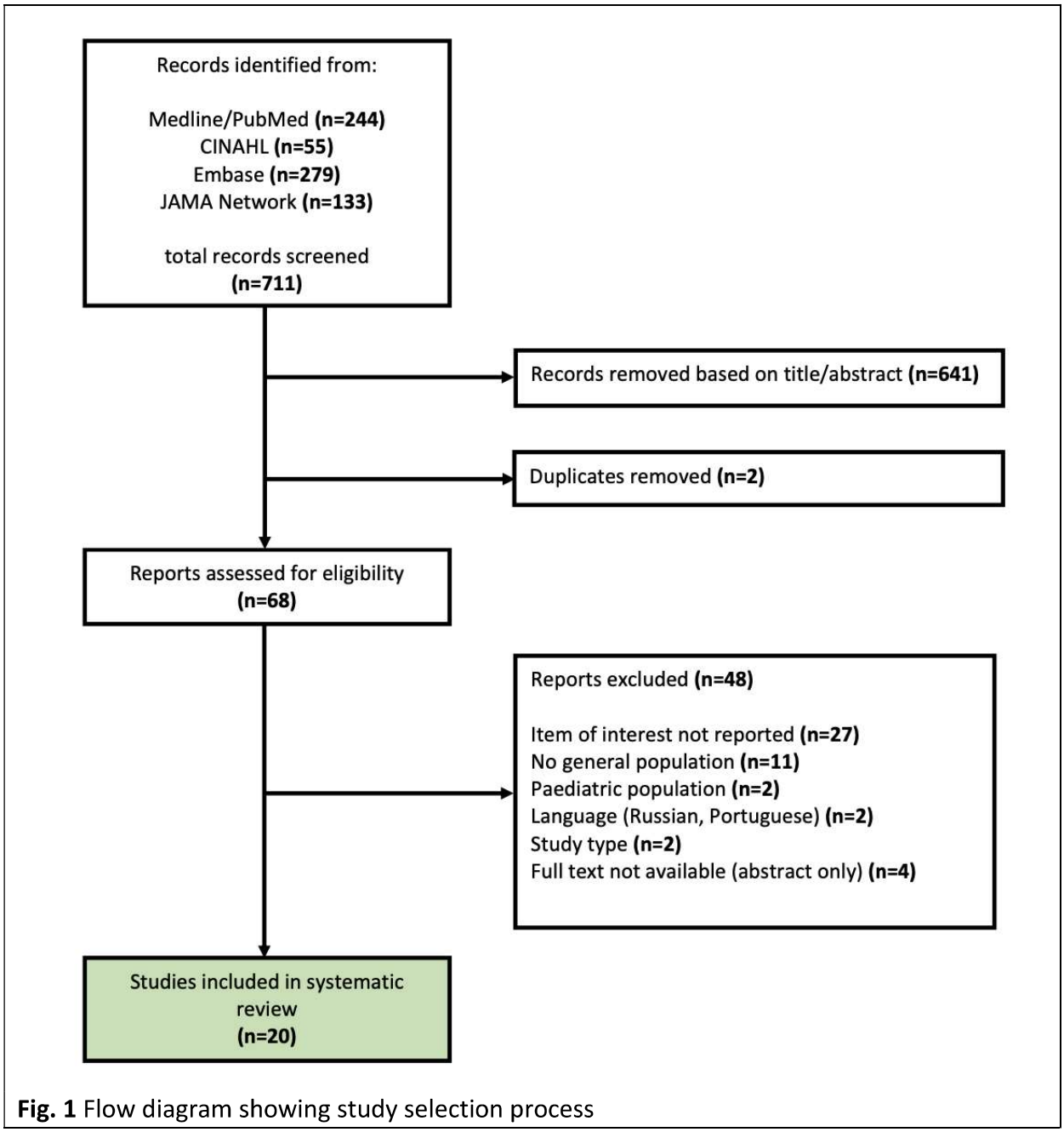


Fig. 1 Flow diagram showing study selection process

	Was the sample frame appropriate to address the target population?	Were study participants sampled in an appropriate way?	Was the sample size adequate?	Were the study subjects and the setting described in detail?	Was the data analysis conducted with sufficient coverage of the identified sample?	Were valid methods used for the identification of the condition?	Was the condition measured in a standard and reliable way for all participants?	Was there appropriate statistical analysis?	Was the response rate adequate, and if not, was the low response rate managed appropriately?	**Overall**
Ahmed et al., 2012[14]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Bowden et al., 2011[15]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Currow et al., 2021[16]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Currow et al., 2017[17]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Currow et al., 2020[18]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Currow et al., 2009[19]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Ekerljung et al., 2011[20]	✓	✓	✓	X	✓	?	?	✓	✓	**6**
Ekström et al., 2019[21]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Ekström et al., 2018[22]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Figarska et al., 2012[23]	?	?	?	✓	✓	✓	✓	✓	✓	**6**
Grønseth et al., 2014[24]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Gulsvik et al., 2020[25]	✓	?	✓	✓	✓	✓	✓	✓	✓	**8**
Ho et al., 2001[26]	?	X	?	✓	✓	✓	✓	✓	✓	**6**
Johnson et al., 2012[27]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Kainu et al., 2016[28]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Kochovska et al., 2020[29]	✓	?	?	✓	✓	✓	✓	X	✓	**6**
Sandberg et al., 2020[30]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**
Sele et al., 2015[31]	✓	✓	?	✓	✓	?	✓	✓	?	**6**
Smith et al., 2016[32]	✓	✓	✓	✓	✓	?	?	✓	✓	**7**
Toren et al., 2020[33]	✓	✓	✓	✓	✓	✓	✓	✓	✓	**9**

Fig.2 Overview of study quality based on JBI checklist for prevalence studies; ✓=yes, X=no, ?=not clear

Tab. 1 Overview of included studies

Author, Year	Study design	Population	Age (years)	Method used to assess dyspnea	Definition of dyspnea	Prevalence estimate for dyspnea (%)	Factors associated with dyspnea
Ahmed et al., 2012[14]	longitudinal, population-based	N=1,169 United Kingdom 62.2% female	≥70; mean 77.6	MRC	3-5	32.3	female sex (35.4% vs 27.4% in males) reversible airway disease (p=0.009) COPD (p=0.0003) left ventricular dysfunction (p=0.0001) 10-year mortality (p=0.02)
Bowden et al., 2011[15]	cross-sectional, population-based	N=5,331 Australia 57.7% female	≥15	mMRC	≥1	11.1	female sex (p<0.001) higher age (p<0.001) separated or widowed (p<0.001) lower SES (p<0.001) smoking history (p<0.001) higher BMI (p<0.001) decreased physical activity (p<0.001)
Currow et al., 2009[16]	cross-sectional, population-based	N=5,473 Australia 51.0% female	≥15	mMRC	≥1	8.9	sleep problems (OR=2.3, 95%CI 1.6; 3.3)
Currow et al., 2017[17]	cross-sectional, population-based	N=4,321 Australia 47.7% female	≥18; mean 47.9	mMRC	≥1	2.5	obesity (OR 2.05, 95%CI 1.22, 3.43) severe obesity (OR 3.53, 95%CI 1.87, 6.63)
Currow et al., 2020[18]	cross-sectional, population-based	N=2,977 Australia 51.2% female	≥18; mean 45.0	mMRC	≥2	2.4	depression (OR 3.0, 95%CI 1.2, 7.8)
Currow et al., 2021[19]	cross-sectional, population-based	N=2,900 Australia 51.0% female	≥18; mean 48.2	mMRC	≥1	8.8	female sex (p<0.001) full time employment (p<0.001) low income (p=0.007)
Ekerljung et al., 2011[20]	cross-sectional, population-based	N=16,380 Sweden	16-75	OLIN GA2LEN	Any dyspnea? - yes	5.0	
Ekström et al., 2018[21]	cross-sectional, population-based	N=1,013 Sweden 49.0% female	50-64; mean 58	mMRC	≥1	9.0	female sex (p<0.001) underweight (OR 1.72, 95%CI 1.08, 2.73) overweight (OR 1.53, 95%CI 1.36, 1.72) obesity (OR 4.37, 95%CI 3.70, 5.16)

Ekström et al., 2019[22]	cross-sectional, population-based	N=13,437 Sweden 52.5% female	50-64; mean 57.5	mMRC	≥1	9.6	female sex (OR 2.20, 95%CI 1.32, 3.66) lower absolute TLC, FVC, IC, DLCO
Figarska et al., 2012[23]	longitudinal, population-based	N=7,360 Netherlands 48.0% female	20-65	MRC	3-5	6.2	increased mortality (HR 1.3, 95%CI 1.2, 1.5)
Grønseth et al., 2014[24]	cross-sectional, population-based	N=9,484 multinational (15 sites) 51.0% female	≥40; mean 55.5	mMRC	≥1	13.0	female sex (OR 2.16, 95%CI 1.94, 2.42) cardiac disease (OR 2.26, 95%CI 1.94, 2.63) FEV1/FVC<LLN (OR 2.29, 95%CI 1.98, 2.64) 10% increase in FVC (OR 0.78, 95%CI 0.75, 0.81)
Gulsvik et al., 2020[25]	cross-sectional, population-based	N=114,380 Norway 22.0% female	15-75	Norwegian Respiratory Questionnaire	≥1	21.0	increased mortality (HR 1.90, 95%CI 1.80, 2.00)
Ho et al., 2001[26]	cross-sectional, population-based	N=1,169 United Kingdom	≥70; mean 77.6	MRC	3-5	32.3	obesity (p<0.05) reversible airway disease (p=0.009) COPD (p=0.0003) left ventricular dysfunction (p=0.0001) reduced functional status (p<0.0001) reduced quality of life (p<0.0001)
Johnson et al., 2012[27]	cross-sectional, population-based	N=2,824 Australia 51.0% female	mean 45.8	MRC	≥1	8.9	age >65years (p=0.000) lower educational level (p=0.003) lower household income (p=0.000)
Kainu et al., 2016[28]	cross-sectional, population-based	N=2,449 Finland 55.7% female	20-69	mMRC	≥2	13.6	
Kochovska et al., 2020[29]	cross-sectional, population-based	N=3,000 Australia 49.7% female	≥18; mean 50	mMRC	≥1 for ≥3 months	19.4	lower physical activity levels with higher grade of dyspnea

Sandberg et al., 2020[30]	cross-sectional, population-based	N=1,097 Sweden 50.0% female	50-65; mean 57.5	mMRC	≥1	9.8	respiratory disease (OR 2.0, 95%CI 1.3, 3.2) cardiac disease (OR 6.9, 95%CI 4.0, 11.9) anxiety/depression (OR 3.3, 95%CI 2.1, 5.1) obesity (OR 2.7, 95%CI 1.8, 4.2)
Sele et al., 2015[31]	cross-sectional, population-based	N=49,706 Denmark 53.2% female	mean 52	Danish Symptom Cohort Questionnaire	Breathlessness - yes (within the preceding 4 weeks)	8.0	
Smith et al., 2016[32]	longitudinal, population-based	N=3,671 United States 58.0% female	≥70; mean 78.2	1 question: How often do you become short of breath while awake?	often or sometimes	25.0	ADL impairment (p<0.001) depression/anxiety (p<0.001) more hospitalizations (p<0.001) lower educational level cardiac disease respiratory disease smoking history
Toren et al., 2020[33]	cross-sectional, population-based	N=15,128 Sweden 52.0% female	50-64; mean 57.5	mMRC	≥1	5.0	

Abbreviations: CI=Confidence Interval; COPD=Chronic Obstructive Pulmonary Disease; HR=Hazard Ratio; OR=Odds Ratio; SES=Socioeconomic Status

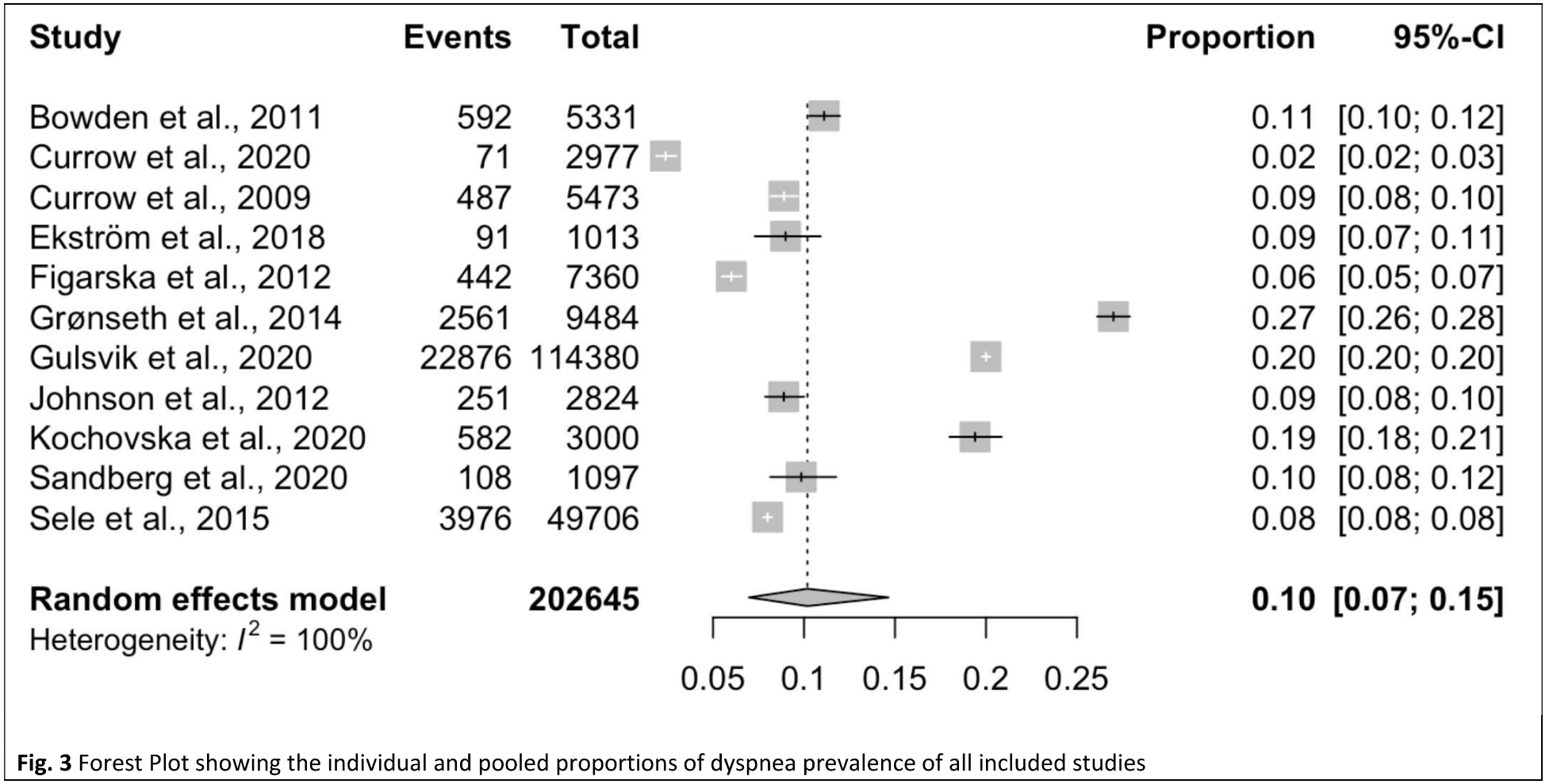


Fig. 3 Forest Plot showing the individual and pooled proportions of dyspnea prevalence of all included studies