REVIEW

Prevalence of osteoarthritis in individuals with COPD: a systematic review

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Abstract: The objective of this review was to examine the prevalence of osteoarthritis (OA) in individuals with COPD. A computer-based literature search of CINAHL, Medline, PsycINFO and Embase databases was performed. Studies reporting the prevalence of OA among a cohort of individuals with COPD were included. The sample size varied across the studies from 27 to 52,643 with a total number of 101,399 individuals with COPD recruited from different countries. The mean age ranged from 59 to 76 years. The prevalence rates of OA among individuals with COPD were calculated as weighted means. A total of 14 studies met the inclusion criteria with a prevalence ranging from 12% to 74% and an overall weighted mean of 35.5%. Our findings suggest that the prevalence of OA is high among individuals with COPD and should be considered when developing and applying interventions in this population.

Keywords: COPD, osteoarthritis, prevalence, comorbidities, pulmonary rehabilitation

Introduction

COPD is characterized by symptoms of dyspnea and reduced exercise tolerance.[1] It is widespread globally and destined to become the third most common cause of mortality within the next few years.[2,3] COPD is a leading cause of disability.[4,5] Although the primary pathophysiology is respiratory in COPD, several secondary impairments and co-occurring cardiovascular, metabolic and musculoskeletal conditions have been noted.[6–14] Inflammatory mediators, oxidative stress, prescribed corticosteroids, hypoxemia and hypercapnia all contribute to the extra-pulmonary manifestations such as cardiovascular compromise, osteoporosis and muscle dysfunction.[15,16]

An important co-occurring condition is osteoarthritis (OA), a degenerative joint disease characterized by damaged articular cartilage, bone remodeling, osteophyte formation, muscle weakness and ligamentous damage.[17,18] OA is also a widely prevalent cause of disability, which is responsible for chronic pain and diminished exercise tolerance.[19–21] Many risk factors for OA include age, weight, being female, ethnicity, previous joint injury or repetitive use, muscle weakness and joint laxity.[22]

As both COPD and OA diminish physical activity and increase the time spent in sedentary behavior,[1,23] the co-occurrence of these two conditions is important as both promote decreased participation and a diminution in health-related quality of life.[24–26] Notwithstanding the abovementioned information, there is very limited information regarding the prevalence of OA among those with COPD. Therefore, the purpose of this study was to conduct a systematic review to estimate the mean prevalence of OA in individuals with COPD.

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Methods

The review protocol followed PRISMA guidelines[27] and was registered with PROSPERO (CRD42017055795).

Search strategy and study selection

A systematic computerized literature search of Medline, CINAHL, Embase and PsycINFO databases was carried out with the timescale starting from their inception up to April 2017. The keywords used to carry out the search were as follows: chronic obstructive pulmonary disease (MeSH), osteoarthritis (MeSH) and prevalence (MeSH). The detailed search strategy for each database is provided in the Supplementary materials.

We included studies reporting the prevalence of OA in a cohort of individuals with COPD. Articles where individuals with COPD could not be isolated from the overall sample or where OA could not be distinguished from other comorbidities (such as rheumatoid arthritis) were excluded. Articles that reported the co-occurrence of COPD and OA without referring to the main diagnosis and comorbidity were also excluded.

Case–control, cohort, cross-sectional and interventional studies that reported the prevalence of OA as a comorbidity in a sample of individuals with COPD were included, while conference articles, editorials and non-English articles were excluded. Reviews were excluded, although their reference lists were searched manually for potentially relevant articles.

Data collection and analysis

Data extraction was performed by two reviewers (AW, DB). The data extracted were the following: full citation, type of study, country of origin of the study, sample size (of individuals with COPD), mean and SD of the age of the sample, percentage of females included, the races/ethnicities of the population examined, percentage of overweight and/or obese individuals, smoking status and percentage of OA among the sample. The three factors, age, sex and obesity, are common to both diseases. Prevalence rates of OA in individuals with COPD were calculated as weighted means, whereby the sample size of each study was multiplied by the corresponding prevalence rate and divided by the total sample size of all the studies. The overall mean prevalence of OA in individuals with COPD was the sum of the weighted means. A similar methodology was performed previously elsewhere.[28]

During the screening process, it was evident that some studies examined patients from the same database. To avoid the bias that might be caused by the inclusion of multiple studies of the same cohort on the calculated prevalence mean, only the larger sample size study was included.

Assessment of study quality

Quality assessment of the included studies was undertaken according to the "checklist for prevalence studies" as suggested by the Joanna Briggs Institute.[29] This tool consists of nine questions aimed at addressing the possibility of bias in the design, methods and analysis for studies that include prevalence data. The questions are self-explanatory and answers are as follows: yes, no, unclear or not applicable. Question 6 on methods was answered with "yes" if the diagnoses of both COPD and OA were based on diagnostic criteria. If the conditions (or one of them) were assessed using observer reported, or self-reported scales, then the question was answered by "no." Question 7 on reliability of identifying the conditions was answered with "yes" only if both conditions were measured in the same way for all participants.[29]

Two researchers (DB, AW) conducted the quality assessment separately with any contestations being solved by discussion. The assessment of study quality had no impact on the inclusion or exclusion of the study.

Results

The search resulted in 2,203 articles being identified, of which 266 were duplicates. A total of 1,821 abstracts were excluded based on being unrelated to the topic.

Another 107 articles were excluded for various reasons, including the following: conference articles (eight articles); not including data on OA (92 articles); multiple analysis of the same patients (three articles). The manual search resulted in identifying five additional articles. The PRISMA flowchart from articles identified to those included is shown in Figure 1.

The articles included in the review and their characteristics are summarized in Table 1. Six studies[30,33,35,38–40] were conducted on populations in the USA, and one study[34] examined patients from nine countries. The remainder (published in English) were from the following: the Netherlands,[31,41] UK,[32,42] Korea,[37] South Africa[36] and Germany.[43] Seven studies[31,33,37–39,42,43] (50%) followed the observational cohort design; six[30,32,34–36,41] were cross-sectional (43%) and only one[40] (7%) was a case–control study. Studies varied in sample size[39,42] (27–52,643) as well as age[33,42] (59.3–76 years). In six studies,[32–34,36,37,40] data on age and/or sex could not be extracted, and in five,[33,36,40–42] data on obesity was unavailable. Seven studies[31,33,34,36,39,41,42] out of 14 reported data on smoking status among their sample.
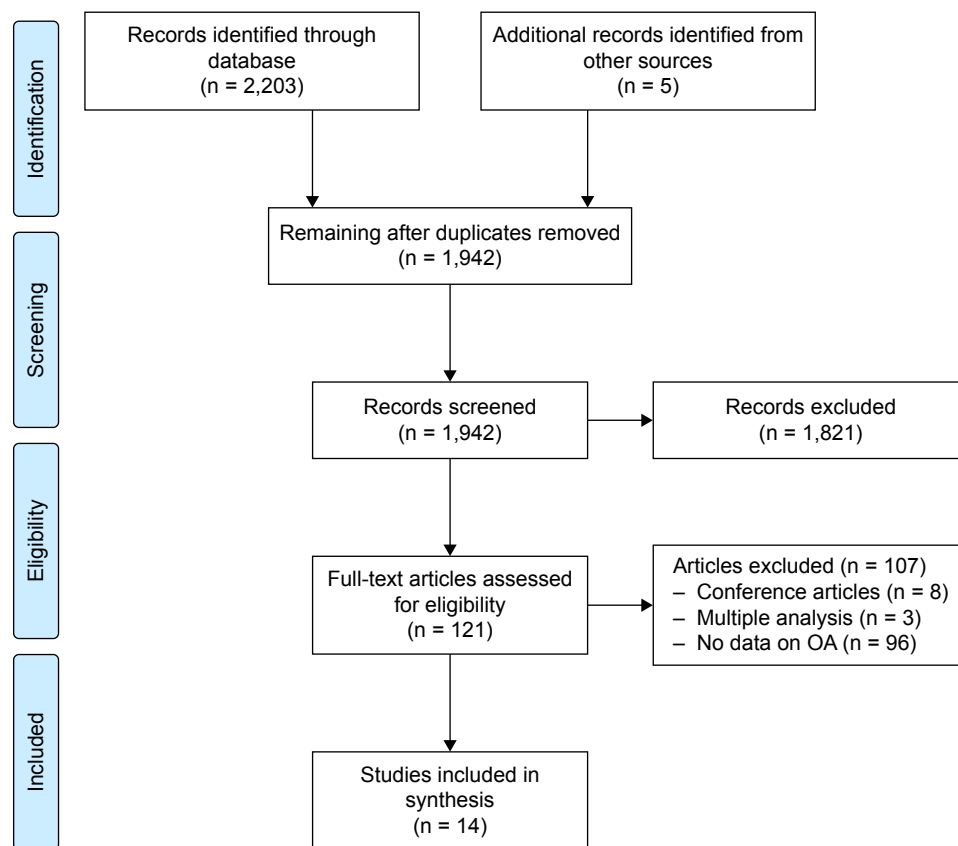
Figure 1 PRISMA flow diagram of the search and study selection.
Abbreviation: OA, osteoarthritis.

The prevalence of OA varied across the studies from 11.9%[37] to 74%,[42] and the weighted mean of the prevalence of OA varied from 0.02%[36,42] to 22.7%.[39] The overall weighted mean of the prevalence of OA in individuals with COPD for the 14 identified studies was 35.5%.

Risk of bias and quality assessment

The quality assessment results are illustrated in Table 2. A total of 10 articles (71%) used self-reported diagnosis to diagnose COPD and OA. In 11 studies (79%), the question regarding the adequacy of response rate was marked as not applicable as the studies were observational with information extracted from databases (Table 2).

We calculated the weighted mean of the prevalence of OA in COPD in 10 articles in which COPD and/or OA were self-reported and in the four studies in which COPD and/or OA were measured objectively, and noted prevalence rates of 30.7% and 37.6%, respectively.

Discussion

This is the first article that systematically examined the prevalence of OA in individuals with COPD. In a sample of more than 100,000 individuals with COPD, we noted

prevalence rates ranging from 12% to 74% across the studies with a weighted average of 35.5%. The wide ranges of the prevalence rates might well be explained by the heterogeneity of the study designs, cohort characteristics, sample size and method of sampling. In some studies, COPD was diagnosed without spirometric confirmation, and in others, OA was not confirmed radiologically. Prevalence results vary quite substantially. For example, Yeo et al[42] in an observational study of a cohort of only 27 older (aged >70 years) individuals with COPD drawn from a single primary care practice reported that 74% of their sample had OA. In contrast, Park et al,[37] reporting on the Korean National Health and Nutrition Examination Survey (KNHANES) study, nationally designed to assess the health of community-dwelling adults, found a prevalence rate of knee or hip joint OA (defined as Kellgren–Lawrence grade ≥2) in only 12% of individuals with COPD (n = 1,905; mean age = 65 years). The study by Schwab et al,[39] mean age 70.6 years (9.6), represented the greatest contribution to the overall weighted mean of the prevalence of OA in COPD (23%) because of its large sample size of 52,643.

Smoking status varied significantly across the studies. These differences add to the heterogeneity noted in cohort

Table 1 Characteristics of the included studies with the timescale starting from the inception of the databases up to April 2017

Article	Study type	Population	Method of identification	Country	Race	Mean age in years (SD)	Females	Obesity (%)	Smoking status	% OA reported	Weighted mean
Schnell et al[30]	Cross-sectional	995 with COPD from NHANES	Search	USA	% (95% CI): White: 84.6 (81.4–87.4); Black: 6.8 (5.1–8.9); Hispanic: 4.4 (3.0–6.3)	62.7 (95% CI 61.7–63.8)	60.1%	40.3%	Ever smoked (68.9%); >10 pack-years (43%)	54.6%	0.54%
Westerik et al[31]	Retrospective cohort study	14,603 with COPD from health records in Dutch general practices	Search	the Netherlands	Not reported	66.5 (SD 11.5)	46.9%	4.4%	Not reported	17.6%	2.53%
Rai et al[32]	Cross-sectional	608 with COPD out of 1,889 from Birmingham COPD cohort study	Manual search	UK	Not reported	Age: 38–49 (11.2%); 50–59 (41.6%); 60–64; (47.2%)	43.6%	BMI (kg/m²): underweight (<18.5) = 2.8%; normal weight (18.5–24.9) = 26.8%; overweight (25.0–29) = 35.2%; obese (30.0–39) = 29.6%; morbidly obese (>40.0) = 5.7%	Current smokers (49.7%); ex-smokers (42.8%); never smoked (7.5%)	16.8%	0.10%
Lee et al[33]	Cohort study	15,540 with COPD (55–64 years) from National Veterans Health Administration database	Manual search	USA	Not reported	59.3 (3.1)	Not reported (mostly males)	Not reported	Not reported	20%	3.07%
Garin et al[34]	Cross-sectional study	3,339 with COPD from 41,909 adults >50 years from nine countries	Search	Nine countries: China, Ghana, India, Mexico, Russia, South Africa, Finland, Spain and Poland	Not reported	Not reported	Not reported	19%	Not reported	44%	1.45%
Kumbhare et al[35]	Cross-sectional, observational study	4,807 with COPD from the 2012 BRFSS, an annual random digit-dialed telephone survey	Search	USA	White, non-Hispanic (82.9%); Black, non-Hispanic (8.2%); other race, non-Hispanic (3%); multiracial, non-Hispanic (2.8%); Hispanic (1.8%)	67.1 (SD 11.8)	61.6%	BMI (kg/m²) categories: underweight (<18.5) = 7%; normal weight (18.5–24.9) = 29.8%; overweight (25.0–29.9)=30.9%;obese (30.0–39.9) = 26.3%; morbidly obese (>40.0) = 6.1%	Current smokers (34.3%); ex-smokers (45.5%); never smoked (20.2%)	61.2%	2.9%

Study	Study type	Sample	Search method	Country	Ethnicity	Mean age	% males	BMI	Smoking status		
Lalkhen and Mash[36]	Cross-sectional study	140 with COPD from primary health care facilities in South Africa	Search	South Africa	Not reported	Not reported	Not reported	Not reported	Not reported	12.1%	0.02%
Park et al[37,*]	Retrospective cohort	1,905 with COPD from the database of the fourth and fifth (2007–2012) KNHANES	Search	Korea	Not reported	64.5 (10.2)	32%	BMI (kg/m²) categories (<18.5) = 3.3%; (18.5–23.0) = 68.2%; (≥23.0) = 28.5%	Current smokers (39.6%); ex-smokers (17.6%); never smoked (42.8%)	11.9%	0.22%
Putcha et al[38]	Cohort study	3,690 African-Americans and non-Hispanic Whites among GOLD 2–4 COPD patients	Search	USA	African-Americans (23%); non-Hispanic Whites (77%)	63.4 (8.5)	44%	Mean BMI (SD) 28.1 (6.3)	Current smokers (40.7%)	20.7% (calculated not reported)	0.75%
Schwab et al[39]	Retrospective cohort study	52,643 with COPD from US claims database (Humana Inc., Louisville, KY, USA)	Search	USA	Not reported	70.6 (9.6)	55%	19.65%	Not reported	43.8%	22.7%
Mapel et al[40,**]	Case–control study	200 with COPD from 1,522 from the Managed Care Database, New Mexico	Manual search	USA	Hispanic (17.8%); non-Hispanic (82.2%)	67.5	48.9%	Not reported	Current smokers (46%); ex-smokers (34%); never smoked (14.5%)	22% (moderate-to-severe arthritis only)	0.04%
Wijnhoven et al[41]	Cross-sectional study	161 with COPD from 25 primary care practices in the Netherlands	Manual search	the Netherlands	Not reported	61 (10.3)	44.7%	Not reported	Not reported	23%	0.04%
Yeo et al[42]	Observational cohort study	27 with COPD ≥70 years from the UK primary care	Manual search	UK	Not reported	76 (4.36)	40.7%	Not reported	Not reported	74%	0.02%
Karch et al[43]	Cohort study	2,741 with COPD from 31 centers in Germany	Manual search	Germany	Not reported	65.1 (8.6)	41%	Mean BMI (SD) 27.0 (5.4)	Current smokers (24%); ex-smokers (68%); never smoked (8%)	40.1%	1.08%
		Total = 101,399					Not reported				Total = 35.5%

Notes: *The characteristics of the percentage of males and the mean age are for the overall sample in the original study (n = 2,108) not for the patients included in our analysis (n = 1,905). **The characteristics of the percentage of males and the mean age are for the overall sample in the original study (n = 1,522) not for the patients included in our analysis (n = 1,522) not for the patients included in our analysis (n = 200). Smoking history not documented for 5.5% of the patients.
Abbreviations: BMI, body mass index; BRFSS, Behavioral Risk Factor Surveillance System; KNHANES, Korean National Health and Nutrition Examination Survey; NHANES, National Health and Nutritional Examination Study; OA, osteoarthritis; GOLD, Global Initiative for Obstructive Lung Disease scale.

Table 2 The quality assessment results for the included articles starting from the inception of the databases to April 2017

Article	1. Sample frame appropriate to target population?	2. Study participants sampled in an appropriate way?	3. Sample size adequate?	4. Study subjects and setting described in detail?	5. Analysis conducted with sufficient coverage of the identified sample?	6. Valid methods to identify condition?	7. Condition measured in a standard, reliable way?	8. Appropriate statistical analysis?	9. Response rate adequate or was low response rate managed appropriately?
Schnell et al[30]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
Westerik et al[31]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Not applicable
Rai et al[32]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Not applicable
Lee et al[33]	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Yes	Not applicable
Garin et al[34]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Not applicable
Kumbhare et al[35]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Not applicable
Lalkhen and Mash[36]	Yes	No	Yes	Yes	Unclear	No	No	Unclear	Not applicable
Park et al[37]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable
Putcha et al[38]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Not applicable
Schwab et al[39]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable
Mapel et al[40]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Not applicable
Wijnhoven et al[41]	Yes	Yes	Unclear	Yes	Yes	No	Yes	Yes	No
Yeo et al[42]	No	Yes	No	Yes	No	No	Yes	Yes	No
Karch et al[43]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Not applicable

characteristics and may have influenced the findings of this review. There is some evidence to suggest that smoking may be associated with a lower risk of developing OA,[44–46] but it is unclear as to whether this observed inverse relationship between smoking and OA is direct (caused by smoking itself) or indirect (caused by the lower body mass index [BMI] associated with smokers compared to their nonsmoker peers).[47] Of note, none of the included articles in this systematic review reported the prevalence of OA by smoking status.

Obesity is a major risk factor for OA.[22] The prevalence rates of obesity reported by only six studies varied quite substantially from 4.4% to 40.3%. In the study by Schwab et al,[39] less than one-fifth (19.65%) of the sample were obese.

Most studies (10/14) relied on self-reported questionnaires to establish a diagnosis with only four out of 14 articles using confirmatory diagnostic tests.[33,37,39,40,48,49] Although the use of objectively measured vs self-reported identification of OA could impact reporting accuracy, the difference in the prevalence of OA among self-reported questionnaires and those objectively measured was not substantial (30.7% vs 37.6%).

The prevalence of OA in COPD may exceed that of the non-COPD population. For example, among more than 4,000,000 Canadians living in British Columbia,[50] the prevalence of OA in 2001 was 10.8% and in a study[51] conducted in Malmo, Sweden, among 10,000 adults (56–64 years) radiographically confirmed knee osteoarthritis was 25.4%. In the study by Framingham[52] and the Johnston County Osteoarthritis Project,[53] both of which enrolled healthy adults, it was 19.2% and 27.8%, respectively. Notwithstanding study variations, we report a prevalence of OA in COPD of 35.5%.

Importantly, the shared risk factors between COPD and OA such as older age and female gender may increase the possibility of the co-occurrence of both conditions. In fact, Kopec et al[50] noted that age is associated with an exponential increase in OA between the age group of 20 and 50 years and a linear increase between the age group of 50 and 80 years. None of the articles in this systematic review categorized OA in COPD by the age group. The mechanism whereby OA is prevalent in COPD, whether by increased systemic inflammatory mediators, reduced skeletal muscle function or an increase in physical inactivity, remains to be established.[16,54–56]

The increased prevalence of OA is not likely to be confined to COPD as it has been noted to occur frequently in other chronic conditions such as asthma, coronary artery disease, cerebrovascular disease and depression.[34] However,

as both COPD and OA reduce mobility, an awareness of their co-occurrence will inform management programs such as pulmonary rehabilitation (PR) which aim to improve exercise capacity and health-related quality of life. Co-occurring conditions may adversely affect PR,[57–60] and in a prospective study[58] of 316 outpatients enrolled in PR, musculoskeletal comorbidities were identified in 10.2% of participants. Their exact impact on referral, participation and completion remains unclear especially as patients with severe comorbidities may be excluded from enrollment in an exercise training program.[58] Of interest, notwithstanding detailed guidelines and statements on PR,[61,62] there are no formal guidelines on the assessment and management of those with co-occurring conditions.

As PR programs move closer to being patient rather than disease focused, exercise training using endurance, resistance, flexibility and balance will be modified to focus on the specific impairments and activity limitations. For example, in the presence of lower limb comorbidities, aquatic exercise has been reported as being equally effective as land-based exercise in improving function. McNamara et al[63] randomized 53 individuals with COPD and lower limb comorbidities to receive either land-based or aquatic exercise and reported similar improvements in 6-minute walking distance in both groups and greater improvements in incremental shuttle walk as well as fatigue in the aquatic group.

The findings of this systematic review support the development of new pharmacological approaches in this patient population. Both COPD and OA are associated with chronic systemic inflammation, and increased levels of neutrophil elastase have been noted in COPD.[64–67] There is emerging evidence that neutrophil elastase is associated with articular tissue destruction in inflammatory joint diseases.[68] Neutrophil elastase inhibitors, already used in the management of COPD, have been shown to have protective and reparative effects on joint inflammation.[69] Therefore, the development of new pharmacologic approaches that might slow tissue destruction and promote repair would be of great benefit to the population with coexisting COPD and OA.

This review is limited by the heterogeneity of study designs and cohort characteristics. A number of articles were of poor quality, and only English language articles were included. It was not possible to obtain information regarding the location and severity of OA or its clinical impact. The results may have been biased toward one large study,[39] which was responsible for approximately 23% of the overall calculated weighted mean of the prevalence of OA in COPD. The observation that the weighted mean of the prevalence of

OA in COPD in eight studies[30,32,36–38,40–42] out of 14 was <1% suggests that only a few studies significantly contributed to the overall calculated average prevalence rate.

Conclusion

Accurate information on the prevalence of OA in COPD is limited by the heterogeneity of studies. However, it is a frequently co-occurring condition that an awareness of which will inform the way health care providers manage symptoms, mobility, participation and health-related quality of life in the COPD population.

Disclosure

The authors report no conflicts of interest in this work.

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Supplementary materials
Search strategies for each database
Search strategy for Medline and PsycINFO databases

1. lung diseases, obstructive/or bronchitis/or pulmonary disease, chronic obstructive/or bronchitis, chronic/or pulmonary emphysema/
2. COPD.tw
3. (chronic obstruct* pulmonary diseas* or chronic obstruct* respiratory diseas*).tw
4. 1 or 2 or 3
5. osteoarthritis/or osteoarthritis, hip/or osteoarthritis, knee/or osteoarthritis, spine/
6. (osteoarthr* or arthr* or joint* degenerat*).tw
7. 5 or 6
8. morbidity/or prevalence/
9. (common* or frequen* or comorbid* or multimorbid* or epidemio* or prevalen*).tw
10. 8 or 9
11. 4 and 7 and 10

Search strategy for Embase database

1. chronic obstructive lung disease/or obstructive airway disease/
2. copd.tw
3. (chronic obstruct* pulmonary diseas* or chronic obstruct* respiratory diseas*).tw
4. 1 or 2 or 3
5. osteoarthritis/or arthritis/or degenerative disease/or osteoarthropathy/or experimental osteoarthritis/or hand osteoarthritis/or hip osteoarthritis/or knee osteoarthritis/or spondylosis/

6. (osteoarthr* or arthr* or joint* degenerat*).tw
7. 5 or 6
8. prevalence/or epidemiological data/or epidemiology/
9. morbidity/
10. (common* or frequen* or comorbid* or multimorbid* or epidemio* or prevalen*).tw
11. 8 or 9 or 10
12. 4 and 7 and 11

Search strategy for CINAHL database

S1 (MH "Lung Diseases, Obstructive+") OR (MH "Bronchitis") OR (MH "Emphysema") OR (MH "Pulmonary Disease, Chronic Obstructive+") OR (MH "Bronchitis, Chronic")
S2 COPD
S3 chronic obstruct* pulmonary diseas* OR chronic obstruct* respiratory diseas*
S4 S1 OR S2 OR S3
S5 (MH "Osteoarthritis, Hip") OR (MH "Osteoarthritis, Knee") OR (MH "Osteoarthritis+") OR (MH "Osteoarthritis, Spine+") OR (MH "Osteoarthritis, Wrist")
S6 osteoarthr* OR arthritis OR arthrosis OR joint* degenerat*
S7 S5 OR S6
S8 (MH "Prevalence") OR (MH "Morbidity+")
S9 common* or frequen* or comorbid* or multimorbid* or epidemi*
S10 S8 OR S9
S11 S4 AND S7 AND S10