International Journal of COPD

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REVIEW

Epidemiology of chronic obstructive pulmonary disease: a literature review

This article was published in the following Dove Press journal:
International Journal of COPD
19 July 2012
Number of times this article has been viewed

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Abstract: The aim of this study is to quantify the burden of chronic obstructive pulmonary disease (COPD) – incidence, prevalence, and mortality – and identify trends in Australia, Canada, France, Germany, Italy, Japan, The Netherlands, Spain, Sweden, the United Kingdom, and the United States of America. A structured literature search was performed (January 2000 to September 2010) of PubMed and EMBASE, identifying English-language articles reporting COPD prevalence, incidence, or mortality. Of 2838 articles identified, 299 full-text articles were reviewed, and data were extracted from 133 publications. Prevalence data were extracted from 80 articles, incidence data from 15 articles, and mortality data from 58 articles. Prevalence ranged from 0.2%–37%, but varied widely across countries and populations, and by COPD diagnosis and classification methods. Prevalence and incidence were greatest in men and those aged 75 years and older. Mortality ranged from 3–111 deaths per 100,000 population. Mortality increased in the last 30–40 years; more recently, mortality decreased in men in several countries, while increasing or stabilizing in women. Although COPD mortality increased over time, rates declined more recently, likely indicating improvements in COPD management. In many countries, COPD mortality has increased in women but decreased in men. This may be explained by differences in smoking patterns and a greater vulnerability in women to the adverse effects of smoking.
Keywords: COPD, incidence, literature review, mortality, prevalence

Video abstract

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Introduction

Chronic obstructive pulmonary disease (COPD) is a chronic respiratory disease characterized by a decline in lung function over time and accompanied by respiratory symptoms, primarily dyspnea, cough, and sputum production.[1] Consequently, COPD is associated with a significant economic burden, including hospitalization, work absence, and disability.[1] Current data suggest that COPD mortality is increasing, and by 2020, COPD is predicted to be the third-leading cause of death worldwide.[2]

The severity of COPD can be determined and classified by different methods. Incidence and prevalence estimates differ greatly, depending on the methods used for diagnosis and classification. It is important to understand the true epidemiology of COPD to monitor trends over time and to determine the effectiveness of potential treatments or preventive measures.

The objectives of this study were to conduct a structured, comprehensive literature review to identify articles on the epidemiology of COPD in eleven developed countries (Australia, Canada, France, Germany, Italy, Japan, The Netherlands, Spain, Sweden, the United Kingdom, and the United States of America [USA]); quantify the burden of illness of COPD in terms of incidence, prevalence, and mortality; identify trends in

these data over time; and identify any trends regarding age, sex, and/or disease severity.

Methods

A structured and comprehensive search of medical literature indexed in the electronic PubMed (http://www.ncbi.nlm.nih.gov/sites/entrez) and EMBASE (http://www.embase.com/info/accessing-embase) databases was conducted using a detailed search strategy with a combination of free-text search terms and medical subject headings. Search terms included terms related to COPD, chronic bronchitis, and pulmonary emphysema, and terms for epidemiology including incidence, prevalence, rate of mortality, and risk of dying (see Table S1). The search was restricted to articles in English published between January 2000 and September 2010.

Articles identified from each literature search were screened in two phases by one reviewer using predefined inclusion and exclusion criteria. Phase 1 involved reviewing all titles and abstracts to determine whether to include or exclude them, and Phase 2 involved reviewing the full text of the articles identified in Phase 1 to determine their inclusion or exclusion for data extraction.

Articles were included if they reported incidence, prevalence, and/or mortality in COPD, or trends in such data for at least one of the countries of interest (Australia, Canada, France, Germany, Italy, Japan, The Netherlands, Spain, Sweden, the UK, or the USA). Articles were excluded if they met at least one of the following exclusion criteria; that is, if the article:

- was a comment, an editorial, a letter, a case report, or a clinical trial;
- did not report data specifically for COPD;
- did not report data on incidence, prevalence, and/or mortality, or trends in such data;
- was not concerned with any of the countries of interest;
- focused on a limited population, including studies in small numbers of patients, patients in very limited subpopulations, such as patients who were hospitalized, and patients with an existing condition that increased their risk for COPD, or studies that investigated risk factors for COPD;
- reported a study conducted in a single site, clinic, hospital, or city;
- focused on comorbidities in patients with COPD; or reported incidence, prevalence, or mortality associated specifically with exacerbations of COPD, not COPD overall;
- reported incidence or prevalence estimates from a model (ie, the article was not the primary data source);
- reported on design of a study but did not report results;
- was a duplicate of an article that had been previously identified.

Inclusion and exclusion processes were documented fully, and a Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow chart was completed.[3]

Relevant data were extracted from the included articles into evidence tables for each country. Quality-control checks verifying the summarized data against the source articles to confirm correct extraction were performed by an independent quality-control specialist on all extracted data.

Results

Summary of identified studies

The PRISMA flow chart (Figure 1) presents the two-phase screening approach, and the number of articles included, and excluded at each phase. From the initial database searches, 2838 unique articles were identified of which 299 articles were retrieved for full-text evaluation. Of those, 133 were included for data extraction.

Overall, the greatest number of relevant articles was identified for the USA (n = 49), Sweden (n = 19), and Canada (n = 12) (see Table S2). A total of 19 articles were identified that reported data for more than one country ("multicountry" studies). Most articles (80) focused on prevalence of COPD; another 15 articles reported incidence, and 58 reported mortality associated with COPD (Table S2). Twelve articles reported trends in incidence and/or prevalence, whereas 25 articles reported trends in mortality.

Prevalence

The reported prevalence of COPD ranged from 0.2% in Japan to 37% in the USA, but this varied widely across countries and populations, by diagnosis method, and by age group analyzed. Table 1 presents those studies that measured COPD by multiple methods within the same population to compare prevalence estimates resulting from different methods. Prevalence estimates varied according to the method of diagnosis and classification of COPD.[4–7] When individuals were identified by spirometry, and classified using the 2001 Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria for COPD (forced expiratory volume in 1 second/forced vital capacity [FEV_1/FVC] < 0.70), a greater COPD prevalence was reported than when using other classification methods such as the British Thoracic Society (BTS), European Respiratory Society (ERS), American Thoracic Society (ATS) spirometric, or ATS clinical criteria.[4–6,8,9]

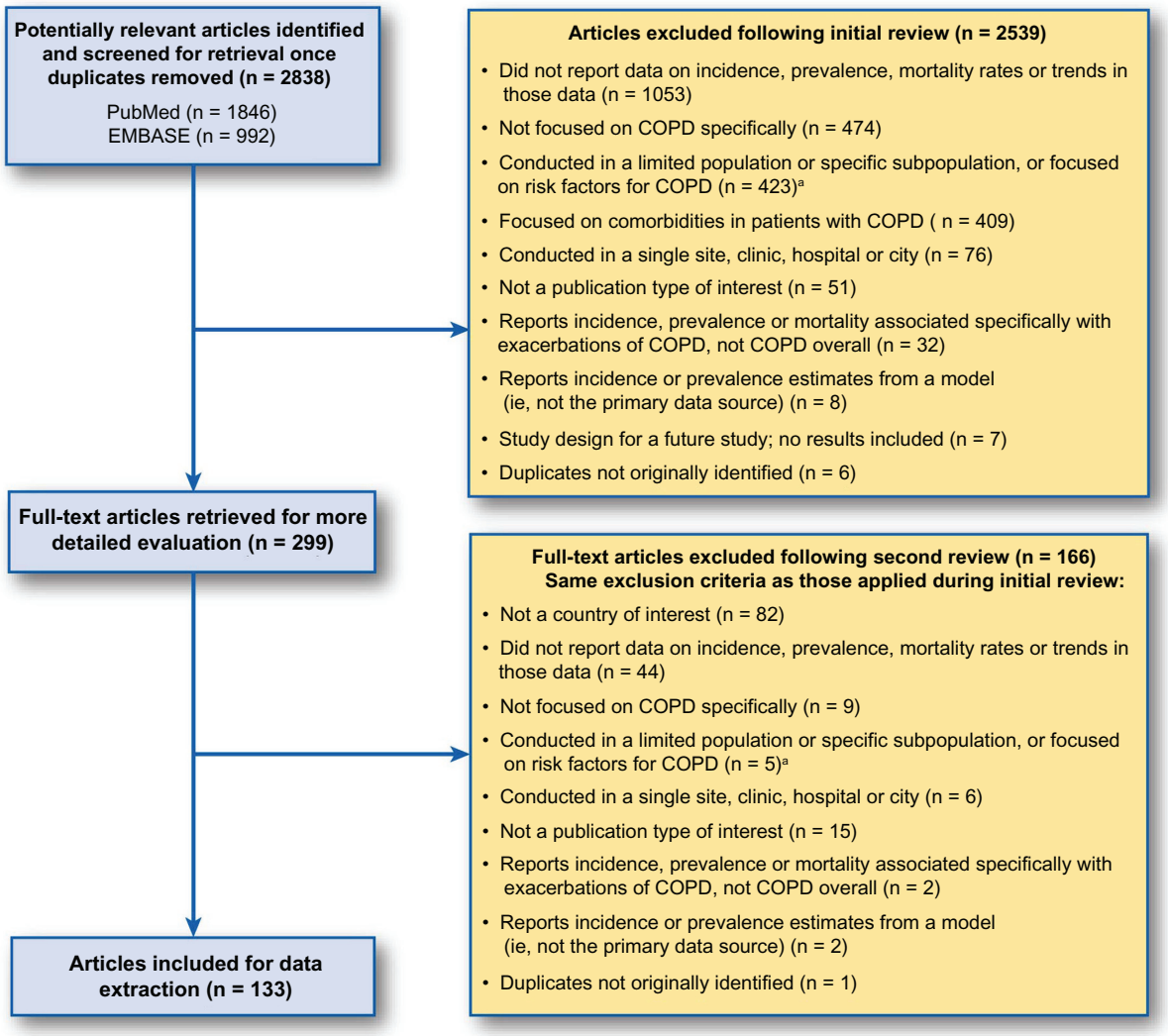

Figure 1 PRISMA flow diagram of the literature review.
Notes: [a]Includes studies in small numbers of patients, patients in very specific populations, patients who are hospitalized, patients with an existing condition that increases risk for COPD, and studies investigating risk factors for COPD.
Abbreviations: COPD, chronic obstructive pulmonary disease; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

This was supported by information from other studies that found that prevalence estimates by spirometry were higher than those estimated using methods based on symptoms (Table 1).[5,6,10–16] Some multicountry studies reported similar findings when looking at data from several countries, reporting a greater prevalence of COPD diagnosed by spirometry compared with self-reporting (see Table 1).

COPD was more commonly reported in older populations and was most prevalent in adults aged 75 years and older. Overall, the studies showed that the prevalence of COPD has increased over time, although the rate of increase has declined in recent years, particularly among men.

Details of all studies providing prevalence data are given in Table S3 in the supplementary material.

Incidence

Table 2 presents a summary of the population-incidence data reported in the identified articles. The incidence of COPD varied greatly between countries, but it is difficult to compare estimates because they are reported in different units and over different lengths of time. In most of the studies, the incidence of COPD was greater in men than in women.[17–21] The incidence of COPD was also greater in older individuals, particularly in those aged 75 years and older.[15,21] Six articles reported trends in incidence over time for Australia, Canada, Sweden, and the USA.[15,18,22–25] Although COPD incidence has increased over the last 20 years, within the last 10 years, there has been an overall decrease. Studies in Canada[18] and the USA[25] reported that trends in incidence over time were similar between men and women; however, in Australia, COPD incidence

Table 1 COPD prevalence studies comparing multiple methods

Reference	Study design	Patient population (n)	Method	Prevalence (%) (overall and/or by sex, where available)	Prevalence (%), by age
Canada					
Al-Hazmi et al[11]	Multicentre, two-stage study (six Canadian locations) to assess airflow obstruction (reversible = asthma, not entirely reversible = COPD).	21,449 randomly selected adults were sent ECRHS questionnaire, which 18,616 completed; of these, 2819 adults, aged 20–44 years, were screened in the laboratory.	LLN for FEV_1/FVC (1999 method) GOLD stage I[a] (2001 method) Self-reported CB	6.6 (M: 6.7; F: 6.5) 4.2 1.7	NR NR NR
Italy					
Cricelli et al[63,b]	Comparison of COPD prevalence from the HSD and the HIS6.[c] Prevalence rates age-standardized to overall population.	119,799 adults (aged ≥ 15 years). 432,747 adults (aged ≥ 15 years).	Self-reported as being physician-diagnosed COPD diagnosis of ICD-9 codes 491, 492, or 496, and a relevant prescription during study period	M: 5.55 F: 4.45 M: 4.03 F: 2.60	See Supplementary materials, Table S3 See Supplementary materials, Table S3
Viegi et al[12]	Two prospective cross-sectional surveys (in Po River Delta [1988–1991] and in Pisa [1991–1993]) plus spirometry.	Po River Delta: 2463 aged 36.3 years (range, 8–75 years). Pisa: 1890 aged 42.1 years (range, 8–75 years).	Self-reported obstructive lung disease (CBE and/or asthma) GOLD 2001 criteria[d]	Po River Delta: 6.9 Pisa: 10.9 Po River Delta: 11.0 Pisa: 6.7	NR NR
Sweden					
Lindberg et al[4]	Survey (mailed questionnaire) of random sample of adults (1992–1995).	4851 surveyed, 645 interviewed and had spirometry. Among those invited for examination, mean age was 49.1 years. Smokers: none, 45.3%; former, 28.2%; current, 26.5%.	BTS 1997 criteria[e] GOLD 2001 criteria[d] ATS 1986 guidelines[f] ATS: clinical (CBE defined as a physician report or productive cough) ERS 1995 consensus statement[g]	7.6 (M: 8.4; F: 6.8) 14.1 (M: 15.3; F: 13.0) 34.1 (M: 37.1; F: 31.2) 12.2 (M: 13.7; F: 10.8) 14.0 (M: 13.1; F: 14.8)	See Supplementary materials, Table S3
Lundbäck et al[9] Lindberg et al[8]	Random sample of population-based survey respondents in 1996 were invited to screening interview and spirometry. Respondents were from OLIN 1st survey in 1985.	1237 aged 46–77 years. Smokers: (M) current, 24%; former, 47%; non, 29%. (F) current, 26%; former, 24%; non, 51%.	BTS 1997 criteria[e] GOLD 2001 criteria[d]	8.1 14.3	See Supplementary materials, Table S3
Montnémery et al[64]	Population-based survey, Malmö, Sweden (2000).	In 2000, questionnaire sent to 5179 randomly selected people aged 20–59 years. 3692 respondents. Smokers: (all) 28.4%; (M) 28.0%; (F) 28.1%.	Self-reported CBE or COPD from self-administered questionnaire Physician diagnosis of CBE/COPD	3.6 (M: 2.9; F: 4.2) 4.3	See Supplementary materials, Table S3 NR

UK					
Shahab et al[65]	Study using data from HSE to describe prevalence of spirometry-defined COPD in England. Private households identified and members invited to participate. Prevalence rates age-standardized to overall population.	8215 aged > 35 years in HSE, with self-report data and valid spirometry. Mean age: 55.5 years. Smokers: current, 24.1%; ever, 55.1%.	ATS/ERS 2004 criteria[h] Self-reported CBE	13.3 1.1	NR NR
Soriano et al[66]	From a multicounty study: Retrospective analysis of UK GPRD, which records visits to a healthcare specialist (1998).	3 million inhabitants of England and Wales. Mean age: 37.6 years.	Patients coded with OXMIS and Read codes	CB: 0.5 Current emphysema: 0.5	Aged ≥ 50 years: • Current CB: 1.1 • Emphysema: 1.1
USA					
Celli et al[5]	NHANES III (1988–1994) population-based survey. Included questionnaire, laboratory examination, and lung-function testing. Prevalence rates weighted to general US population.	9838 aged 30–80 years of Caucasian, non-Hispanic white, non-Hispanic black, or Mexican-American origin, with a satisfactory spirometry test.	Self-reported CBE GOLD stage I or higher (2001 criteria) GOLD stage IIA or higher (2001 criteria) ATS 1999 guidelines[i] ERS 1995 guidelines[g]	7.73 (M: 5.82; F: 9.55) 16.8 (M: 19.90; F: 13.83) 7.87 (M: 8.48; F: 7.29) 14.2 (M: 15.00; F: 13.45) 16.0 (M: 16.09; F: 15.92)	See Supplementary materials, Table S3
Celli et al[13]	NHANES III (1988–1994) population-based survey. Included questionnaire, laboratory examination, and lung-function testing. Prevalence rates weighted to general US population.	10,276 aged 30–80 years with satisfactory spirometry test. Smokers: ever, 5,732; never, 4,544.	GOLD stage I or higher (2004 guidelines) Self-reported CBE	Smokers: ever, 21.9; never, 9.12 (M: 10.06; F: 8.58) Smokers: ever, 10.0; never, 4.5	See Supplementary materials, Table S3 NR
Hnizdo et al[14]	Data from NHANES III in a working population (1988–1994). Included questionnaire, laboratory examination, lung-function testing. Prevalence rates weighted to general US population.	9823 aged 30–75 years. Excluded subjects with problems with lung-function tests, diagnosed current asthma, or missing occupational code.	GOLD stage II or higher (2001 criteria) Physician-diagnosed emphysema Physician-diagnosed CB	7.1 (M: 7.8; F: 6.1) 1.6 4.5	See Supplementary materials, Table S3 NR NR
Hnizdo et al[6]	Retrospective analysis of data from population-based NHANES III (1988–1994). Included questionnaire and spirometry.	13,842 aged 20–80 years; Caucasian, African-American, or Mexican-American origin with spirometry data.	Self-reported CB Self-reported emphysema GOLD stage I (2001 criteria) GOLD stage II or higher (2001 criteria) LLN-1 (mild or greater severity [1991 ATS criteria])[j] LLN-2 (moderate or greater severity [1991 ATS criteria])[k]	5.7 1.8 14.2 6.9 12.3 6.2	See Supplementary materials, Table S3

(*Continued*)

Table 1 (*Continued*)

Reference	Study design	Patient population (n)	Method	Prevalence (%) (overall and/or by sex, where available)	Prevalence (%), by age
Mannino et al[67]	Retrospective analysis of data from NHANES III (1988–1994). Prevalence rates weighted to general US population.	16,084 aged ≥ 17 years with lung-function testing. Mean age: 42.8 years; FEV_1 predicted: 95.3%; FEV_1/FVC ratio: 0.79.	Self-reported CB (current), asthma (current), or emphysema (ever)	8.5	NR
			FEV_1/FVC < 0.7; FEV_1 > 80% predicted (ATS, 1995 criteria)	7.2	NR
			OLD stage I (ATS, 1995 criteria)[l]	6.8	NR
			OLD stage 2 (ATS, 1995 criteria)[m]	5.35	NR
			OLD stage 3 (ATS, 1995 criteria)[n]	1.45	NR
Mannino et al[15]	NHANES III, phase 2 (1991–1994). Prevalence rates age-adjusted to 2000 US population.	6600 noninstitutionalized adults aged ≥ 25 years with spirometry data.	Self-reported COPD	4.7	NR
			GOLD stage I (2001 criteria)	7.4	NR
			GOLD stage II and higher (2001 criteria)	8.0	NR
Methvin et al[16]	Survey including questionnaire and spirometry (study period NR). Prevalence estimates weighted to reflect target population.	508 noninstitutionalized adults aged ≥ 40 years, with completed questionnaires and pre- and postbronchodilator spirometry.	Self-reported COPD or CB	17.1	NR
			Self-reported emphysema	8.6	NR
			GOLD stage 0 (2001 criteria)[o]	36.3 (M: 41.0; F: 32.4)	See Supplementary materials, Table S3
			GOLD stage I or higher (2007 criteria)	19.6 (M: 18.3; F: 20.8)	
			Restricted	17.6 (M: 15.0; F: 19.9)	
Soriano et al[66]	From a multicountry study: Retrospective analysis of NHANES III survey conducted in the USA, including questionnaire and spirometry (1988–1994).	33,994 noninstitutionalized subjects, of whom 22,431 had spirometry. Mean age: 34.3 years.	Self-reported physician diagnosis of CB (current), emphysema (ever), and asthma (current)	CB: 3.2 Emphysema: 1.5	Aged ≥ 50 years: • Current CB: 5.8 • Emphysema: 5.0
Vaz Fragoso et al[7]	Retrospective cohort study of subjects in the NHANES III (1988–1994); followed up until December 2000.	3502 white subjects aged 40–80 years with no self-reported asthma and acceptable spirometry data. Mean age: 60.7 years.	ATS/ERS-LLN_5 (2005 criteria)	7.1	See Supplementary materials, Table S3
			GOLD stage I or higher (2007 criteria)	27.0	
			LMS-LLN_5 (2008 criteria)	13.8	
Multicountry					
Cerveri et al[10]	Self-completed questionnaire about respiratory health, followed by clinical assessment and spirometry in Belgium, Denmark, Germany, Spain, France, Ireland, Italy, The Netherlands, UK, Iceland, Norway, Sweden, Switzerland, New Zealand, the USA, and Australia (1991–1993).	17,966 aged 20–44 years. Of these, 14,819 had reliable FEV_1 and FVC measurements.	Self-reported CB	3.2	NR
					NR
			ATS 1979 criteria[o]	With CB: 8.4% No CB: 4.3%	

decreased in men between 1998 and 2003 but increased in women.[22] Two articles, both conducted in Sweden as part of the Obstructive Lung Disease in Northern Sweden (OLIN) study, reported incidence rates in smokers (Table 2).[20,26] These studies reported a two- to three-times greater incidence in smokers than nonsmokers when measured by spirometry, and assessed by GOLD or BTS criteria.[20,26] One study also reported that COPD incidence in former smokers was more than double that in nonsmokers.[26]

Mortality

The 58 articles that presented mortality associated with COPD varied in the way they reported the data. Twenty-four articles reported the mortality rate within a group of patients with COPD, 14 reported the proportion of all deaths that could be attributed to COPD, and 21 articles reported overall mortality from COPD within the whole population.

Of the studies that reported mortality rates within patients with COPD, length of follow-up differed, which resulted in difficulties comparing studies. However, the one-year mortality rate of COPD (all severity stages) was reported in four studies and varied from 4.1% in patients aged 45 years and older, to 27.7% in patients aged 65–100 years in Canada,[18,27,28] and to 5.1% in patients aged 41–83 years in Sweden.[29]

Between 2.3% and 8.4% of all deaths were caused by COPD, and this proportion was greater in men than women,[30–32] and greatest in subjects aged 65–74 years.[33]

Measuring the number of COPD deaths per whole population provides a true picture of the burden of COPD mortality within the population. The overall mortality rate varied between countries, ranging from 3–9 deaths per 100,000 population in Japan to 7–111 deaths per 100,000 population in the USA. In almost all these studies, COPD mortality was greater within the male population than within the female population[15,34–45] and was greatest in elderly adults aged 75 years and older.[15,35–38,43]

Two studies were identified that reported deaths due to COPD as a proportion of deaths attributable to smoking: numbers ranged from 12.8% across several industrialized countries[46] to 20.9% in the USA.[47] One study also reported that 19%–24% of all smoking-related deaths in women and 52%–54% of all smoking-related deaths in men resulted from COPD.[48] One US study reported that mortality in a population of those who quit smoking was almost half of that in a population of individuals who switched from cigarette smoking to spit tobacco (49 versus 89 per 100,000 population).[49]

Notes: [a]GOLD stage 1, $FEV_1/FVC < 0.70$; FVC predicted > 0.80. [b]For Cricelli et al 2003,[63] prevalence values reported in this study were reported as prevalence per 1000 but have been translated to % (prevalence per 100) for consistency in this table. [c]HSD, a computerized general-practice database; HIS6, a population-based survey. [d]GOLD 2001 criteria, $FEV_1/FVC < 0.70$ and $FEV_1 < 80\%$. [e]ATS 1986 guidelines, $FEV_1/FVC < 0.75$ (ATS, 1986).[68] [g]ERS 1995 consensus statement, FEV_1/FVC <88% predicted in men; <89% predicted in women (Siafakas et al 1995).[69] [h]ATS/ERS 2004 criteria, $FEV_1/FVC < 0.70$. [i]ATS 1995 guidelines, $FEV_1/FVC < LLN$. [j]LLN-1 (mild or greater severity), $FEV_1/FVC < LLN$; $FEV_1 < 100\%$ predicted (1991 ATS criteria). [k]LLN-2 (moderate or greater severity), $FEV_1/FVC < LLN$; $FEV_1 <$ LLN (~80% predicted) (1991 ATS criteria). [l]OLD stage 1 ($FEV_1/FVC < 0.7$; $FEV_1 < 80\%$ predicted) or higher (ATS, 1995 criteria). [m]OLD stage 2 ($FEV_1/FVC < 0.7$; $FEV_1 > 50\%$ and $< 80\%$ predicted) (ATS, 1995 criteria). [n]OLD stage 3 ($FEV_1/FVC < 0.7$; $FEV_1 < 50\%$ predicted) (ATS, 1995 criteria). [o]GOLD stage 0 (symptoms of cough, sputum, wheeze, or breathlessness without airflow obstruction or restriction; 2001 criteria). [p]ATS 1979 criteria, $FEV_1/FVC < 0.70$.

Abbreviations: ATS, American Thoracic Society; ATS/ERS-LLN$_S$, ATS/ERS defined LLN at the 5th percentile; BTS, British Thoracic Society; CB, chronic bronchitis; CBE, chronic bronchitis or emphysema; COPD, chronic obstructive pulmonary disease; ECRHS, European Community Respiratory Health Survey; ERS, European Respiratory Society; F, female; FEV_1, forced expiratory volume in one second; FVC, forced vital capacity; GOLD, Global Initiative for Chronic Obstructive Lung Disease; GPRD, General Practice Research Database; HSE, Health Survey for England; LLN, lower limit of normal; LMS, Lambda-mu-sigma; LMS-LLN$_S$, LMS defined LLN at the 5th percentile; M, male; NHANES, National Health and Nutrition Examination Survey; NR, not reported; OLD, obstructive lung disease; OLIN, obstructive lung disease in Northern Sweden; OXMIS, Oxford Medical Information Systems; UK, United Kingdom; US(A), United States (of America).

Table 2 Identified studies presenting data on incidence of COPD

Source, study name, study period	Study design	Patient characteristics (n)	Method for diagnosing COPD	Incidence (n)
Multicountry study				
de Marco et al[17] ECRHS II Study period: 1999–2002	Follow-up of patients in ECRHS I who completed respiratory health questionnaire, underwent clinical assessment, and spirometry, from 12 countries (Europe and the USA).[a] Median follow-up: 8.9 years.	5002 without asthma, aged 20–44 years, with normal lung function,[b] who participated in stage 2 of ECRHS I.	$FEV_1/FVC \geq 70\%$ at baseline (ECRHS I), and $FEV_1/FVC < 70\%$ at end of follow-up (ECRHS II)	Cases per 1000 per year: All: 2.8; M: 3.2; F: 2.4 Aged 20–30 years: 1.5; 30–40 years: 2.6; 40–45 years: 4.7
Canada				
Gershon et al[18] NA Study period: 1991–2007	Population-based cohort from administrative health information system (2007).	7,082,086 in database population (denominator), 708,743 with COPD. Age: ≥35 years.	≥1 physician billing claims and/or ≥1 hospital discharges with diagnosis of COPD using ICD-9 codes 491, 492, 496; or ICD-10 codes J41, J42, J43, J44 Cases had to be >35 years when claim or discharge occurred	Cases per 1000 in 2007: All: 8.5; M: 9.4; F: 7.8 Aged 35–49 years: 4.4; 50–64 years: 8.8; Aged 65+ years: 17.9 Cases per 1000 in 1996, 2002, 2007 All: 11.8; 8.9; 8.5 M: 13.9; 10.1; 9.4 F: 10.4; 8.1; 7.8 Aged 35–49 years: 5.0; 3.9; 4.4 Aged 50–64 years: 11.5; 8.7; 8.8 Aged 65+ years: 28.5; 21.0; 17.9
Japan				
Kojima et al[19] NA Study period: April 1997 to March 2005	Large longitudinal study to estimate incidence of COPD.	17,106 aged 25–74. Mean: M, 47.7 years; F, 48.0 years.	Spirometry: GOLD stage I and higher	Cases per 100 person-years: All: M, 0.81; F, 0.31 M: Aged 25–29 years, 0.62; 30–34 years, 0.31; 35–39 years, 0.35; 40–44 years, 0.47; 45–49 years, 0.61; 50–54 years: 1.05; 55–59 years, 1.25; 60–64 years: 1.67; 65–69 years, 2.75; 70–74 years, 4.95 F: Aged 25–29 years, 0.00; 30–34 years, 0.16; 35–39 years, 0.13; 40–44 years, 0.18; 45–49 years, 0.19; 50–54 years, 0.42; 55–59 years, 0.35; 60–64 years, 1.02; 65–69 years, 1.69; 70–74 years, 2.05
Sweden				
Lindberg et al[20] Study period: 1986–1996 OLIN	Survey in eight areas of northern Sweden. Those with symptoms were offered examination in 1986, then follow-up survey in 1996. 10% were lost to follow-up.	1986: 1506 interviewed and examined. 1996: 1109 with adequate spirometry.	BTS: $FEV_1/FVC < 0.70$, $FEV_1 < 80\%$ GOLD: $FEV_1/FVC < 0.70$	Cumulative incidence per 100 population over 10 years by BTS or GOLD spirometric criteria: BTS: All: 8.2; M: 9.0; F: 7.5 Born 1949–1950: 4.1; 1934–1935: 11.0; 1919–1920: 9.8 "Persistent" smoking: 16.7; nonsmoking: 4.8

				GOLD: All: 13.5; M: 15.3; F: 11.8 Born 1949–1950: 6.9; 1934–1935: 16.5; 1919–1920: 18.9 "Persistent" smoking: 24.5; nonsmoking: 9.4
Nihlen et al[70] Study period: 2000	n = 4933 from a 1992 questionnaire,[c] all aged 20–59 years in 1992.	4280 studied in 1992 and 2000. Smokers: Current, 32.8 (1992); 26.3 (2000). Former, 24.8 (1992); 30.7 (2000).	Self-reported physician's diagnosis of COPD, CBE/COPD	Cumulative incidence per 100 population of self-reported CBE/COPD physician's diagnoses between 1992 and 2000 (aged 28–67 years in 2000) Overall: 2.9 By age in 2000: 28–37 years, 1.9; 38–47 years, 2.9; 48–57 years, 2.5; 58–67 years: 4.2 By sex: M, 2.7; F, 3.1
Lindberg et al[26] Study period: 1996–2003 OLIN	Ongoing population-based cohort with survey and subgroup invited for examination. (3rd update of OLIN cohort 1).	5189 surveyed in 1996. 963 with spirometry data were followed up in 1996 and 2003. Ever smoked: 59%. Mean FEV_1% predicted: 97.45.	GOLD: Stage I–IV: $FEV_1/FVC < 0.70$ GOLD II: Stage II–IV: $FEV_1/FVC < 0.70$ and $FEV_1 < 80\%$	Cases per 100 population in 7 years: GOLD I–IV: Overall: 11.0; M: 9.7; F: 12.2 Age at entry: 46–47 years, 7.4; 61–62 years: 14.6, 76–77 years: 18.7 Smokers: non, 7.6; former, 10.5; current, 18.8 GOLD II–IV: Overall: 4.9; M: 4.4; F: 5.4 Age at entry: 46–47 years, 3.7; 61–62 years, 6.8; 76–77 years, 4.3 Smokers: non, 1.6; former, 5.2; current, 10.6
UK				
García Rodríguez et al[21] Study period: 1996	Cohort study in GPRD database. Followed by nested case-control study.	808,513 aged 40–89 years; 1-year prescription history and ≥2 years total enrolment; followed to end of 1996; no history of kyphoscoliosis, asthma, COPD, cancer, pulmonary fibrosis. Potential COPD cases = 2351.	Diagnoses in OXMIS and Read coding	Cases of COPD diagnosis per 1000 person-years: Overall: 2.6 (2.5–2.7) 40–49 years: M, 0.21; F, 0.26 50–59 years: M, 1.62; F, 1.16 60–69 years: M, 3.69; F, 1.82 70–79 years: M, 6.33; F, 3.37 80–89 years: M, 7.03; F, 3.46
Soriano et al[71] Study period: 1990–1997 GPRD	Retrospective cohort study in UK GPRD data.	78,172 diagnosed with COPD 1990–1997. 50,174 incident COPD cases 1990–1997.	Diagnosed COPD found with OXMIS codes in general practitioner records	Incidence rate NR. Incident cases (50,714) counted for 1990–1997 and described. Severity of COPD based on type of drugs prescribed and whether oxygen was used. Severity defined for incident cases 1990–1997. Percentage of all incident cases of COPD in 1990–1997, by severity: Overall: mild, 35.5; moderate, 56.4; severe, 8.1 F: mild, 34.1; moderate, 57.7; severe, 8.2. M: mild, 36.7; moderate, 55.2; severe, 8.1

(*Continued*)

Table 2 (*Continued*)

Source, study name, study period	Study design	Patient characteristics (n)	Method for diagnosing COPD	Incidence
USA				
Mannino et al[15] Report of several surveys or studies conducted by the CDC's NCHS	NAMCS to measure physician office visits (1980–2000); NHAMCS to measure hospital outpatient visits (1995–2000).	~30,000 visits to physician's office; ~30,000 outpatient department encounters (in 2000).	COPD as first-listed diagnosis (ICD-9 code: 490–492, 496)	Incidence per 1000 population: All: 45.0; M: 46.8; F: 43.4 Aged 25–44 years: 17.7; 45–54 years: 31.9; 55–64 years: 46.3; 65–74 years: 119.9; ≥ 75 years: 125.7 Incidence per 1000 population over time: All: 1980, 44.5; 1985, 53.8; 1990, 67.6; 1995, 68.7; 1996, 58.6; 1997, 58.3; 1998, 81.6; 1999, 58.9; 2000, 45.0 M: 1980, 45.7; 1985, 57.4; 1990, 65.3; 1995, 74.2; 1996, 60.6; 1997, 62.5; 1998, 78.7; 1999, 51.9; 2000, 46.8 F: 1980, 37.8; 1985, 51.4; 1990, 68.6; 1995, 63.4; 1996, 56.7; 1997, 54.4; 1998: 84.5; 1999: 66.2; 2000: 43.4
Mannino et al[15] Report of several surveys/ studies conducted by the CDC's NCHS	NHAMCS to measure emergency department visits (1992–2000).	~30,000 emergency department encounters (in 2000).	COPD as first-listed diagnosis (ICD-9 code: 490–492, 496)	Incidence per 10,000 population: All: 87.2; M: 80.7; F: 94.4 Aged 25–44 years: 58.7; 45–54 years: 52.4; 55–64 years: 131.6; 65–74 years: 147.1; ≥75 years: 176.1 Incidence per 10,000 population over time: All: 1992, 67.6; 1995, 84.9; 1996, 72.7; 1997, 77.6; 1998, 82.6; 1999, 87.4; 2000, 87.2 M: 1992, 57.5; 1995, 90.0; 1996, 70.8; 1997, 4.1; 1998, 72.7; 1999, 93.0; 2000, 80.7 F: 1992, 76.6; 1995, 82.0; 1996, 75.9; 1997, 82.7; 1998, 93.1; 1999, 85.7; 2000, 94.4

Notes: [a]12 countries: Belgium, Estonia, France, Germany, Iceland, Italy, Norway, Spain, Sweden, Switzerland, the UK, and the USA. [b]Normal lung function, $FEV_1/FVC \geq 70\%$. [c]Appears to be a subset of patients in a Montnémery study published 1998; original 1992 sample was a population based in the Malmö area.

Abbreviations: BTS, British Thoracic Society; CBE, chronic bronchitis and emphysema; CDC, Centers for Disease Control and Prevention; COPD, chronic obstructive pulmonary disease; ECRHS, European Community Respiratory Health Survey; F, female; FEV_1, forced expiratory volume in one second; FVC, forced vital capacity; GOLD, global obstructive lung disease initiative; GPRD, General Practice Research Database; ICD-9, International Classification of Diseases, 9th Revision; ICD-10, International Classification of Diseases, 10th Revision; M, male; NA, not applicable; NAMCS, National Ambulatory Medical Care Survey; NCHS, National Center for Health Statistics; NHAMCS, National Hospital Ambulatory Medical Care Survey; NR, not reported; OLIN, Obstructive Lung Disease in Northern Sweden; OXMIS, Oxford Medical Information Systems; UK, United Kingdom; USA, United States of America.

Trends in mortality

A total of 25 articles reported COPD mortality over different years to allow trends to be observed, 14 of which reported the changes in COPD mortality within the overall population. These included studies conducted in Australia (2), Canada (1), France (1), and the USA (10) (Table 3). Our literature review did not identify any articles reporting trends in mortality in Germany, Italy, Japan, The Netherlands, Spain, Sweden, or the UK. In general, the studies reported an overall increase in COPD mortality rates within the last 30–40 years, with a much greater increase in mortality in women compared with men.[15,34,35,38,40,42,45] Some studies have indicated that more recently (within the last 10 years) mortality rates have increased at a slower rate or have decreased, particularly in men.[22,34,35,42,43,45] Some remarkable differences in COPD mortality exist between countries, particularly regarding the differences between men and women. In Australia, one study[34] reported a decrease in COPD mortality in men between 1979 and 1997, whereas an increase was seen in women over the same period. In France, COPD mortality has increased in women over time, whereas a decrease has been reported in men.[35] Data from several US studies show more heterogeneity. Data from two studies showed a clear increase in COPD mortality in women and only a slight increase in men between 1980 and 2000.[15,45] Data from a later study[43] suggested that COPD mortality decreased between 2000 and 2005 in men, with little change in women.

Discussion

We conducted a structured and comprehensive literature review to identify published data on the prevalence, incidence, and mortality in COPD, and/or trends in those data. The review identified a wealth of data on the prevalence of COPD in the eleven countries studied (Australia, Canada, France, Germany, Italy, Japan, The Netherlands, Spain, Sweden, the UK, and the USA). However, data on mortality and incidence were sparser. Only 15 articles reported incidence data, and six reported trends in incidence; 21 articles reported mortality from COPD within the whole population, and 14 of those reported trends in those data.

Several other literature reviews have previously been conducted to identify prevalence and/or mortality data.[50–53] One of these reported data only for the Asia-Pacific region and, of those countries investigated here, included only Japan.[53] Results from the other three literature reviews can be compared with findings from our review. One review included articles published between 1962 and 2001 that were indexed on MEDLINE,[51] one review included articles published between 1990 and 2004 that were indexed on PubMed, and also provided pooled estimates of prevalence by means of a meta-analysis,[52] and the third review included articles reporting prevalence, and/or mortality in Europe published between 1991 and 2009 in the Science Citation Index database via the Web of Science.[50]

As with our study, all three published reviews reported substantial heterogeneity between studies, particularly in terms of the definition of COPD used, methods used (eg, self-report, spirometry), diagnostic criteria (eg, GOLD, ATS), populations studied, and year(s) of study.[50–53] The estimates obtained from the multicountry studies in our review ranged from 3.6%–10.1%, which is in line with the estimates reported in two of the previous reviews (4%–10%,[51] 9%–10%[52]). When all studies in our review were taken into account, prevalence estimates ranged from 0.2%–37%, which was in line with the most recent published review (2.1%–26.1%[50]). Differences can be accounted for by the wider scope of our study, which identified 80 studies reporting prevalence estimates in Europe, the USA, Canada, Australia, and Japan compared with 32 studies reporting estimates for Europe only, as identified by Atsou et al.[50]

Our findings with respect to mortality were also similar to those reported in a recent literature review regarding both mortality within the overall population (3–111 per 100,000 [current review] versus 7.2–36.1 per 100,000 [review by Atsou et al[50]]) and the greater mortality rate in men compared with women.[50] The slightly higher mortality rates identified in our studies again relate to the scope of the two reviews. The lowest and highest mortality estimates in our review were from Japan and the USA, respectively,[38,54] which were not captured in the European-focused literature review.[50] Therefore, it is likely that the inclusion of countries outside Europe led to the greater heterogeneity in estimates that were identified in our review.

The current review also reported that, although COPD mortality rates have increased over time, rates have declined in more recent years, which suggests improvements in COPD management. However, several studies identified within the review also reported that the mortality rate in women with COPD has increased or stabilized, whereas it has decreased in men.

The difference in these trends may be explained by trends in smoking prevalence in the countries of interest. A relationship between smoking and COPD mortality can be investigated by examining trends in smoking prevalence such as using data from the Organisation for Economic Co-operation and Development (OECD).[55]

Table 3 Articles providing data allowing calculation of trends in COPD mortality in the overall population

Source, study name, study period	Study design	Patient characteristics (n)	Trends in mortality (by years)
Australia			
Berend[34] 1921–1991 (Trends in mortality data are provided in the publication for 1979–1997 only)	Analysis of data collected by the ABS and presented by the AIHW.	Age: NR (all assumed). Sex (% F): NR. Disease severity: NR. Comorbidities: NR.	Trends in crude mortality rates for COPD per 100,000 population (interpreted from Figure 4 in the publication): M: 1979, 65; 1981, 65; 1983, 64; 1985, 58; 1987, 64; 1989, 65; 1991: 48; 1993: 47; 1995, 46; 1997, 38 F: 1979, 10; 1981, 12; 1983, 13; 1985, 16; 1987, 15; 1989, 18; 1991, 16; 1993, 17; 1995, 17; 1997, 15
Tan et al[22] (1991–2004)	Retrospective analysis of mortality and hospitalization data from the Asia-Pacific region.[a]	Data are presented only for the country of interest (ie, Australia). Adults aged ≥ 40 years (population size unknown).	Annual change in COPD mortality rates: 1991–2004: –3.6% (M: –5.1%; F: –1.4%) 1997–2004: –4.4% (M: –5.8%; F: –2.4%)
Canada			
Stewart and McRae[72] CCHS 1950–2002	Pop surveillance on COPD via the CCHS (2005).	Subjects aged ≥ 35 years participating in survey (population size unknown).	Age-standardized mortality rates from COPD (ICD-10 codes: J40–44) per 100,000 population (interpreted from Figure 1 in publication): 1950: 5; 1960: 9; 1970: 19; 1980: 22; 1990: 26; 2000: 26; 2003: 25
France			
Fuhrman et al[35] 1979–2002	Mortality study using death cert data, 1979–1999 (ICD-9 codes), and 2000–2002 (ICD-10 codes).	Deaths reported in database during 1979–1999 and 2000–2002 in those aged ≥ 45 years (population size unknown).	Years: Mortality (mean annual age-standardized rates per 100,000 from COPD, M; F) 1979–1981: 81.6; 20.1 1984–1986: 85.6; 22.0 1989–1991: 75.6; 22.8 1994–1996: 74.0; 24.6 1998–1999: 75.4; 25.9 % change, 1979–1999: –0.7%; +1.4%
USA			
Day et al[37] (1979–2003)	Retrospective analysis of NCI's SEER program.	Alaskan natives (3404 deaths), US white residents, and Alaskan white residents.	Mortality rates (per 100,000 population) between 1979 and 2003 for Alaskan natives; US white residents: 1979–1983: 22.3; 29.8 1984–1988: 49.4; 35.8 1989–1993: 62.0; 39.2 1994–1998: 72.6; 42.2 1999–2003: 65.1; 45.8 Overall change in mortality rate between 1979 and 2003: Alaskan natives: 192%; US white residents: 54%
Day and Lanier[36] (1979–1998)	Retrospective analysis of death certificates and Indian Health Service population estimates for the Alaskan native population.	~91,300 Alaskan natives.	Mortality rates (per 100,000 population) between 1979 and 1998 for Alaskan natives: 1979–1983: 12.8; 1984–1988: 25.8; 1989–1993: 31.2; 1994–1998: 37.2 Mortality rates (per 100,000 population) between 1981 and 1996 for US white residents:

			1981: 16.8; 1986: 19.3; 1991: 20.6; 1996: 21.5 Overall change in mortality rate: Alaskan natives: 191% between 1979 and 1983, and 1994 and 1998 US white residents: 28% between 1981 and 1996
Edwards et al[38] (1980–2000)	Retrospective analysis of public mortality database, the CDC WONDER database.	Adults in Wisconsin aged ≥ 45 years (population size unknown).	Age-adjusted mortality rate (per 100,000 population) for COPD (ICD-10 J40–J44)

	1980	2000
All; M; F	59; 112; 23	111; 150; 89
45–54 years (M; F)	7.3; 2.6	4.5; 5.0
55–64 years (M; F)	43; 14	29; 29
65–74 years (M; F)	170; 4	180; 111
75–84 years (M; F)	350; 58	478; 254
>85 years (M; F)	484; 82	773; 334

Jemal et al[73] (1970–2002)	Retrospective analysis of death certificates from NCHS.	Deaths in USA 1970–2002 (population size unknown).	Age-adjusted mortality rate (per 100,000 per years) from COPD (ICD-8 490–493, 519.3; ICD-9 490–496; ICD-10 J40–47): 1970: 21.4; 2002: 43.4 Change: 102.8%
Kazerouni et al[40] (1968–1999)	Retrospective analysis of the national mortality files compiled by the CDC's NCHS.	Deaths in the USA 1968–1999 (population size unknown).	Age-adjusted mortality rate (per 100,000 population) from COPD (ICD-8 490–492, 519; ICD-9 490–492, 496; ICD-10 J40–44), 1969 rate; 1999 rate; % increase: M: 35; 44; 27% F: 9; 41; 382%
Mannino et al[15] Report of several surveys and studies conducted by CDC's NCHS (1980–2000)	Retrospective analysis of the Mortality Component of the National Vital Statistics System to identify deaths due to COPD.	Adults aged ≥ 25 years.	Annual mortality from COPD (per 100,000 population): All: 1980, 40.7; 1985, 50.0; 1990, 53.3; 1995, 58.4; 1996, 59.3; 1997, 60.2; 1998, 61.3; 1999, 67.6; 2000, 66.9 M: 1980, 73.0; 1985, 81.9; 1990, 80.0; 1995, 78.9; 1996, 78.3; 1997, 79.0; 1998, 79.0; 1999, 85.9; 2000, 82.6 F: 1980, 20.1; 1985, 30.2; 1990, 37.0; 1995, 45.4; 1996, 47.2; 1997, 48.1; 1998, 49.9; 1999, 55.6; 2000, 56.7
Miller et al[42] (1980–1996)	Retrospective analysis of death certificates from Missouri Center for Health Information Management and Epidemiology.	Subjects with deaths recorded in database.	Age-adjusted COPD mortality rate (per 100,000 per years), 1980–1996; 1990–1996; projected to 2006: All: 20.8; 22.6; 30.4 M: 30.2; 30.4; 32.5 F: 14.5; 17.5; 33.5
CDC[43] (2000–2005)	Retrospective analysis of the CDC's WONDER compressed mortality database of the National Vital Statistics System.	Adults aged ≥ 25 years.	Mortality rate (per 100,000 population) from COPD as underlying cause in 2000; 2001; 2002; 2003; 2004; 2005: All: 65.2; 64.7; 64.4; 64.3; 61.1; 64.3 M: 83.8; 81.3; 80.4; 78.7; 74.5; 77.3 F: 54.4; 54.7; 54.6; 55.4; 52.8; 56.0 25–44 years: 0.6; 0.7; 0.7; 0.7; 0.7; 0.7 45–54 years: 6.9; 6.9; 7.1; 7.1; 7.0; 7.9 55–64 years: 41.7; 41.7; 40.1; 41.0; 38.5; 40.1 65–74 years: 164.5; 163.5; 158.9; 159.5; 150.2; 157.2 ≥75 years: 439.7; 435.6; 440.6; 438.6; 419.2; 444.2

(*Continued*)

Table 3 (*Continued*)

Source, study name, study period	Study design	Patient characteristics (n)	Trends in mortality (by years)
Singh and Hiatt[45] NHIS	Retrospective analysis of NHIS data (1993–2003), national mortality database (1979–2001), and US census data (1980, 1990, 2000).	1980: 212,467,094 US-born (median age: 29.0 years); 14,079,906 foreign-born (37.0 years). 1990: 228,942,557 US-born (31.4 years); 19,767,316 foreign-born (37.3 years). 2000: 252,463,000 US-born (35.1 years); 33,471,000; foreign-born (38.4 years).	Annual age-adjusted mortality rates (per 100,000 population) for COPD (by ICD-9 and ICD-10 codes) in 1979–1981; 1989–1991; 1999–2000: M: US-born, 50.45; 57.25; 59.67 (18.28% change from 1979–2000) Foreign-born, 33.16; 35.45; 32.76 (–1.21% change from 1979–2000) F: US-born, 15.03; 27.81; 38.99 (159.41% change from 1979–2000) Foreign-born, 9.30; 16.09; 20.58 (121.29% change from 1979–2000)
Polednak[74] (study in smokers)	Retrospective analysis of mortality data from NCI (1990–2009).	Adults aged ≥ 35 years in California; New Jersey and New York; the USA exclusive of California; and six tobacco-growing southern states.[b]	Annual age-adjusted mortality rate (per 100,000 per years) for COPD (ICD-10 J40–47; ICD-9 490–496; ICD-8 490–493 and 519.3) in 1990; 2005: Age 35–64 years (all) California: 14.6; 11.5 (–21% change); all except California: 14.5; 14.1 (–3% change); New Jersey, New York: 12.3; 9.6 (–22% change); six southern states: 17.3; 17.3 (no change) Age ≥ 65 years (all) California: 281.4; 288.7 (3% change); all except California: 243.0; 299.8 (23% change); New Jersey, New York: 212.2; 225.4 (6% change); six southern states: 241.9; 329.4 (36% change)

Notes: [a]Australia, Pacific Canada (British Columbia), Hong Kong, South Korea, and Taiwan. [b]Kentucky, Georgia, North Carolina, South Carolina, Tennessee, and Virginia.

Abbreviations: ABS, Australian Bureau of Statistics; AIHW, Australian Institute of Health and Welfare; CCHS, Canadian Community Health Survey; CDC, Centers for Disease Control and Prevention; COPD, chronic obstructive pulmonary disease; F, female; ICD-9, International Classification of Diseases, 9th Revision; ICD-10, International Classification of Diseases, 10th Revision; M, male; NCI, National Cancer Institute; NCHS, National Center for Health Statistics; NHIS, National Health Interview Survey; NR, not reported; SEER, Surveillance Epidemiology and End Results; USA, United States of America; WONDER, Wide-ranging Online Data for Epidemiologic Research.

We were specifically interested in those countries where a difference in COPD mortality trends was observed between men and women (ie, Australia, France, and the USA). These countries all showed an overall decline in smoking rates with the greatest prevalence in men.[55] Recently, the discrepancy in smoking rate between men and women has reduced because the rate in men has declined at a much greater rate than in women.

In Australia,[34] COPD mortality between 1979 and 1997 followed a pattern similar to that observed in smoking prevalence between 1965 and 1980, with a decrease in men and an increase in women. The mortality data mirrored the smoking patterns with a delay of 15–20 years in women and 20–25 years in men. This "lag time" between smoking and COPD onset has been reported in previous literature.[46] In France, both smoking prevalence and COPD mortality have increased over time, whereas a decrease in smoking prevalence and COPD mortality has been reported in men.[35] Smoking prevalence data in France were not available from the OECD before 1981, which made it difficult to determine whether a lag time between smoking and COPD onset occurred. However, COPD mortality data from US studies show more heterogeneity; smoking prevalence substantially decreased over time in both men and women, whereas COPD mortality increased to a greater extent in women than men between 1980 and 2000, after which a decrease was observed in men, and a plateau in women between 2000 and 2005.

Although smoking prevalence might explain some of the discrepancy between men and women in COPD mortality, other reasons must be considered as well. Recent evidence suggests that women younger than 55 years are significantly more susceptible to severe COPD than men.[56] Furthermore, women tend to have smaller airways and lung volumes than men,[57] and previous studies have shown that females are consequently more vulnerable to the adverse effects of smoking than men.[58–60]

As with all literature reviews, both the current review and the data identified had certain limitations. First, this review focused on only eleven countries of interest (Australia, Canada, France, Germany, Italy, Japan, The Netherlands, Spain, Sweden, the UK, and the USA). Although the literature search itself was not restricted to certain countries, articles related only to countries outside those of interest were excluded from the review during the screening process. Second, the search was limited to articles published in English, so we may not have identified relevant articles published in other languages, particularly those relating to the non–English-speaking countries of interest. Third, several articles did not report true population-based estimates of prevalence or incidence, but instead reported prevalence or incidence of COPD within a population at increased risk for the condition. Fourth, and as with similar reviews involving searches of literature databases, any articles that were not indexed in PubMed or EMBASE would not have been initially identified. Fifth, the studies varied widely in the ages of populations studied, so they were difficult to compare and to draw conclusions from overall. Finally, differences between countries in terms of COPD diagnosis and management will also lead to discrepancies and hinder meaningful comparisons across countries.

However, our review has certain strengths when compared with other similar literature reviews in the epidemiology of COPD. Our review was a comprehensive literature review that identified literature from the MEDLINE and EMBASE databases. Furthermore, we investigated data on prevalence, incidence, and mortality as well as trends in prevalence, incidence, and mortality. Our review included more recent data (published from January 2000 to September 2010) compared with the previous reviews.[51,52] Also, compared with the most recent review, which only reviewed data from countries in Europe,[50] our review considered data from Australia, Canada, Japan, and the USA as well as from European countries. Consequently, we anticipate that our review contains more complete epidemiology data that present a current picture of the burden of COPD in major developed countries.

Although our review reported an overall decrease in the burden of COPD, in incidence, prevalence, and mortality in certain countries in recent years,[18,22,25,26,31,61,62] COPD remains a substantial health problem throughout the world. We found that several data gaps exist within the current literature on the epidemiology of COPD, particularly regarding studies reporting the incidence of COPD or trends in mortality data. Also, no studies were identified that reported incidence or trends in incidence in France, Germany, Italy, Spain, and The Netherlands, or trends in overall mortality in Germany, Italy, Japan, The Netherlands, Spain, Sweden, or the UK. A need exists for studies in these countries to examine trends in COPD incidence and mortality to fully understand the true burden of COPD in the population. There is also a need to continue to improve uniformity in definitions and methods of diagnosis to improve understanding of the burden of disease and aid in clearer evaluation of the patient response to treatment.

Acknowledgments

This study was sponsored by Boehringer Ingelheim GmbH. Dr Rycroft, Ms Heyes, and Dr Lanza are full-time employees

of RTI Health Solutions. Dr Becker is a full-time employee of Boehringer Ingelheim GmbH.

Disclosure

The authors report no conflicts of interest in this work.

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Supplementary materials

Table S1 Search strategy used for literature search

Search number	Search terms[a]
COPD	
#1	"Pulmonary Disease, Chronic Obstructive"[MeSH] OR "chronic obstructive pulmonary disease"[Text Word] OR "COPD"[Text Word] OR "Pulmonary Emphysema"[MeSH] OR "emphysema"[Text Word] OR "Bronchitis, Chronic"[MeSH] OR "chronic bronchitis"[Text Word]
Epidemiology data	
#2	"Epidemiology"[MeSH] OR "Incidence"[MeSH] OR "Prevalence"[MeSH] OR "Cause of Death"[MeSH] OR ("Hospital Mortality"[MeSH] NOT "Hospital Mortality/ethnology"[MeSH]) OR "Morbidity"[MeSH]
#3	"Pulmonary Disease, Chronic Obstructive/epidemiology"[Majr] OR "Pulmonary Disease, Chronic Obstructive/mortality"[Majr] OR "Pulmonary Emphysema/epidemiology"[Majr] OR "Pulmonary Emphysema/mortality"[Majr] OR "Bronchitis, Chronic/epidemiology"[Majr] OR "Bronchitis, Chronic/mortality"[Majr] OR "Lung Diseases, Obstructive/epidemiology"[Majr:NoExp] OR "Lung Diseases, Obstructive/mortality"[Majr:NoExp]
#4	(#1 AND #2) OR #3
Exclusionary terms	
#5	"Comment"[Publication Type] OR "Editorial" [Publication Type] OR "Letter"[Publication Type] OR "Case Reports"[Publication Type] OR "Clinical Trial"[Publication Type]
#6	"Animals"[MeSH] NOT "Humans"[MeSH][b]
Total	
#7	#4 NOT (#5 OR #6)

Notes: [a]Search limits: English language; and publication date from January 2000 to September 2010. [b]NOT ("Animals"[MeSH] NOT "Humans"[MeSH]) excludes articles that have only the tag for animal studies. By using this approach instead of selecting the "humans" limitation in PubMed, recent articles that have not been fully indexed (including the "humans" tag) but that are exclusively in humans will not be excluded.
Abbreviations: COPD, chronic obstructive pulmonary disease; MeSH, Medical Subject Headings.

Table S2 Summary of articles included in literature review

Country	Number of articles reporting data types[a]				
	All articles	Multicountry articles	Prevalence	Incidence	Mortality
Multicountry studies	19	NA	12	2	7
Australia	4	4	2	1	6
Canada	12	4	13	2	6
France	2	4	3	0	3
Germany	1	4	4	0	1
Italy	3	5	7	0	2
Japan	6	2	5	1	2
The Netherlands	2	5	4	0	4
Spain	7	5	7	0	5
Sweden	19	4	14	4	7
The United Kingdom	9	5	11	2	4
The United States	49	6	29	4	30
Total	133	NA	80	15	58

Notes: [a]All numbers reported in this table also include any multicountry studies that also provided separate data in the countries of interest. Therefore, a multicountry article could be counted more than once in each column.
Abbreviation: NA, not applicable.

Table S3 Articles reporting prevalence included in literature review

Reference	Study design	Population	Method	Population (n)	Age (years)	Prevalence (%)
Multicountry studies						
Boutin-Forzano et al[75]	Questionnaire, conducted in eight European cities 2003–2004.	6915 subjects from 3373 homes across eight cities; 47.2% female. Mean age: 46.7 years.	CBE diagnosed and/or treated in the previous 12 months	6915	≥18	6.2
Buist et al[76]	Population-based study in 12 countries including questionnaire on respiratory symptoms and health status, and spirometry tests (data collection completed December 2006).	9425 subjects aged ≥ 40 years.	Spirometry: GOLD stage	9425	≥40	10.1
	Germany	49% female. Mean age: 57.3–58.5 years.	Spirometry: GOLD stage	683	≥40 40–49 50–59 60–69 ≥70	M: 8.7; F: 3.7 M: 0; F: 2.5 M: 10.7; F: 2.9 M: 8.9; F: 4.4 M: 19.0; F: 6.2
	Canada	58% female. Mean age: 56.4–57.5 years.	Spirometry: GOLD stage	827	≥40 40–49 50–59 60–69 ≥70	M: 9.3; F: 7.3 M: 2.8; F: 1.3 M: 6.4; F: 1.3 M: 12.0; F: 10.8 M: 26.2; F: 20.7
	USA	58% female. Mean age: 56.6–57.5 years.	Spirometry: GOLD stage	508	≥40 40–49 50–59 60–69 ≥70	M: 12.7; F: 15.6 M: 1.8; F: 5.1 M: 17.9; F: 11.0 M: 19.6; F: 25.6 M: 19.2; F: 29.6
	Australia	50% female. Mean age: 57.6–59.9 years.	Spirometry: GOLD stage	541	≥40 40–49 50–59 60–69 ≥70	M: 9.3; F: 12.2 M: 2.7; F: 4.9 M: 4.1; F: 6.8 M: 13.8; F: 13.8 M: 22.4; F: 23.8
Cerveri et al[10]	Self-completed questionnaire in 16 countries about respiratory health, followed by clinical assessment and spirometry (1991–1993).	17,966 subjects aged 20–44 years; of these, 14,819 with reliable FEV_1 and FVC measurements.	Patient-reported chronic bronchitis Spirometry: ATS criteria	17,966 14,819	20–44 20–44	3.2 8.4 with chronic bronchitis; 4.3 without chronic bronchitis

Menotti et al[77]	Subset of the prospective cohort study, the Seven Countries Study, with follow-up 10 years after the study start: The Netherlands (1985–1995).	2285 men aged 65–84 years (716 in Finland, 887 in The Netherlands, 682 in Italy).	Productive cough for at least 3 months per year, and a clinical diagnosis by the examining physician	887	65–84	13.8
	Subset of the prospective cohort study, the Seven Countries Study, with follow-up 10 years after the study start: Italy (1985–1995).	2285 men aged 65–84 years (716 in Finland, 887 in The Netherlands, 682 in Italy).	Productive cough for at least 3 months per year, and a clinical diagnosis by the examining physician	682	65–84	22.8
Rennard et al[78]	International survey of eight countries to identify subjects who had been diagnosed with COPD and to quantify the burden of COPD (2000).	201,921 households.	Subjects with ≥10 pack-years (cumulative cigarette consumption, based on cigarettes smoked per day and years of daily smoking), who had been diagnosed with COPD, emphysema or chronic bronchitis	201,921 households	≥45	2.8
	Canada		Subjects with ≥10 pack-years (cumulative cigarette consumption, based on cigarettes smoked per day and years of daily smoking), who had been diagnosed with COPD, emphysema or chronic bronchitis	201,921 households	≥45	5.8
	France		Subjects with ≥10 pack-years (cumulative cigarette consumption, based on cigarettes smoked per day and years of daily smoking), who had been diagnosed with COPD, emphysema or chronic bronchitis	201,921 households	≥45	6.0
	Germany		Subjects with ≥10 pack-years (cumulative cigarette consumption, based on cigarettes smoked per day and years of daily smoking), who had been diagnosed with COPD, emphysema or chronic bronchitis	201,921 households	≥45	7.5
	Italy		Subjects with ≥10 pack-years (cumulative cigarette consumption, based on cigarettes smoked per day and years of daily smoking), who had been diagnosed with COPD, emphysema or chronic bronchitis	201,921 households	≥45	6.1

(*Continued*)

Table S3 (*Continued*)

Reference	Study design	Population	Method	Population (n)	Age (years)	Prevalence (%)
	The Netherlands		Subjects with ≥10 pack-years (cumulative cigarette consumption, based on cigarettes smoked per day and years of daily smoking), who had been diagnosed with COPD, emphysema or chronic bronchitis	201,921 households	≥45	8.6
	Spain		Subjects with ≥10 pack-years (cumulative cigarette consumption, based on cigarettes smoked per day and years of daily smoking), who had been diagnosed with COPD, emphysema or chronic bronchitis	201,921 households	≥45	5.8
Soriano et al[66]	Retrospective analysis of cross-sectional NHANES III survey conducted in the USA, including questionnaire and spirometry (1988–1994).	33,994 noninstitutionalized subjects, of whom 22,431 had spirometry. Mean age: 34.3 years.	Self-reported physician diagnosis of chronic bronchitis (current)	33,994	Mean: 34.3 ≥50	3.2 5.8
	Retrospective analysis of cross-sectional NHANES III survey conducted in the USA, including questionnaire and spirometry (1988–1994).	33,994 noninstitutionalized subjects, of whom 22,431 had spirometry. Mean age: 34.3 years.	Self-reported physician diagnosis of emphysema (ever)	33,994	Mean: 34.3 ≥50	1.5 5.0
	Retrospective analysis of the UK GPRD, which records visits to a health-care specialist (1998).	3 million inhabitants of England and Wales. Mean age: 37.6 years.	Patients coded with Oxford Medical Information System (OXMIS) and Read codes for chronic bronchitis	3 million	Mean: 37.6 ≥50	0.5 1.1
	Retrospective analysis of the UK GPRD, which records visits to a health care specialist (1998).	3 million inhabitants of England and Wales. Mean age: 37.6 years.	Patients coded with Oxford Medical Information System (OXMIS) and Read codes for emphysema	3 million	Mean: 37.6 ≥50	0.5 1.1
Svanes et al[79]	Self-completed questionnaire in 17 countries in Europe about adult respiratory health (study period not reported).	18,922 subjects aged 20–44 years from 37 centers.	Chronic bronchitis, defined as having both regular cough and phlegm	18,922	20–44	11

de Marco et al[80]	Self-completed questionnaire about respiratory health, followed by clinical assessment and spirometry in 35 centers in 16 countries (1991–1993).	18,412 subjects aged 20–44 years. Of these, 14,855 subjects completed the clinical interview and had at least two reliable FEV_1 and FVC measurements.	Spirometry: GOLD stage 1 and higher	18,412	20–44	3.6
Canada						
Al-Hazmi et al[11]	Multicentre, two-stage study (six Canadian locations) to assess airflow obstruction (reversible = asthma, not entirely reversible = COPD). 21,449 randomly selected adults were sent ECRHS questionnaire, which 18,616 completed. A random subset of 2819 adults was screened in laboratory.	2819 screened in laboratory; 54.0% female; aged 20–44 years.	Airflow obstruction, defined by the LLN for FEV_1/FVC using Hankinson's equations	2819	20–44	6.6
			Spirometry: GOLD stage 1	2819	20–44	4.2
			Self-reported chronic bronchitis	2819	20–44	1.7
Camp et al[27]	Analysis of the British Columbia MOH administrative health services databases.	1,708,418 subjects included in the MOH administrative databases, aged 45 yearsand older.	ICD-9 codes: 491, 492, 496	1,708,418	≥45 45–64 ≥65	M: 4.7; F: 4.0 M: 1.9; F: 1.6 M: 10.8; F: 7.9
Gershon et al[18]	Population-based cohort fom administrative health information system (2007).	7,082,086 in database population (denominator), 708,743 with COPD; 51.8% female; aged ≥ 35 years	ICD-9 codes 491, 492, 496; ICD-10 codes J41, J42, J43, J44	7,082,086	≥35 35–49 50–64 ≥65	9.5 2.7 10.2 22.2
Lacasse et al[81]	Validity assessment of COPD diagnoses using a large administrative database (RAMQ) using data from the National Population Health Survey.	7.4 million people in RAMQ database.	ICD-9 codes 491, 492, and 496	7.4 million	45–54 55–64 65–74 75+	2.5 5.5 10.7 17.8
			ICD-9 codes 490, 491, 492, and 496	7.4 million	45–54 55–64 65–74 75+	13.7 17.6 23.1 31.2
Ohinmaa et al[82]	Analysis of CCHS data to determine health care costs associated with specific health behaviors among residents of Alberta.	2,133,413 non-First Nation, noninstitutionalized subjects residing in Alberta, aged ≥ 20 years.	Self-reported diagnosis of COPD	2,133,413	≥20 20–44 45–64 ≥65	0.83 0.12 0.76 2.90
Stewart and McRae[83]	Population surveillance on COPD via the CCHS (2005)	Subjects aged ≥ 35 years participating in the CCHS (population size unknown).	Self-reported diagnosis of COPD, chronic bronchitis, or emphysema	NA NA	≥35 ≥75	4.4 All: 9.3 M: 11.8; F: 7.5
Chen et al[84]	Population-based survey in all provinces of Canada.	19,600 households; COPD patients 52.6% female; aged 35–64 years.	Self-reported diagnosis of chronic bronchitis or emphysema	19,600 households	35–44 45–54 55–64	M: 1.8; 3.5 M: 1.5; F: 3.6 M: 5.0; F: 4.5

(*Continued*)

Table S3 (*Continued*)

Reference	Study design	Population	Method	Population (n)	Age (years)	Prevalence (%)
Hill et al[85]	Clinic-based assessment (interview and spirometry) of patients from three primary care sites to assess COPD prevalence.	Subjects with a smoking history of at least 20 pack-years; 47.4% female; aged ≥ 40 years. Mean age: 59.1 years.	Patient interview and spirometry: GOLD stage II and higher	1003 smokers	≥40	20.7
Vozoris et al[86]	Cross-sectional, population-based survey data were analyzed for second-hand smoke exposure and health variables (including COPD).	Aged ≥ 12 years. Never-smokers, 57.6% female; former smokers, 46.9% female.	Self-reported chronic bronchitis	48,540 never-smokers; 48,117 former smokers	≥12	Never-smokers, 1.56; Former smokers, 2.76
			Self-reported emphysema	48,540 never-smokers; 48,117 former smokers	≥12	Never-smokers, 0.27; Former smokers, 1.40
France						
Huchon et al[87]	Population-based survey to determine the prevalence of symptoms indicative of chronic bronchitis.	n = 14,076 population sample; 54% female (M:F ratio, 0.85 :1) aged ≥25 years. Mean age: 51.1 years.	Patient-reported chronic bronchitis	14,076	≥25	4.1
Italy						
Anecchino et al[88]	Cross-sectional study conducted using administrative health services databases from 22 Italian local health units participating in the ARNO project.	3,535,371 National Health System users; 126,283 patients with COPD; 47.8% female; aged ≥ 45 years.	Treatment with inhaled/ oral bronchodilators, inhaled steroids, or fixed-dose combinations	3,535,371	≥45	3.6
					45–64	1.9
					65–74	4.8
					75–84	6.8
					≥85	5.6
Cricelli et al[63]	Comparison of COPD prevalence from the HSD, a computerized general-practice database, and the HIS6, a population-based survey.	HIS6: 119,799 adults; HSD: 432,747 adults.	Self-reported and physician-diagnosed COPD	119,799	≥15	M: 5.6; F: 2.6
					15–24	M: 0.9; F: 0.9
					25–34	M: 1.0; F: 0.9
					35–44	M: 1.6; F: 1.8
					45–54	M: 3.6; F: 3.3
					55–64	M: 8.1; F: 5.6
					65–69	M: 13.8; F: 7.3
					70–74	M: 17.6; F: 10.5
					75–79	M: 21.1; F: 12.0
					≥80	M: 25.2; F: 15.8
			A COPD diagnosis (ICD-9 codes 491, 492, 496) and a relevant prescription during the study period	432,747	≥15	M: 4.0; F: 2.6
					15–24	M: 1.1; F: 0.7
					25–34	M: 0.8; F: 0.8
					35–44	M: 1.4; F: 1.3
					45–54	M: 2.7; F: 2.0
					55–64	M: 5.7; F: 3.5
					65–69	M: 9.7; F: 4.6
					70–74	M: 12.7; F: 5.8
					75–79	M: 15.6; F: 6.4
					≥80	M: 14.9; F: 6.7

Viegi et al[12]	Two prospective cross-sectional surveys (one in Po River Delta and one in Pisa) plus spirometry.	Po River Delta: 2,463; 50.8% female. Mean age: 36.3 years (SD, 16.5; range, 8–75). Pisa: 1,890; 49.6% female. Mean age: 42.1 years (SD, 17.5; range, 8–75).	Self-reported obstructive lung disease (chronic bronchitis, emphysema, and/or asthma)	Po River Delta: 2,463; Pisa: 1,890	Po River Delta: mean 36.3 (range, 8–75) Pisa: mean 42.1 (range, 8–75)	Po River Delta: 6.9 Pisa: 10.9
Japan						
Fukahori et al[89]	Prospective, clinic-based study.	n = 1424; 46.5% female; aged ≥40 years. Mean age: 66.0 years.	Spirometry (GOLD stage I and higher)	1424	≥40	13.6
Fukuchi et al[90]	A retrospective study conducted in 18 (out of 47) Japanese prefectures, representing 49% of the Japanese population.	2343 patients; 48% female. Mean age: 58 years. Disease severity (mean): FEV_1, 2.68; FVC, 3.41. FEV_1/FVC: 78.67%.	Self-report plus spirometric testing (GOLD stage I and higher)	2343	Mean: 58 40–49 50–59 60–69 70–79	10.9 3.5 5.8 15.7 24.4
Kojima et al[91]	Prospective cohort study of subjects undergoing health checkups. Study included questionnaire and spirometry (April 2001 to March 2002).	11,460 subjects without asthma or tuberculosis; 33.9% female; aged 25–74 years.	Spirometry (GOLD stage I and higher)	11,460	25–74	1.9
Tatsumi[92]	Cross-sectional survey of patients, conducted by Ministry of Health and Welfare.	220,000 with COPD (70% chronic bronchitis, 30% emphysema) in total population; 41% female; age NR.	Patients visiting hospitals or private clinics for treatment of COPD, chronic bronchitis, or emphysema (classification system not described)	NR	NR	0.20
The Netherlands						
Bischoff et al[62]	Trend analysis of COPD data from a 27-year prospective cohort (based on patients in four general practices).	Approximately 15,000 patients aged ≥ 40 years from four general practices.	Diagnosis codes for "chronic bronchitis," "lung emphysema," and "COPD" from the general-practice database	~15,000	≥40	5.44
Spain						
Miravitlles et al[93]	Telephone survey throughout Spain to determine prevalence of COPD in representative sample of general population.	6758 total patients, 24% of whom reported one or more respiratory symptoms; 70.2% female; aged ≥ 40 years. Mean age: 58 years. Smokers in the survey sample: current, 19.2%; former, 18%; never, 62.8%.	Patient reported being diagnosed with COPD by a physician	6758	≥40	0.43
			Patient reported being diagnosed with acute bronchitis by a physician	6758	≥40	14

(Continued)

Table S3 (*Continued*)

Reference	Study design	Population	Method	Population (n)	Age (years)	Prevalence (%)
Miravitlles et al[94]	Representative sample of 3802 residents of the general population aged 40–80 years in ten cities in Spain, using a questionnaire and offering pre- and postbronchodilator spirometry.	n = 3802; 52.7% female. Mean age: 56.6 years. Smokers: current, 26%; former, 30.9%.	Spirometry: GOLD (FEV_1/FVC ratio < 0.70)	3802	40–80 40–49 50–59 60–69 70–80	10.2 3.8 7.0 14.5 22.8
Peña et al[95]	Cohort study based in the general population. A randomized, age- and sex-stratified sample of 5014 individuals was taken in 7 areas of Spain using census data. Mail and telephone contact were used to recruit subjects.	n = 3981; aged 40–69 years. 363 people had COPD, of which 269 had negative BDT, and 79 had positive BDT, with <88% (males) or <89% (females) predicted FEV_1/FVC; 15 did not have BDT but had FEV_1/FVC < 81% and FEV_1 < 70%.	Spirometry: ERS criteria were used (FEV_1/FVC ratio <88% of predicted for men and <89% for women)	3981	40–69 Nonsmokers (40–49 years) Nonsmokers (50–59 years) Nonsmokers (60–69 years) Ever-smokers (40–49 years) Ever-smokers (50–59 years) Ever-smokers (60–69 years)	9.1 M: 1.9; F: 3.4 M: 5.3; F: 2.8 M: 9.3; F: 5.2 M: 8.6; F: 4.3 M: 14.5; F: 2.8 M: 30.6; F: 6.1
De Torres et al[96]	Cross-sectional study of a cohort of self-selected current or former smokers who attended wards or clinics at two medical centers in Spain and who agreed to be screened for lung cancer and airway obstruction.	n = 764; 34.3% female. Mean age: 53 years Mean pack-years of smoking: 33 (36 M; 30 F).	Spirometry: GOLD	764 (current or former smokers)	Mean: 53 ≤50 >50	26 19 26
Sweden						
Ekberg-Aronsson et al[97]	Prospective, longitudinal population-based screening programme in Malmö.	Cohort of 22,044; 33.6% female; aged 27–61 years. Mean age, baseline: M, 46.4 (SD, 5.7); F, 47.5 (SD, 7.8).	Spirometry + self-reported symptoms on questionnaire; GOLD stage I and higher	22,044	<29 30–34 35–39 40–44 45–49 50–54 55–59 60–64	M: 4.2; F: 4.0 M: 0; F: 0 M: 11.6; F: 7.9 M: 13.4; F: 5.4 M: 19.8; F: 9.2 M: 19.4; F: 10.2 M: 28.0; F: 14.4 M: 27.8; F: NR
Hasselgren et al[98]	Varmland County population-based cohort, first a postal survey then a clinical screening examination (only on those with symptoms).	4814 was the sample of the country population. Of survey responders, 206 were randomly picked for clinical examination;	Spirometry: BTS criteria	4814	18–70	2.1

		43.8% female; aged 18–70 years. Mean age: 43 years. Smokers: M, 24.9%; F, 28.5%.				
Lindberg et al[4]	Survey (mailed questionnaire) of a random sample of 4851 adults aged 20–69 years.	4851 were surveyed; of these, 645 were interviewed and had spirometry Among the 666 invited for examination: 50.6% female; mean age 49.1 years. Smokers: non, 45.3%; former, 28.2%; current, 26.5%.	Spirometry: GOLD	645	20–69 20–44 45–69	14.1 9.1 17.1
			Spirometry: BTS	645	20–69 20–44 45–69	7.6 4.1 9.7
			Spirometry: ERS	645	20–69 20–44 45–69	14 11.6 15.4
			Spirometry: ATS	645	20–69 20–44 45–69	34.1 21.5 41.7
			Clinical: ATS	645	20–69 20–44 45–69	12.2 5.1 16.5
Lindberg et al[8]	A random sample from a population-based survey in 1996 was invited to a screening interview and spirometry. People were from OLIN 1st survey in 1985.	n = 1237; 51% female; aged 46–77 years. Smokers: (M) current, 24%; former, 47%; non, 29%. (F) current, 26%; former, 24%; non, 51%.	Spirometry: GOLD	1237	46–77 46–47 61–62 76–77	14.3 6.5 17.1 28.7
			Spirometry: BTS	1237	46–77 46–47 61–62 76–77	8.1 2.8 9.0 19.7
Lindberg et al[26]	Ongoing population-based cohort with survey and subgroup invited for examination (3rd update of OLIN cohort 1).	5189 surveyed in 1996; 963 followed up who had spirometry data in 1996 and 2003; 51.4% female. Ever smoked: 59%. Mean FEV_1% predicted: 97.45	Spirometry: GOLD stage I–IV	963	46–77 46–47 61–62 76–77	11.0 7.4 14.6 18.7
Lindstrom et al[99]	Prospective cross-sectional studies of respiratory symptoms and diseases in two population samples of the same age living in Northern Sweden were performed six years apart (1986–1987 compared with 1993–1994) with postal questionnaire, structured interview, lung-function tests	Total study 1986: 5698 1992: 5617 Ages: 35–36; 50–51; 65–66. % female for questionnaire respondents: 49.2% (1986–1987), 51.0% (1993–1994);	Spirometry: BTS	5617	35–66 35–36 50–51 65–66	11 1.9 7.2 22.5

(*Continued*)

Table S3 (*Continued*)

Reference	Study design	Population	Method	Population (n)	Age (years)	Prevalence (%)
		Clinical examination: 47.6% (1986–1987), 50.6% (1993–1994)				
Lundbäck et al[9]	OLIN longitudinal population-based study, 3rd survey of the 1st cohort, sample taken of survey respondents.	1237 who had lung-function test that was technically adequate Current smokers: M, 23.6%; F, 25.6% Former smokers: M, 47.0%; F, 23.7% Nonsmokers: M, 29.3%; F, 50.6% Age range: 46–77 years.	Spirometry: BTS	1,237	46–77 Nonsmokers: 46–47 Nonsmokers: 61–62 Nonsmokers: 76–77 Smokers: 46–47 Smokers: 61–62 Smokers: 76–77	8.1 1 2 16 5
			Spirometry: GOLD		46–77 Nonsmokers: 46–47 Nonsmokers: 61–62 Nonsmokers: 76–77 Smokers: 46–47 Smokers: 61–62 Smokers: 76–77	24 45 14.3 3 5 21 11 42 50
Montnémery et al[100]	Population-based survey in Malmö, sampled from population records of Southern Sweden.	Total sampled = 12,079; questionnaire sent and 8469 (70.1%) responded; 52.2% female Smokers: overall, 33.8%; M, 33.1%; F, 34.4%.	Self-reported chronic bronchitis or emphysema	8469	NR	4.6
Montnémery et al[64]	Population-based survey, Malmö	In 2000, questionnaire sent to 5179 randomly selected people; aged 20–59 years. Total respondents: 3692; 52.1% female.	Self-report of chronic bronchitis, emphysema, or COPD	3692	20–59 20–29 30–39 40–49 50–59	3.6 1.9 2.7 4.1 5.7
		Smokers: overall, 28.4%; M, 28.0%, F, 28.1%.	Physician diagnosis of CBE/COPD	3692	20–59	4.3
Nihlen et al[70]	4933 people from a 1992 questionnaire; appears to be a subset of patients in a Montnémery study published in 1998. Original 1992 sample was population-based in the Malmö area; all aged 20–59 years in 1992.	4280 still in the study area who had been studied in 1992 and 2000; 53.9% female. Smokers: Current, 32.8 (1992); 26.3 (2000). Former, 24.8 (1992); 30.7 (2000).	Self-reported physician's diagnosis of COPD, chronic bronchitis, and/or emphysema	4280	20–59	4.3

Pallasaho et al[101]	A random sample was sent a postal questionnaire in 1996 in Stockholm, Helsinki, and Tallinn (data for Stockholm and Helsinki only).	n = 18,741; 56.5% female. Stockholm: M: 2484 F: 2851 Smokers (M/F)%: 32/33 Helsinki M: 2429 F: 3242 Smokers: (M/F)%: 38/31.	Postal questionnaire and GP diagnosis of chronic bronchitis or emphysema	5335	NR	3.0
Rönmark et al[102]	A cross-sectional study by postal survey in Western Sweden. Random sample of 30,000 from population registry in Sweden, aged 16–75 years.	Total respondents: 18,087 (62%). Focus of study was impact of nonresponse.	Questionnaire asked about physician-diagnosed CBE/COPD	18,087	16–75	M: 2.5; F: 3.6
Wiréhen et al[103]	Population-based administrative health care database in Ostergötland County, with hospital and primary care data.	Data for residents of the area; a total of 415,000 people.	At least one health care contact for COPD using ICD-10 code J44 between 1999 and 2003	415,000	All ages 0–14 15–24 25–34 35–44 45–54 55–64 65–74 75–84 ≥85	1.2 M: 0; F: 0 M: 0; F: 0 M: 0; F: 0 M: 0; F: 0.2 M: 0.5; F: 0.8 M: 1.7; F: 1.9 M: 4.0; F: 4.1 M: 6.7; F: 4.2 M: 6.5; F: 2.7
UK						
Faulconer and de Lusignan[104]	Audit of UK general-practice electronic records for quality of coding of COPD.	Patients in practice = 10,975. Age and sex in the practice were distributed similarly to general population; % female: NR. Smoking in those with correct diagnosis of COPD: current, 41.1%; former, 42.7%; never, 11.3%.	Read codes for COPD: H36, H37, H38, and H3z	10,975	NR	1.3
Murtagh et al[105]	Two-stage survey of Greater Belfast population aged 40–69 years; a subsample had spirometry.	Postal survey to 4000; 67% response to survey. 1330 eligible for next part of study. 722 had full assessment Among 722 subjects: F, 54.6% of symptomatic and 44.7% of asymptomatic. Mean age of symptomatic: 45.4 years; asymptomatic: 55.3 years.	MRC Respiratory Symptoms Questionnaire, MRC Dyspnoea Scale, GP diagnosis; spirometry: GOLD	722	40–69 40–49 50–59 60–69	6.3 M: 4.9; F:1.4 M: 9.5; F: 4.7 M: 12.3; F: 4.5

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Table S3 (*Continued*)

Reference	Study design	Population	Method	Population (n)	Age (years)	Prevalence (%)
Nacul et al[106]	Mathematical model using demographic data to estimate undiagnosed plus diagnosed burden of COPD; uses data from Health Survey for England 2001. HSE had lung-function data.	Population-based national survey data from 10,750 respondents, aged ≥15 years, used as input to model that also uses risk-factor relationships from literature to estimate prevalence of COPD in England. Final model included sex, age, smoking, ethnicity, rural/urban residence, deprivation index. Baseline odds of COPD taken from the survey data for nonsmokers <35 years.	Spirometry: BTS criteria	10,750	≥15 15–44 45–54 55–64 65–74 ≥75	3.1 1.10 2.19 5.48 7.29 7.89
Shahab et al[65]	A study using HSE data to describe the prevalence and extent of underdetection of spirometry-defined COPD in England. Private households were identified with a multistage probability samplingdesign and its members invited to participate. Data were collected on age, sex, ethnicity, and occupational status.	Total sample 8215; 53.6% female; aged >35 years in HSE, self-report data, and valid spirometry. Mean age: 55.5 years. Smokers: current, 24.1%; ever, 55.1%.	Spirometry: ATS/ERS criteria Self-reported diagnosis of chronic bronchitis or emphysema	8215 8215	>35 >35	13.3 1.1
Soriano et al[71]	Retrospective cohort study in UK database of general-practice electronic medical record data (GPRD). 3.4 million patients in data in 1998.	Total 78,172 patients with diagnosed prevalent COPD in 1990; 45.9% female. Mean age: 66.7 years. Incident COPD cases in 1990–1997: 50,174 in total. 146,026 person-years of follow-up.	Diagnosed COPD found with OXMIS codes in GP records	78,172	Mean: 66.7	M: 1.35; F: 0.80
USA						
Bang et al[107]	Retrospective study of data from the NHIS (1997–2004).	127,624,000 adult workers; 46.3% female; aged ≥18 years.	Self-reported chronic bronchitis or emphysema	127,624,000	>18 18–44 45–64 65–74 ≥75	4.0 3.5 4.8 6.9 6.8

Bhattacharyya[108]	Retrospective study of data from the NHIS (1997–2006).	313,982 adults. Mean age: 45.2 years.	Self-reported chronic bronchitis	313,982	Mean 45.2	4.8
Bhattacharyya[109]	Retrospective study of data from the NHIS (1998–2006).	851,581 adults; 21.8% female (M:F ratio, 0.93:1). Mean age: 35.7 years.	Self-reported chronic bronchitis	851,581	Mean 35.7	4.5
Celli et al[5]	NHANES III (1988–1994) population-based survey. Included questionnaire, laboratory examination, and lung-function testing.	9838 subjects, aged 30–80 years, of Caucasian, non-Hispanic white, non-Hispanic black, or Mexican American origin with a satisfactory spirometry test.	Self-reported chronic bronchitis or emphysema	9838	30–80	7.73
					30–34	4.93
					35–39	3.95
					40–44	6.56
					45–49	7.71
					50–54	8.68
					55–59	9.23
					60–64	10.94
					65–69	12.40
					70–74	13.70
					75–80	12.19
			GOLD stage IIa or higher	9838	30–80	7.87
					30–34	1.73
					35–39	1.82
					40–44	3.57
					45–49	5.02
					50–54	10.25
					55–59	13.76
					60–64	15.24
					65–69	17.93
					70–74	18.90
					75–80	19.48
			Spirometry: ATS	9838	30–80	14.2
					30–34	8.37
					35–39	9.25
					40–44	11.58
					45–49	13.88
					50–54	15.61
					55–59	19.18
					60–64	19.77
					65–69	21.25
					70–74	22.86
					75–80	22.72

(*Continued*)

Table S3 (*Continued*)

Reference	Study design	Population	Method	Population (n)	Age (years)	Prevalence (%)
			Spirometry: ERS	9838	30–80	16.0
					30–34	9.04
					35–39	10.01
					40–44	12.71
					45–49	15.25
					50–54	17.88
					55–59	21.21
					60–64	23.44
					65–69	25.61
					70–74	25.83
					75–80	26.18
			GOLD stage I or higher	9838	30–80	16.8
					30–34	4.47
					35–39	5.46
					40–44	9.48
					45–49	13.35
					50–54	18.19
					55–59	25.56
					60–64	31.15
					65–69	34.54
					70–74	40.62
					75–80	41.69
Chamberlain et al[110] ARIC study	Prospective population-based cohort study of four cities to determine burden of COPD on all-cause mortality (baseline: 1987–1989; end: 2004). Included home interview and four clinic visits. Follow-up: 15 years.	10,333 adults; aged 45–64 years. 2047 black (59.5% female); 8286 white (52.6% female).	GOLD stage II or higher	10,333	45–64	Black M: 13.1; F: 4.9 White M: 15.2; F: 7.4
Hnizdo et al[14]	Data from NHANES III in a working population (1988–1994). Included questionnaire, laboratory examination, and lung-function testing.	9823 subjects aged 30–75 years. These excluded subjects with problems with lung-function tests, diagnosed current asthma, or missing occupational code.	GOLD stage II or higher	9823	30–75	7.1
					30–39	1.9
					40–49	6.7
					50–59	13.3
					60–75	17.5
			Physician-diagnosed emphysema	9823	30–75	1.6

			Physician-diagnosed chronic bronchitis	9823	30–75	4.5
Hnizdo et al[111]	Data from the NHANES III in a working population (1988–1994). Included questionnaire, laboratory examination, and lung-function testing.	9428 subjects aged 30–75 years. These excluded subjects with problems with lung-function tests, diagnosed current asthma, missing occupational code, or unspecified racial/ethnic background.	Airflow obstruction ($FEV_1/FVC < 75\%$ and $FEV_1 < 80\%$ predicted)	9428	30–75	Caucasian: 10.7 African-American: 7.5 Mexican-American: 3.9
Hnizdo et al[6]	Retrospective analysis of data from population-based NHANES III (1988–1994). Included questionnaire and spirometry.	13,842 subjects, aged 20–80 years, of Caucasian, African-American, or Mexican-American origin, with spirometry data.	GOLD stage I	13,842	20–80 20–49 50–80	14.2 6.3 30.5
			GOLD stage II or higher	13,842	20–80 20–49 50–80	6.9 2.5 16.1
			LLN-1 (mild or greater severity): $FEV_1/FVC <$ LLN; $FEV_1 <$ 00% predicted	13,842	20–80 20–49 50–80	12.3 8.9 19.2
			LLN-2 (moderate or greater severity): $FEV_1/FVC <$ LLN; $FEV_1 <$ LLN (~80% predicted)	13,842	20–80 20–49 50–80	6.2 3.6 11.8
			Self-reported chronic bronchitis	13,842	20–80 20–49 50–80	5.7 5.0 7.2
			Self-reported emphysema	13,842	20–80 20–49 50–80	1.8 0.5 4.6
Jackson and Hubbard[112]	Cross-sectional survey (NHANES III) (study period unknown).	3874 white subjects, aged 50–90 years, not including people with self-reported asthma.	Airflow obstruction ($FEV_1/FVC < 70\%$ and $FEV_1 < 80\%$ predicted)	3874	50–90	7.1
Jordan and Mann[113]	Retrospective cohort study of subjects in the NHANES III (1988–1994)	16,707 subjects aged > 17 years with spirometry data and completing the interview.	GOLD stage I or higher	16,707	>17	15.1

(*Continued*)

Table S3 (*Continued*)

Reference	Study design	Population	Method	Population (n)	Age (years)	Prevalence (%)
Lipton et al[114]	Retrospective database analysis of annual audited hospital discharge data in 1707 zip codes in California (2000).	3,775,711 patients discharged from hospital.	ICD-9 codes	3,775,711	NR	7.3
Mannino et al[67]	Retrospective analysis of data from NHANES III (1988–1994).	16,084 subjects aged ≥17 years, classified as white or black, with lung-function testing; 52.3% female. Mean age: 42.8 years. FEV_1 predicted, 95.3%; FEV_1/FVC ratio: 0.79.	GOLD stage II or higher	16,084	>17	6.8
Mannino et al[15]	NHIS (1997–2000).	Adults aged ≥ 25 years.	Self-reported chronic bronchitis or emphysema	NR	≥25	6.0
					25–44	3.85
					45–54	5.92
					55–64	7.95
					65–74	9.64
					≥75	10.60
Mannino et al[15]	NHANES I (1971–1975).	5080 noninstitutionalized adults with spirometry data.	GOLD stage I	5080	≥25	7.39
					25–44	4.89
					45–54	10.11
					55–64	12.32
					65–74	13.35
					≥75	NR
			GOLD stage II or higher	5080	≥25	7.74
					25–44	4.43
					45–54	9.73
					55–64	14.07
					65–74	17.38
					≥75	NR
Mannino et al[15]	NHANES III (1988–1994).	13,869 noninstitutionalized adults with spirometry data.	GOLD stage I	13,869	≥25	6.9
					25–44	3.68
					45–54	8.71
					55–64	12.62
					65–74	16.54
					≥75	17.82
			GOLD stage II or higher	13,869	≥25	6.57
					25–44	2.29
					45–54	7.24
					55–64	14.05
					65–74	20.66
					≥75	22.93

Mannino et al[15]	NHANES III, phase 2 (1991–1994).	6600 noninstitutionalized adults aged ≥ 25 years with spirometry data.	Physician-diagnosed COPD	6600	≥25	4.7
			GOLD stage I	6600	≥25	7.4
			GOLD stage II or higher	6600	≥25	8.0
Mannino et al[115]	Retrospective study of data from NHANES I (1971–1975), including original survey, hospital records, and death certificates. Follow-up surveys conducted 1982–1984, 1986, 1987, and 1992. Follow-up: 22 years.	5542 noninstitutionalized adults with satisfactory lung-function test data; 54.7% female; aged 25–74 years.	Symptoms only	5542	25–74	16.1
			GOLD stage I	5542	25–74	7.9
					25–39	4.0
					40–49	7.0
					50–59	9.5
					60–69	12.7
					70–74	14.1
			GOLD stage II	5542	25–74	7.1
					25–39	2.8
					40–49	5.9
					50–59	10.4
					60–69	10.7
					70–74	13.5
Methvin et al[16]	Survey including questionnaire and spirometry (BOLD study) (study period not reported).	508 noninstitutionalized adults aged ≥ 40 years with completed questionnaires, and pre- and postbronchodilator spirometry; 59.5% female.	Self-reported COPD or chronic bronchitis	508	≥40	17.1
			Self-reported emphysema	508	≥40	8.6
			GOLD stage I or higher	508	≥40	19.6
					40–49	6.1
					50–59	19.1
					60–69	27.4
					≥70	35.2
O'Malley et al[116]	Medicare claims database analysis (2000–2002).	509,613 Medicare beneficiaries, aged ≥ 65 years, who did not die; enter hospice, long-term care facility, or Medicare-managed care; and who did not have end-stage renal disease in 2000; 62% female.	ICD-9 codes	509,613	≥65	17.9
Pleis and Barnes[117]	Retrospective study of data from the NHIS (2000–2003).	127,596 civilian noninstitutionalized adults from NHIS; 51.0%–51.8% female.	Self-reported COPD or CBE	127,596	NR	White: 6 American Indian or Alaska native: 6.5 White and American Indian or Alaska native: 13.1

(*Continued*)

Table S3 (*Continued*)

Reference	Study design	Population	Method	Population (n)	Age (years)	Prevalence (%)
Schneider et al[118]	Administrative claims database analysis of the Medicare Chronic Condition Data Warehouse (2005).	1,649,574 Medicare beneficiaries; 56.6% female. Aged: <65 years, 15.4%; 65–74 years, 38.9%; 75–84 years, 32.2%; ≥85 years, 13.5%.	ICD-9 and HCPCS codes	1,649,574	All patients	10.9
Tinkelman et al[119]	Retrospective analysis of managed care administrative claims database (2000–2001).	414,231 enrollees; 56.8% female; aged ≥ 45 years. Mean age: 66.2 years.	ICD-9 codes	414,231	≥45 45–54 55–64 65–74 75–84 ≥85	4.7 0.96 3.14 5.90 7.58 7.27
Vaz Fragoso et al[7]	Retrospective cohort study of subjects in the NHANES III (1988–1994). Followed up until December 2000.	3502 white subjects aged 40–80 years with no self-reported asthma and with acceptable spirometry data; 52.2% female. Mean age: 60.7 years. Subjects each had a mean of 0.69 self-reported physician-diagnosed chronic conditions.	ATS/ERS defined LLN at the 5th percentile (ATS/ERS-LLN_5) GOLD stage I or higher ($LMS-LLN_5$)	3502 3502 3502	40–80 40–64 65–80 40–80 40–64 65–80 40–80 40–64 65–80	7.1 15.6 19.2 27.0 19.1 37.7 13.8 14.3 13.2
Wilson et al[120]	Retrospective study of data from the NHIS (1985–1996).	NR.	ICD-9 codes for chronic bronchitis and emphysema	NR	NR	Overall: 6.18 Chronic bronchitis: 5.4% Emphysema: 0.78%
Celli et al[13]	NHANES III (1988–1994) population-based survey. Included questionnaire, laboratory examination, and lung-function testing.	10,276 subjects aged 30–80 years with a satisfactory spirometry test. Never-smokers: 4544; ever-smokers: 5732.	GOLD stage I or higher	10,276 (4544 never-smokers; 5732 ever-smokers)	30–80 Never-smokers only: 30–39 Never-smokers only: 40–49 Never-smokers only: 50–59 Never-smokers only: 60–69 Never-smokers only: 70–80	16.50 3.04 8.33 7.15 16.02 28.03

			Self-reported chronic bronchitis or emphysema (ever)	5732 4544	Ever-smokers only: 30–80 Never-smokers only: 30–80	10.0 4.5
Ohar et al[121]	Cohort study of subjects referred for a work-related medical evaluation (1980–2008), including questionnaire, chest radiographs, and lung-function tests.	3955 subjects screened for a work-related medical evaluation. Mean age: 64.1 years. 1038 nonsmokers or <20 pack-years smokers; 74.9% FEV_1 predicted.	Spirometry: GOLD stage I or higher Self-reported COPD, chronic bronchitis, emphysema, or asthma	3955	Mean: 64.1	Overall: 37.0 Smokers: 43.5 Smokers: 18.0

Abbreviations: ATS, American Thoracic Society; ATS/ERS-LLN_5, ATS/ERS-defined LLN at the 5th percentile; BDT, bronchodilator test; BTS, British Thoracic Society; CBE, chronic bronchitis or emphysema; CCHS, Canadian Community Health Survey; COPD, chronic obstructive pulmonary disease; ECRHS, European Community Respiratory Health Survey; ERS, European Respiratory Society; F, female; FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; GOLD, Global Initiative for Chronic Obstructive Lung Disease; GP, general practitioner; GPRD, General Practice Research Database; HCPCS, Healthcare Common Procedure Coding System; HIS6, a population-based survey; HSD, a computerized general-practice database; HSE, Health Survey for England; ICD-9, International Classification of Diseases, 9th Revision; ICD-10, International Classification of Diseases, 10th Revision; LLN, lower limit of normal; LMS-LLN_5, lambda-mu-sigma-defined LLN at the 5th percentile; M, male; MOH, Ministry of Health; NA, not applicable; NHANES, National Health and Nutrition Examination Survey; NHIS, National Health Interview Survey; NR, not reported; OLIN, obstructive lung disease in Northern Sweden; SD, standard deviation; UK, United Kingdom; USA, United States of America.