Epidemiology of chronic obstructive pulmonary disease: a literature review

Catherine E Rycroft
Anne Heyes
Lee Lanza
Karin Becker

1Market Access and Outcomes Strategy, RTI Health Solutions, Manchester, United Kingdom; 2Epidemiology, RTI Health Solutions, Waltham, MA, USA; 3Global Health Economics and Outcomes Research, Boehringer Ingelheim GmbH, Ingelheim, Germany

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

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

Correspondence: Catherine E Rycroft
RTI Health Solutions, 2nd Floor, The Pavilion, Towers Business Park, Wilmslow Road, Didsbury, Manchester, M20 2LS, UK
Tel +44 0161 447 6022
Fax +44 0161 434 8232
Email crycroft@rti.org
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 sub-populations, 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.4–6 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 [FEV1/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
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 Canada18 and the USA25 reported that trends in incidence over time were similar between men and women; however, in Australia, COPD incidence
| Reference                     | Study design                                                                 | Patient population (n)       | Method                                                                 | Prevalence (%) (overall and/or by sex, where available) | Prevalence (%), by age |
|-------------------------------|-------------------------------------------------------------------------------|-----------------------------|----------------------------------------------------------------------|--------------------------------------------------------|------------------------|
| **Canada**                    |                                                                               |                             |                                                                      |                                                        |                        |
| Al-Hazmi et al<sup>11</sup>   | 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<sub>1</sub>/FVC (1999 method) or GOLD stage I (2001 method) or Self-reported CB | 6.6 (M: 6.7; F: 6.5) | NR                     |
|                               |                                                                               |                             |                                                                      |                                                        |                        |
| Italy                         |                                                                               |                             |                                                                      |                                                        |                        |
| Cricelli et al<sup>6, b</sup> | Comparison of COPD prevalence from the HSD and the HIS6.<sup>c</sup> Prevalence rates age-standardized to overall population. | 119,799 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 | See Supplementary materials, Table S3 |
|                               |                                                                               |                             |                                                                      | F: 4.45                                               |                        |
|                               |                                                                               |                             |                                                                      | M: 4.03                                               |                        |
|                               |                                                                               |                             |                                                                      | F: 2.60                                               |                        |
| Viegi et al<sup>12</sup>      | 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<sup>d</sup> | Po River Delta: 6.9 | NR                     |
|                               |                                                                               |                             |                                                                      | Pisa: 10.9                                            |                        |
|                               |                                                                               |                             |                                                                      | Po River Delta: 11.0                                  |                        |
|                               |                                                                               |                             |                                                                      | Pisa: 6.7                                             |                        |
| Sweden                        |                                                                               |                             |                                                                      |                                                        |                        |
| Lindberg et al<sup>4</sup>    | 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<sup>e</sup> or GOLD 2001 criteria<sup>e</sup> or ATS 1986 guidelines<sup>f</sup> or ATS: clinical (CBE defined as a physician report or productive cough) | 7.6 (M: 8.4; F: 6.8) | See Supplementary materials, Table S3 |
|                               |                                                                               |                             |                                                                      | 14.1 (M: 15.3; F: 13.0)                               |                        |
|                               |                                                                               |                             |                                                                      | 34.1 (M: 37.1; F: 31.2)                               |                        |
|                               |                                                                               |                             |                                                                      | 12.2 (M: 13.7; F: 10.8)                               |                        |
| Lundbäck et al<sup>9</sup>    | 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<sup*e</sup> or GOLD 2001 criteria<sup>e</sup> or ERS 1995 consensus statement<sup>g</sup> | 14.0 (M: 13.1; F: 14.8) | See Supplementary materials, Table S3 |
| Lundberg et al<sup>8</sup>    |                                                                               |                             |                                                                      | 8.1                                                   |                        |
| Monténery et al<sup>64</sup>  | 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 | 3.6 (M: 2.9; F: 4.2) | See Supplementary materials, Table S3 |
|                               |                                                                               |                             |                                                                      | Physician diagnosis of CBE/COPD                        | 4.3                    | NR                     |

<sup>1</sup> BTS 1997 criteria: Bronchitis and/or COPD defined as a physician report or productive cough.

<sup>2</sup> ATS: clinical: (CBE defined as a physician report or productive cough).

<sup>3</sup> ERS 1995 consensus statement.

<sup>4</sup> ATS 1986 guidelines.

<sup>5</sup> ATS: clinical (CBE defined as a physician report or productive cough).

<sup>6</sup> ERS 1995 consensus statement.

<sup>7</sup> ATS: clinical (CBE defined as a physician report or productive cough).

<sup>8</sup> ATS 1986 guidelines.

<sup>9</sup> ATS: clinical (CBE defined as a physician report or productive cough).
### UK

**Shahab et al.**

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.

| Study Details | Participants | Prevalence | Reference |
|---------------|--------------|------------|-----------|
| 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%. | 13.3 NR | ATS/ERS 2004 criteria<sup>h</sup> | Self-reported CBE | 1.1 NR | 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%. | 13.3 NR | ATS/ERS 2004 criteria<sup>h</sup> | Self-reported CBE | 1.1 NR |

### USA

**Celli et al.**

NHANES III (1988–1994) population-based survey. Included questionnaire, laboratory examination, and lung-function testing. Prevalence rates weighted to general US population.

| Study Details | Participants | Prevalence | Reference |
|---------------|--------------|------------|-----------|
| 9838 aged 30–80 years of Caucasian, non-Hispanic white, non-Hispanic black, or Mexican-American origin, with a satisfactory spirometry test. | 7.73 (M: 5.82; F: 9.55) | Self-reported CBE | 16.8 (M: 19.90; F: 13.83) | GOLD stage I or higher (2001 criteria) | See Supplementary materials, Table S3 |
| 10,276 aged 30–80 years with satisfactory spirometry test. Smokers: ever, 5,732; never, 4,544. | 16.0 (M: 16.09; F: 15.92) | Self-reported CBE | 14.2 (M: 15.00; F: 13.45) | GOLD stage I or higher (2004 guidelines) | See Supplementary materials, Table S3 |

**Hnizdo et al.**

Data from NHANES III in a working population (1988–1994). Included questionnaire, laboratory examination, lung-function testing. Prevalence rates weighted to general US population.

| Study Details | Participants | Prevalence | Reference |
|---------------|--------------|------------|-----------|
| 9823 aged 30–75 years. Excluded subjects with problems with lung-function tests, diagnosed current asthma, or missing occupational code. | 7.1 (M: 7.8; F: 6.1) | Self-reported CBE | 1.6 | GOLD stage II or higher (2001 criteria) | See Supplementary materials, Table S3 |
| 13,842 aged 20–80 years; Caucasian, African-American, or Mexican-American origin with spirometry data. | 1.8 | Self-reported CBE | 4.5 | Physicican-diagnosed emphysema | NR |

**Soriano et al.**

From a multicounty study: Retrospective analysis of UK GPRD, which records visits to a healthcare specialist (1998).

| Study Details | Participants | Prevalence | Reference |
|---------------|--------------|------------|-----------|
| 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: | See Supplementary materials, Table S3 |
| 13.3 | Self-reported CBE | 1.1 |

**Celli et al.**

NHANES III (1988–1994) population-based survey. Included questionnaire, laboratory examination, and lung-function testing. Prevalence rates weighted to general US population.

| Study Details | Participants | Prevalence | Reference |
|---------------|--------------|------------|-----------|
| 10,276 aged 30–80 years with satisfactory spirometry test. Smokers: ever, 5,732; never, 4,544. | 9.12 (M: 10.06; F: 8.58) | Self-reported CBE | 10.0; never, 4.5 | GOLD stage I or higher (2004 guidelines) | See Supplementary materials, Table S3 |

**Hnizdo et al.**

Retrospective analysis of data from population-based NHANES III (1988–1994). Included questionnaire and spirometry.

| Study Details | Participants | Prevalence | Reference |
|---------------|--------------|------------|-----------|
| 13,842 aged 20–80 years; Caucasian, African-American, or Mexican-American origin with spirometry data. | 5.7 | Self-reported CB | 1.8 | Self-reported CBE | See Supplementary materials, Table S3 |
| 12.3 | GOLD stage I (2001 criteria) | 6.9 | GOLD stage II or higher (2001 criteria) | 14.2 |
| 12.3 | LLN-1 (mild or greater severity [1991 ATS criteria])<sup>j</sup> | 6.2 | LLN-2 (moderate or greater severity [1991 ATS criteria])<sup>k</sup> | NR |

---

<sup>(Continued)</sup>
### Table 1 (Continued)

| Reference | Study design | Patient population (n) | Method | Prevalence (%) (overall and/or by sex, where available) | Prevalence (%), by age |
|-----------|--------------|------------------------|--------|-----------------------------------------------------|------------------------|
| Mannino et al\(^a\) | 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) FEV\(_1\)/FVC < 0.7; FEV\(_1\) > 80% predicted (ATS, 1995 criteria) OLD stage 1 (ATS, 1995 criteria) OLD stage 2 (ATS, 1995 criteria) OLD stage 3 (ATS, 1995 criteria) | 8.5 | NR |
| Mannino et al\(^b\) | NHANES III, phase 2 (1991–1994). Prevalence rates age-adjusted to 2000 US population. | 6600 noninstitutionalized adults aged ≥ 25 years with spirometry data. Mean age: 42.8 years; FEV\(_1\), predicted: 95.3%; FEV\(_1\)/FVC ratio: 0.79. | Self-reported COPD GOLD stage I (2001 criteria) GOLD stage II and higher (2001 criteria) | 4.7 | NR |
| Medvin et al\(^c\) | 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. Mean age: 60.7 years. | Self-reported COPD or CB Self-reported emphysema GOLD stage 0 (2001 criteria) GOLD stage I or higher (2007 criteria) Restricted | 4.7 | NR |
| Soriano et al\(^d\) | 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) | 17.1 | NR |
| Vaz Fragoso et al\(^e\) | 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\(_j\) (2005 criteria) GOLD stage I or higher (2007 criteria) LMS-LLN\(_j\) (2008 criteria) | 7.1 | NR |
| Multicountry | 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. Mean age: 60.7 years. | Self-reported CB ATS 1979 criteria With CB: 8.4% No CB: 4.3% | 3.2 | NR |
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 countries46 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
| 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<sup>17</sup> ECRHS II | Follow-up of patients in ECRHS I who completed respiratory health questionnaire, underwent clinical assessment, and spirometry, from 12 countries (Europe and the USA).<sup>1</sup> Median follow-up: 8.9 years. | 5002 without asthma, aged 20–44 years, with normal lung function,<sup>2</sup> who participated in stage 2 of ECRHS I. | FEV<sub>1</sub>/FVC ≥ 70% at baseline (ECRHS I), and FEV<sub>1</sub>/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<sup>18</sup> NA       | 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<sup>19</sup> NA        | 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<sup>20</sup> 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<sub>1</sub>/FVC < 0.70, FEV<sub>1</sub> < 80% GOLD: FEV<sub>1</sub>/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 |
Nihlen et al, 1992
Study period: 2000
n = 4933 from a 1992 questionnaire, all aged 20–59 years in 1992.

Lindberg et al, 1996–2003
OLIN
Ongoing population-based cohort with survey and subgroup invited for examination. (3rd update of OLIN cohort 1).

UK
García Rodríguez et al, 1996
Cohort study in GPRD database. Followed by nested case-control study.

Soriano et al, 1990–1997
GPRD
Retrospective cohort study in UK GPRD data.

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

GOLD: Stage I–IV: FEV$_1$/FVC $<0.70$
GOLD II: Stage II–IV: FEV$_1$/FVC $<0.70$
and FEV$_1$ $<80$

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

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
| Source, study name, study period | Study design | Patient characteristics (n) | Method for diagnosing COPD | Incidence |
|---------------------------------|-------------|-----------------------------|----------------------------|-----------|
| **USA**                         |             |                             |                            |           |
| Mannino et al¹⁵                  | 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 al¹⁵                  | 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:**
1. 12 countries: Belgium, Estonia, France, Germany, Iceland, Italy, Norway, Spain, Sweden, Switzerland, the UK, and the USA.
2. Normal lung function, **FEV**₁/FVC ≥ 70%.
3. Appears to be a subset of patients in a Montenegrin study published 1998, original 1992 sample was a population based in the Male 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. 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. Some remarkable differences in COPD mortality exist between countries, particularly regarding the differences between men and women. In Australia, one study 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. 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. Data from a later study 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. One of these reported data only for the Asia-Pacific region and, of those countries investigated here, included only Japan. 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; 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, 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.

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. 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%, 9%–10%) (Table 3). 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%). 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.

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]) and the greater mortality rate in men compared with women. 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, which were not captured in the European-focused literature review. 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).
| Source, study name, study period | Study design | Patient characteristics (n) | Trends in mortality (by years) |
|---------------------------------|-------------|-----------------------------|-------------------------------|
| **Australia**                   |             |                             |                               |
| Berend et al                     | 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 (1991–2004)            | Retrospective analysis of mortality and hospitalization data from the Asia-Pacific region. | 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 (1991–2004)   | 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 (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 (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% 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: |
| Day and Lanier (1979–1998)       | Retrospective analysis of death certificates and Indian Health Service population estimates for the Alaskan native population. | ∼91,300 Alaskan natives. |                                |
| Study | Retrospective Analysis | Mortality Rate (per 100,000 Population) for COPD (ICD-10 J40–J44) |
|-------|------------------------|------------------------------------------------------------------|
| Edwards et al (1980–2000) | Retrospective analysis of public mortality database, the CDC WONDER database. | Adults in Wisconsin aged ≥ 45 years (population size unknown). |
| Jemal et al (1970–2002) | Retrospective analysis of death certificates from NCHS. | Deaths in USA 1970–2002 (population size unknown). |
| Kazerouni et al (1968–1999) | Retrospective analysis of the national mortality files compiled by the CDC’s NCHS. | Deaths in the USA 1968–1999 (population size unknown). |
| Mannino et al (1968–1999) | Report of several surveys and studies conducted by CDC’s NCHS (1980–2000). | Adults aged ≥ 25 years. |
| Miller et al (1980–1996) | Retrospective analysis of death certificates from Missouri Center for Health Information Management and Epidemiology. | Subjects with deaths recorded in database. |
| CDC (2000–2005) | Retrospective analysis of the CDC’s WONDER compressed mortality database of the National Vital Statistics System. | Adults aged ≥ 25 years. |

**Overall change in mortality rate:***

Alaskan natives: 191% between 1979 and 1983, and 1994 and 1998
US white residents: 28% between 1981 and 1996

**Age-adjusted mortality rate (per 100,000 population) for COPD:**

| Year | All | M | F |
|------|-----|---|---|
| 1980 | 59; 112; 23 | 111; 150; 89 |
| 1990 | 7.3; 2.6 | 4.5; 5.0 |
| 1991 | 43; 14 | 29; 29 |
| 1992 | 170; 4 | 180; 111 |
| 1993 | 350; 58 | 478; 254 |
| 1994 | 484; 82 | 773; 334 |

**Change:** 102.8%

**Mannino et al (1980–2000) Report of several surveys and studies conducted by CDC’s NCHS (1980–2000).**

Mortality rate (per 100,000 population) from COPD as underlying cause in 2000; 2001; 2002; 2003; 2004; 2005:

| Age Group | All | M | F |
|-----------|-----|---|---|
| 25–44 years | 0.6; 0.7 | 0.7; 0.7 | 0.7; 0.7 |
| 45–54 years | 6.9; 7.1 | 7.1; 7.0 | 7.9 |
| 55–64 years | 41.7; 41.7 | 41.0; 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 |

**CDC (2000–2005) Retrospective analysis of the CDC’s WONDER compressed mortality database of the National Vital Statistics System.**

Mortality rate (per 100,000 population) from COPD as underlying cause in 2000; 2001; 2002; 2003; 2004; 2005:

| Age Group | All | M | F |
|-----------|-----|---|---|
| 25–44 years | 0.6; 0.7 | 0.7; 0.7 | 0.7; 0.7 |
| 45–54 years | 6.9; 7.1 | 7.1; 7.0 | 7.9 |
| 55–64 years | 41.7; 41.7 | 41.0; 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)
| Source, study name, study period | Study design | Patient characteristics (n) | Trends in mortality (by years) |
|----------------------------------|-------------|-----------------------------|-------------------------------|
| Singh and Hiatt<sup>1</sup>      | 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). | 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; 37.26 (−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<sup>2</sup>             | 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<sup>3</sup>. | 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 S19.3) 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: <sup>1</sup>Australia, Pacific Canada (British Columbia), Hong Kong, South Korea, and Taiwan. <sup>2</sup>Kentucky, Georgia, North Carolina, South Carolina, Tennessee, and Virginia. <sup>3</sup>Australia, Canada, Germany, Hong Kong, South Korea, and Taiwan. 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; 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. 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, 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 men and 20–25 years in women. This “lag time” between smoking and COPD onset has been reported in previous literature.

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. 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. Furthermore, women tend to have smaller airways and lung volumes than men, and previous studies have shown that females are consequently more vulnerable to the adverse effects of smoking than men.

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. Also, compared with the most recent review, which only reviewed data from countries in Europe, 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, 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 Boehringer Ingelheim.
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.

References
1. Rabe KF, Hurd S, Anzueto A, et al; Global Initiative for Chronic Obstructive Lung Disease. Global strategy for the diagnosis, management, and prevention of chronic obstructive pulmonary disease: GOLD executive summary. Am J Respir Crit Care Med. 2007;176(6):532–555.
2. Murray CJL, Lopez AD. Alternative projections of mortality and disability by cause 1990–2020: Global burden of disease study. Lancet. 1997;349:1498–1504.
3. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. Ann Intern Med. 2009;151(4):264–269, W64.
4. Lindberg A, Jonsson AC, Rönmark E, Larsson LG, Lundbäck B. Prevalence of chronic obstructive pulmonary disease according to BTS, ERS, GOLD, and ATS criteria in relation to doctor’s diagnosis, symptoms, age, gender, and smoking habits. Respiration. 2005;72(5):471–479.
5. Celli BR, Halbert RJ, Isonaka S, Schau B. Population impact of different definitions of airway obstruction. Eur Respir J. 2003;22(2):268–273.
6. Hnizdo E, Glimmehwry HE, Petsonk EL, Enright P, Buist AS. Case definitions for chronic obstructive pulmonary disease. COPD. 2006;3(2):95–100.
7. Vaz Fragoso CA, Concato J, McAvay G, et al. The ratio of FEV1 to FVC as a basis for establishing chronic obstructive pulmonary disease. Am J Respir Crit Care Med. 2010;181(5):446–451.
8. Lindberg A, Bjerg A, Rönmark E, Larsson LG, Lundbäck B. Prevalence and underdiagnosis of COPD by disease severity and the attributable fraction of smoking. Report from the obstructive lung disease in Northern Sweden studies. Respir Med. 2006;100(2):264–272.
9. Lundbäck B, Lindberg A, Lindstrom M, et al; Obstructive Lung Disease in Northern Sweden Studies. Not 15 but 50% of smokers develop COPD? – Report from the Obstructive Lung Disease in Northern Sweden Studies. Respir Med. 2003;97(2):115–122.
10. Ceraverni I, Accordini S, Verlato G, et al; European Community Respiratory Health Survey (ECRHS) Study Group. Variations in the prevalence across countries of chronic bronchitis and smoking habits in young adults. Eur Respir J. 2001;18(1):85–92.
11. Al-Hazmi M, Wooldrage K, Anthonisen NR, et al. Airflow obstruction in young adults in Canada. Can Respir J. 2007;14(4):221–217.
12. Viegi G, Matteelli G, Angino A, et al. The proportional Venn diagram of obstructive lung disease in the Italian general population. Chest. 2004;126(4):1093–1101.
13. Celli BR, Halbert RJ, Nordyke RJ, Schau B. Airway obstruction in never smokers: results from the third national health and nutrition examination survey. Am J Med. 2005;118(12):1364–1372.
14. Hnizdo E, Sullivan PA, Bang KM, Wagner G. Association between chronic obstructive pulmonary disease and employment by industry and occupation in the US population: a study of data from the third national health and nutrition examination survey. Am J Epidemiol. 2002;156(8):738–746.
15. Mannino DM, Homa DM, Akinbami LJ, Ford ES, Redd SC. Chronic obstructive pulmonary disease surveillance: United States, 1971–2000. MMWR Surveill Summ. 2002;51(6):1–16.
16. Methvin JN, Mannino DM, Casey BR. COPD prevalence in southeastern Kentucky: the burden of lung disease study. Chest. 2009;135(1):102–107.
17. de Marco R, Accordini S, Cerveri I, et al. Incidence of chronic obstructive pulmonary disease in a cohort of young adults according to the presence of chronic cough and phlegm. Am J Respir Crit Care Med. 2007;175(1):32–39.
18. Gershon AS, Wang C, Wilton AS, Raut R, To T. Trends in chronic obstructive pulmonary disease prevalence, incidence, and mortality in Ontario, Canada, 1996 to 2007: a population-based study. Arch Intern Med. 2010;170(6):560–565.
19. Kojima S, Sakakibara H, Motani S, et al. Incidence of chronic obstructive pulmonary disease, and the relationship between age and smoking in a Japanese population. J Epidemiol. 2007;17(2):54–60.
20. Lindberg A, Jonsson AC, Rönmark E, Lundgren R, Larsson LG, Lundbäck B. Ten-year cumulative incidence of COPD and risk factors for incident disease in a symptomatic cohort. Chest. 2005;127(5):1544–1552.
21. García Rodríguez LA, Wallander MA, Tolosa LB, Johansson S. Chronic obstructive pulmonary disease in UK primary care: incidence and risk factors. COPD. 2009;6(5):369–379.
22. Tan WC, Seale P, Ip M, et al. Trends in COPD mortality and hospitalizations in countries and regions of Asia-Pacific. Respir Med. 2009;103(1):90–97.
23. Lindgren B. Trends in obstructive lung disease in hospital registers in Sweden 1987–1996. Eur Respir Rev. 2000;10(75):423.
24. Lipton R, Banerjee A. The geography of chronic obstructive pulmonary disease across time: California in 1993 and 1999. Int J Med Sci. 2007;4(4):179–189.
25. Kabir Z, Connolly GN, Koh HK, Clancy L. Chronic obstructive pulmonary disease hospitalization rates in Massachusetts: a trend analysis. QJM. 2010;103(3):163–168.
26. Lindberg A, Eriksson B, Larsson LG, Rönmark E, Sandstrom T, Lundbäck B. Seven-year cumulative incidence of COPD in an age-stratified general population sample. Chest. 2006;129(4):879–885.
27. Camp PG, Chaudhry M, Platt H, et al. The sex factor: epidemiology and management of chronic obstructive pulmonary disease in British Columbia. Can Respir J. 2008;15(8):417–422.
28. Nie JX, Wang L, Upshur RE. Mortality of elderly patients in Ontario after hospital admission for chronic obstructive pulmonary disease. Can Respir J. 2007;14(8):485–489.
29. Lindberg A, Lundbäck B. The Obstructive Lung Disease in Northern Sweden Chronic Obstructive Pulmonary Disease Study: design, the first year participation and mortality. Clin Respir J. 2008;2(Suppl 1):64–71.
30. Janssen F, Kunst AE. Cohort patterns in mortality trends among the elderly in seven European countries, 1950–1999. Int J Epidemiol. 2005;34(5):1149–1159.
31. Wilson DH, Tucker G, Frith P, Appleton S, Ruffin RE, Adams RJ. Trends in hospital admissions and mortality from asthma and chronic obstructive pulmonary disease in Australia, 1993–2003. Med J Aust. 2007;186(8):408–411.
32. Janssen F, Nusselder WJ, Looman CW, Mackenbach JP, Kunst AE. Stagnation in mortality decline among elders in The Netherlands. Gerontologist. 2003;43(5):722–734.
33. Hansell AL, Walk JA, Soriano JB. What do chronic obstructive pulmonary disease and alpha-1-antitrypsin deficiency in Australia. Can Respir J. 2003;10(1):64–71.
34. Berend N. Epidemiological survey of chronic obstructive pulmonary disease prevalence, incidence, and mortality in Sweden Chronic Obstructive Pulmonary Disease Study: design, the third national health and nutrition examination survey. Am J Epidemiol. 2002;156(8):738–746.
35. Mannino DM, Homa DM, Akinbami LJ, Ford ES, Redd SC. Chronic obstructive pulmonary disease surveillance: United States, 1971–2000. MMWR Surveill Summ. 2002;51(6):1–16.
36. Methvin JN, Mannino DM, Casey BR. COPD prevalence in southeastern Kentucky: the burden of lung disease study. Chest. 2009;135(1):102–107.
38. Edwards NM, Umland M, Ahrens D, Remington P. The silent epidemic among Wisconsin women: chronic obstructive pulmonary disease trends, 1980–2000. WMJ. 2005;104(4):50–54.

39. Hughes TS, Muldoon SB, Tollerud DJ. Underestimation of mortality due to chronic obstructive pulmonary disease (COPD) in Kentucky. J Ky Med Assoc. 2006;104(8):331–339.

40. Kazerouni N, Alverson CJ, Redd SC, Mott JA, Mannino DM. Sex differences in COPD and lung cancer mortality trends: United States, 1968–1999. J Womens Health (Larchmt). 2004;13(1):17–23.

41. Lewis DR, Clegg LX, Johnson NJ. Lung disease mortality in the United States: the national longitudinal mortality study. Int J Tuberc Lung Dis. 2009;13(8):1008–1014.

42. Miller N, Simeos EJ, Chang JC, Robling AG. Trends in chronic obstructive pulmonary disease mortality. Mo Med. 2000;97(3):87–90.

43. Centers for Disease Control and Prevention (CDC). Deaths from chronic obstructive pulmonary disease: United States, 2000–2005. MMWR Mortal Morb Wkly Rep. 2008;57(45):1229–1232.

44. Rubia M, Marcos I, Muennig PA. Increased risk of heart disease and stroke among foreign-born females residing in the United States. Am J Prev Med. 2002;22(1):30–35.

45. Singh GK, Hiatt RA. Trends and disparities in socioeconomic and behavioural characteristics, life expectancy, and cause-specific mortality of non-foreign-born and foreign-born populations in the United States, 1979–2003. Int J Epidemiol. 2006;35(4):903–915.

46. Ezzati M, Lopez AD. Region-specific patterns of smoking-attributable mortality in 2000. Tob Control. 2004;13(4):388–395.

47. Centers for Disease Control and Prevention (CDC). Smoking-attributable mortality, years of potential life lost, and productivity losses: United States, 2000–2004. MMWR Mortal Morb Wkly Rep. 2008;57(45):1226–1228.

48. Ezzati M, Lopez AD. Estimates of global mortality attributable to smoking in 2000. Lancet. 2003;362(9387):847–852.

49. Henley SJ,Connell CJ, Richter P, et al. Tobacco-related disease mortality among men who switched from cigarettes to spit tobacco. Tob Control. 2007;16(1):22–28.

50. Atsou K, Chouaid C, Hejblum G. Variability of the chronic obstructive pulmonary disease key epidemiological data in Europe: systematic review. BMC Med. 2011;9:7.

51. Halbert RJ, Isonaka S, George D, Iqbal A. Interpreting COPD prevalence estimates: what is the true burden of disease? Chest. 2003;123(5):1684–1692.

52. Halbert RJ, Natoli JL, Gano A, Badamgarav E, Buist AS, Mannino DM. Global burden of COPD: systematic review and meta-analysis. Eur Respir J. 2006;28(3):523–532.

53. Ko FW, Hui DS, Lai CK. Worldwide burden of COPD in high- and low-income countries, Part III. Asia-Pacific studies. Int J Tuberc Lung Dis. 2008;12(7):713–717.

54. Hurd S. The impact of COPD on lung health worldwide: epidemiology and incidence. Chest. 2000;117(Suppl 2):1S–4S.

55. OECD.StatExtracts [homepage on the Internet]. Organisation for Economic Co-operation and Development; 2011. Non-medical determinants of health: tobacco consumption. Available from: http://stats.oecd.org/index.aspx. Accessed July 13, 2011.

56. Foreman MG, Zhang L, Murphy L, et al. The COPDGene investigators. Early-onset COPD is associated with female gender, maternal factors, and African–American race in the COPDGene study. Am J Respir Crit Care Med. 2011;184(4):414–420.

57. Sheel AW, Guenette JA. Mechanics of breathing during exercise in men and women: sex versus body size differences? Exerc Sport Sci Rev. 2008;36(3):128–134.

58. Prescott E, Bjerg AM, Andersen PK, Lange P, Vestbo J. Gender difference in smoking effects on lung function and risk of hospitalization for COPD: results from a Danish longitudinal population study. Eur Respir J. 1997;10(4):822–827.

59. Langhammer A, Johnsen R, Gulsvik A, Holmen TL, Bjørner L. Sex differences in lung vulnerability to tobacco smoking. Eur Respir J. 2003;21(6):1017–1823.
80. de Marco R, Accordioni S, Cerveri I, et al; European Community Respiratory Health Survey Study Group. An international survey of chronic obstructive pulmonary disease in young adults according to GOLD stages. Thorax. 2004;59(2):120–125.

81. Lacasse Y, Montori VM, Lanthier C, Maltis F. The validity of diagnosing chronic obstructive pulmonary disease from a large administrative database. Can Respir J. 2005;12(5):251–256.

82. Ohmama A, Schopflocher D, Jacobs P, et al. A population-based analysis of health behaviours, chronic diseases and associated costs. Chronic Dis Can. 2006;27(1):17–24.

83. Stewart P, McRae L. Keeping track of COPD in Canada. Can Respir J. 2007;14(Suppl A):SA–7A.

84. Chen Y, Breithaupt K, Muhajarine N. Occurrence of chronic obstructive pulmonary disease in Canadians and sex-related risk factors. J Clin Epidemiol. 2000;53(7):755–761.

85. Hill K, Goldstein RS, Guyatt GH, et al. Prevalence and underdiagnosis of chronic obstructive pulmonary disease among patients at risk in primary care. CMAJ. 2010;182(7):673–678.

86. Vozoris N, Lougheed MD. Second-hand smoke exposure in Canada: prevalence, risk factors, and association with respiratory and cardiovascular diseases. Can Respir J. 2008;15(5):263–269.

87. Huchon GJ, Vergnenegre A, Neukirch F, Brami G, Roche N, Preux PM. Chronic bronchitis among French adults: high prevalence and underdiagnosis. Eur Respir J. 2002;20(4):806–812.

88. Anechino C, Rossi E, Fanizza C, De Rossi M, Tognoni G, Romero M; working group ARNO project. Prevalence of chronic obstructive pulmonary disease and pattern of comorbidities in a general population. Int J Chronic Obstruct Pulmon Dis. 2007;2(4):567–574.

89. Fukuhori S, Matsuse H, Takamura N, et al. Prevalence of chronic obstructive pulmonary diseases in general clinics in terms of FEV1/FVC. Int J Clin Pract. 2009;63(2):269–274.

90. Fukuchi Y, Nishimura M, Ichinose R, et al. COPD in Japan: The NIP study. Chest. 2009;135(2):380–387.

91. Kojima S, Sakakibara H, Motani S, et al. Effects of smoking and age on chronic obstructive pulmonary disease in Japan. J Epidemiol. 2005;15(4):113–117.

92. Tsutumi K. Epidemiological survey of chronic obstructive pulmonary disease in Japan. Respir Med. 2001;95(Suppl S27–S33.

93. Miravitlles M, de la Roza C, Morera J, et al. Chronic respiratory symptoms, spirometry and knowledge of COPD among general population. Respir Med. 2006;100(11):1973–1980.

94. Miravitlles M, Soriano JB, Garcia-Rio F, et al. Prevalence of COPD in Spain: impact of undiagnosed COPD on quality of life and daily life activities. Thorax. 2009;64(10):863–868.

95. Peña VS, Miravitlles M, Gabriel R, et al. Geographic variations in prevalence and underdiagnosis of COPD: results of the IBERPOC multicentre epidemiological study. Chest. 2000;118(4):981–989.

96. de Torres JP, Campo A, Casanova C, Aguirre-Jaime A, Zulueta J. Gender and chronic obstructive pulmonary disease in high-risk smokers. Respiration. 2006;73(3):306–310.

97. Ekberg-Aronsson M, Lofdahl K, Nilsson JA, Lofdahl CG, Nilsson PM. Hospital admission rates among men and women with symptoms of chronic bronchitis and airflow limitation corresponding to the GOLD stages of chronic obstructive pulmonary disease—a population-based study. Respir Med. 2008;102(1):109–120.

98. Hasselgren M, Arne M, Lindahl A, Janson S, Lundbäck B. Estimated prevalences of respiratory symptoms, asthma and chronic obstructive pulmonary disease related to detection rate in primary health care. Scand J Prim Health Care. 2001;19(1):54–57.

99. Lindstrom M, Jonsson E, Larsson K, Lundbäck B. Underdiagnosis of chronic obstructive pulmonary disease in Northern Sweden. Int J Tuberc Lung Dis. 2002;6(1):76–84.

100. Montéméry P, Bengtsson P, Elliott A, Lindholm LH, Nyberg P, Lofdahl CG. Prevalence of obstructive lung diseases and respiratory symptoms in relation to living environment and socio-economic group. Respir Med. 2001;95(9):744–752.

101. Pallashos P, Lundbäck B, Meren M, et al. Prevalence and risk factors for asthma and chronic bronchitis in the capitals Helsinki, Stockholm, and Tallinn. Respir Med. 2002;96(10):759–769.

102. Rönmark EP, Ekerljung L, Lötvall J, Torén K, Rönmark E, Lundbäck B. Large scale questionnaire survey on respiratory health in Sweden: Effects of late- and non-response. Respir Med. 2009;103(12):1807–1815.

103. Wiréhen AB, Karlsson HM, Carstensen JM. Estimating disease prevalence using a population-based administrative healthcare database. Scand J Public Health. 2007;35(4):424–431.

104. Faulconer ER, de Lusignan S. An eight-step method for assessing diagnostic data quality in practice: chronic obstructive pulmonary disease as an exemplar. Inform Prim Care. 2004;12(4):243–254.

105. Murtagh E, Heaney L, Gingles J, et al. Prevalence of obstructive lung disease in a general population sample: the NICECOPD study. Eur J Epidemiol. 2005;20(5):443–453.

106. Nacul LC, Soljak M, Meade T. Model for estimating the population prevalence of chronic obstructive pulmonary disease: Cross sectional data from the health survey for England. Popul Health Metr. 2007;5:8.

107. Bang KM, Syamlal G, Mazurek JM. Prevalence of chronic obstructive pulmonary disease in the U.S. working population: an analysis of data from the 1997-2004 National Health Interview Survey. COPD. 2009;6(5):380–387.

108. Bhattacharyya N. Contemporary assessment of the disease burden of sinusitis. Am J Rhinol Allergy. 2009;23(4):392–395.

109. Bhattacharyya N. Does annual temperature influence the prevalence of otolaryngologic respiratory diseases? Laryngoscope. 2009;119(10):1882–1886.

110. Chamberlain AM, Schabath MB, Folsom AR. Associations of chronic obstructive pulmonary disease with all-cause mortality in Blacks and Whites: the atherosclerosis risk in communities (ARIC) study. Ethn Dis. 2009;19(3):308–314.

111. Hnizdo E, Sullivan PA, Bang KM, Wagner G. Airflow obstruction attributable to work in industry and occupation among U.S. race/ethnic groups: a study of NHANES III data. Am J Ind Med. 2004;46(2):126–135.

112. Jackson H, Hubbard R. Detecting chronic obstructive pulmonary disease using peak flow rate: Cross sectional survey. Br Med J. 2003;327(7416):653–654.

113. Jordan JG Jr, Mann JR. Obesity and mortality in persons with obstructive lung disease using data from the NHANES III. South Med J. 2010;103(4):323–330.

114. Lipton R, Banerjee A, Dowling KC, Treno AJ. The geography of COPD hospitalization in California. COPD. 2005;2(4):435–444.

115. Mannino DM, Buist AS, Petty TL, Enright PL, Redd SC. Lung function and mortality in the United States: data from the First National Health and Nutrition Examination Survey follow up study. Thorax. 2003;58(5):388–393.

116. O’Malley AS, Pham HH, Schrag D, Wu B, Bach PB. Potentially avoidable hospitalizations for COPD and pneumonia: the role of physician and practice characteristics. Med Care. 2007;45(6):562–570.

117. Pleis JR, Barnes PM. A comparison of respiratory conditions between multiple race adults and their single race counterparts: An analysis based on American Indian/Alaska Native and white adults. Ethn Health. 2008;13(5):399–415.

118. Schneider KM, O’Donnell BE, Dean D. Prevalence of multiple chronic conditions in the United States’ Medicare population. Health Qual Life Outcomes. 2009;7:82.

119. Tinkelman DG, George D, Halbert RJ. Chronic obstructive pulmonary disease in patients under age 65: Utilization and costs from a managed care sample. J Occup Environ Med. 2005;47(11):1125–1130.

120. Wilson L, Devine EB, So K. Direct medical costs of chronic obstructive pulmonary disease: chronic bronchitis and emphysema. Respir Med. 2000;94(3):204–213.

121. Ohar JA, Sadeghnejad A, Meyers DA, Donohue JF, Bleecker ER. Do symptoms predict COPD in smokers? Chest. 2010;137(6):1345–1353.
Supplementary materials

Table S1 Search strategy used for literature search

| Search number | Search terms* |
|---------------|--------------|
| 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] |
| Total #7      | #4 NOT (#5 OR #6) |

Notes: Search limits: English language; and publication date from January 2000 to September 2010. ‘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* | Prevalence | Incidence | Mortality |
|--------------------------|----------------------------------------|------------|-----------|-----------|
|                          | All articles | Multicountry articles |               |           |           |
| 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: 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.
| Reference          | Study design                                                                 | Population                                                                 | Method                                      | Population (n) | Age (years) | Prevalence (%) |
|--------------------|------------------------------------------------------------------------------|---------------------------------------------------------------------------|---------------------------------------------|----------------|-------------|----------------|
| **Multicountry studies** |                                                                              |                                                                            |                                             |                |             |                |
| Boutin-Forzano et al<sup>77</sup> | Questionnaire, conducted in eight European cities 2003–2004.                | 6915 subjects from 3373 homes across eight cities; 47.2% female.          | CBE diagnosed and/or treated in the previous 12 months | 6915           | ≥18         | 6.2            |
| Buist et al<sup>76</sup> | 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.                                      | 683                                                                        | Spirometry: GOLD stage                      | 683            | ≥40         | M: 8.7; F: 3.7 |
|                    |                                                                              |                                                                            |                                             |                | 40–49       | M: 0; F: 2.5  |
|                    |                                                                              |                                                                            |                                             |                | 50–59       | M: 1.0; F: 2.9|
|                    |                                                                              |                                                                            |                                             |                | 60–69       | M: 8.9; F: 4.4|
|                    |                                                                              |                                                                            |                                             |                | ≥70         | M: 1.9; F: 6.2|
|                    |                                                                              |                                                                            |                                             |                | ≥40         | M: 9.3; F: 7.3|
|                    |                                                                              |                                                                            |                                             |                | 40–49       | M: 2.8; F: 1.3|
|                    |                                                                              |                                                                            |                                             |                | 50–59       | M: 6.4; F: 1.3|
|                    |                                                                              |                                                                            |                                             |                | 60–69       | M: 1.0; F: 10.8|
|                    |                                                                              |                                                                            |                                             |                | ≥70         | M: 2.6; F: 20.7|
| Canada             | 58% female. Mean age: 56.4–57.5 years.                                      | 827                                                                        | Spirometry: GOLD stage                      | 827            | ≥40         | M: 12.7; F: 15.6|
|                    |                                                                              |                                                                            |                                             |                | 40–49       | M: 1.8; F: 5.1|
|                    |                                                                              |                                                                            |                                             |                | 50–59       | M: 1.7; F: 11.0|
|                    |                                                                              |                                                                            |                                             |                | 60–69       | M: 1.9; F: 25.6|
|                    |                                                                              |                                                                            |                                             |                | ≥70         | M: 1.9; F: 29.6|
| USA                | 58% female. Mean age: 56.6–57.5 years.                                      | 508                                                                        | Spirometry: GOLD stage                      | 508            | ≥40         | M: 9.3; F: 12.2|
|                    |                                                                              |                                                                            |                                             |                | 40–49       | M: 2.7; F: 4.9|
|                    |                                                                              |                                                                            |                                             |                | 50–59       | M: 4.1; F: 6.8|
|                    |                                                                              |                                                                            |                                             |                | 60–69       | M: 1.3; F: 13.8|
|                    |                                                                              |                                                                            |                                             |                | ≥70         | M: 2.2; F: 23.8|
| Australia          | 50% female. Mean age: 57.6–59.9 years.                                       | 541                                                                        | Spirometry: GOLD stage                      | 541            | ≥40         | M: 12.7; F: 15.6|
|                    |                                                                              |                                                                            |                                             |                | 40–49       | M: 1.8; F: 5.1|
|                    |                                                                              |                                                                            |                                             |                | 50–59       | M: 1.7; F: 11.0|
|                    |                                                                              |                                                                            |                                             |                | 60–69       | M: 1.9; F: 25.6|
|                    |                                                                              |                                                                            |                                             |                | ≥70         | M: 1.9; F: 29.6|
| Cerveri et al<sup>75</sup> | 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<sub>1</sub> and FVC measurements. | Patient-reported chronic bronchitis Spirometry: ATS criteria | 17,966          | 20–44       | 3.2            |
|                    |                                                                              |                                                                            |                                             |                | 20–44       | 8.4 with chronic bronchitis; 4.3 without chronic bronchitis |
| Study | Description | Population | Exclusions | Prevalence |
|-------|-------------|------------|------------|------------|
| Menotti et al. | 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. | 65–84 | 13.8 |
| Menotti et al. | 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. | 65–84 | 22.8 |
| Rennard et al. | 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 $\geq 10$ 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 | $\geq 45$ | 2.8 |
| Canada | | 201,921 households. | Subjects with $\geq 10$ 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 | $\geq 45$ | 5.8 |
| France | | 201,921 households. | Subjects with $\geq 10$ 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 | $\geq 45$ | 6.0 |
| Germany | | 201,921 households. | Subjects with $\geq 10$ 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 | $\geq 45$ | 7.5 |
| Italy | | 201,921 households. | Subjects with $\geq 10$ 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 | $\geq 45$ | 6.1 |
| Reference   | Study design                                                                 | Population | Method                                                                 | Population (n)   | Age (years) | Prevalence (%) |
|-------------|------------------------------------------------------------------------------|------------|------------------------------------------------------------------------|------------------|-------------|----------------|
| The Netherlands | Subjects with $\geq 10$ 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 | $\geq 45$                                                             | 8.6              |             |
| Spain       | Subjects with $\geq 10$ 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 | $\geq 45$                                                             | 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   | 3.2 |
|             | 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   | 1.5 |
|             | 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   | 0.5 |
|             | 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   | 0.5 |
| 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  |
| Study | Methodology | Population | Spirometry | Self-reported diagnosis |
|-------|-------------|------------|------------|-------------------------|
| de Marco et al. (1991–1993) | Self-completed questionnaire about respiratory health, followed by clinical assessment and spirometry in 35 centers in 16 countries. | 18,412 subjects aged 20–44 years. Of these, 14,855 subjects completed the clinical interview and had at least two reliable FEV₁ and FVC measurements. | GOLD stage 1 and higher | 18,412 |
| Al-Hazmi et al. (1991–1993) | Multicentre, two-stage study (six Canadian locations) to assess airflow obstruction (reversible = asthma, not entirely reversible = COPD). | 2819 screened in laboratory; 54.0% female; aged 20–44 years. | Airflow obstruction, defined by the LLN for FEV₁/FVC using Hankinson's equations | 2819 |
| Canada et al. (2007) | Analysis of the British Columbia MOH administrative health services databases. | 1,708,418 subjects included in the MOH administrative databases, aged 45 years and older. | ICD-9 codes: 491, 492, 496 | 1,708,418 |
| Gershon et al. (2007) | Population-based cohort from administrative health information system. | 7,082,086 in database; 51.8% female; aged ≥ 35 years | ICD-9 codes 491, 492, 496; ICD-10 codes J41, J42, J43, J44 | 7,082,086 |
| Lacasse et al. (2007) | 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 |
| Ohinmaa et al. (2009) | 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 |
| Stewart and McRae (2005) | 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 |
| Chen et al. (2009) | 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 |

(Continued)
| Reference          | Study design                                                                 | Population                                                                 | Method                                                                 | Population (n) | Age (years) | Prevalence (%) |
|--------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------|------------------------------------------------------------------------|----------------|-------------|----------------|
| Hill et al.        | 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.     | 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, Self-reported emphysema               | 48,540 never-smokers; 48,117 former smokers | ≥12          | Never-smokers, 1.56; Former smokers, 2.76 |
| France             | 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              | 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            |
| Anechino et al.    | Comparison of COPD prevalence from the HSD, a computerized general-practice database, and the HIS6, a population-based survey. | 119,799 adults; HSD: 432,747 adults. | Self-reported and physician-diagnosed COPD                             | 119,799        | ≥15         | M: 5.6; F: 2.6 |
| Cricelli et al.    | Comparison of COPD prevalence from the HSD, a computerized general-practice database, and the HIS6, a population-based survey. | 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 |
| Country | Study | Design | Sample | Spirometry | Age and Sex | Disease Prevalence |
|---------|-------|--------|--------|------------|-------------|-------------------|
| Italy   | Viegi et al. | 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: 36.3% (range, 8–75); Pisa: 36.9% (range, 8–75). | |
| Japan   | Fukahori et al. | 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. | 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): FEV₁, 2.68; FVC, 3.41; FEV₁/FVC, 78.67. | Self-report plus spirometric testing (GOLD stage I and higher) | 2343 | Mean: 58 40–49 10.9 40–49 10.9 50–59 5.8 60–69 15.7 70–79 13.6 |
| Japan   | Kojima et al. | 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 |
| Japan   | Tatsumi et al. | 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. | 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. | 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 |
| Reference          | Study design                                                                 | Population                                                                 | Method                                      | Population (n) | Age (years) | Prevalence (%) |
|--------------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------|---------------------------------------------|----------------|-------------|----------------|
| Miravitlles et al<sup>a</sup> | 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<sub>1</sub>/FVC ratio < 0.70) | 3802           | 40–80       | 10.2           |
| Peña et al<sup>b</sup> | 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<sub>1</sub>/FVC; 15 did not have BDT but had FEV<sub>1</sub>/FVC < 81% and FEV<sub>1</sub> < 70%. | Spirometry: ERS criteria were used (FEV<sub>1</sub>/FVC ratio < 88% of predicted for men and < 89% for women) | 3981           | 40–69       | 9.1            |
| De Torres et al<sup>c</sup> | 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 (current or former smokers) | 764 (current or former smokers) | Mean: 53       | 26              |
| Sweden            |                                                                                 |                                                                              |                                             |                |             |                |
| Ekberg-Aronsson et al<sup>d</sup> | 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         | M: 4.2; F: 4.0 |
| Hasselgren et al<sup>e</sup> | Värmland 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 respondents, 206 were randomly picked for clinical examination; | Spirometry: BTS criteria | 4814           | 18–70       | 2.1             |
| Reference       | Study Description                                                                 | Sample Size | Spirometry | Smoking Status | FEV1 % Predicted |
|-----------------|------------------------------------------------------------------------------------|-------------|-------------|----------------|------------------|
| Lindberg et al  | Survey (mailed questionnaire) of a random sample of 4851 adults aged 20–69 years.  | 4851        | GOLD        | M: 24.9%; F: 28.5% | 20–69: 14.1 |
|                 |                                                                                     | 645         | BTS         | 20–69: 9.1     |
|                 |                                                                                     | 645         | ERS         | 45–69: 17.1    |
|                 |                                                                                     | 645         | ATS         | 20–69: 7.6     |
|                 |                                                                                     | 645         | Clinical    | 20–44: 4.1     |
|                 |                                                                                     | 645         |             | 45–69: 9.7     |
|                 |                                                                                     | 645         |             | 20–69: 1.4     |
|                 |                                                                                     | 645         |             | 20–44: 11.6    |
|                 |                                                                                     | 645         |             | 45–69: 15.4    |
|                 |                                                                                     | 645         |             | 20–69: 34.1    |
|                 |                                                                                     | 645         |             | 20–44: 21.5    |
|                 |                                                                                     | 645         |             | 45–69: 41.7    |
|                 |                                                                                     | 645         |             | 20–69: 12.2    |
|                 |                                                                                     | 645         |             | 20–44: 5.1     |
|                 |                                                                                     | 645         |             | 45–69: 16.5    |
| Lindberg et al  | 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. | 1237        | GOLD        | (M) current: 24%; former: 47%; non: 29% | 46–77: 14.3 |
|                 |                                                                                     | 1237        | BTS         | 46–47: 6.5     |
|                 |                                                                                     | 1237        | ERS         | 61–62: 17.1    |
|                 |                                                                                     | 1237        | ATS         | 76–77: 28.7    |
|                 |                                                                                     | 1237        | Clinical    | 46–77: 8.1     |
|                 |                                                                                     | 1237        |             | 46–47: 2.8     |
|                 |                                                                                     | 1237        |             | 61–62: 9.0     |
|                 |                                                                                     | 1237        |             | 76–77: 19.7    |
| Lindberg et al  | Ongoing population-based cohort with survey and subgroup invited for examination (3rd update of OLIN cohort I). | 5189        | GOLD stage I–IV | 46–77: 11.0   |
|                 |                                                                                     | 5617        |             | 46–47: 7.4     |
|                 |                                                                                     | 5617        |             | 61–62: 14.6    |
|                 |                                                                                     | 5617        |             | 76–77: 18.7    |
| Lindstrom et al | 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 | BTS         | 35–66: 11.3    |
|                 |                                                                                     | 5617        |             | 35–36: 1.9     |
|                 |                                                                                     | 5617        |             | 50–51: 7.2     |
|                 |                                                                                     | 5617        |             | 65–66: 22.5    |

(Continued)
| Reference       | Study design                                                                 | Population                                                                 | Method                      | Population (n) | Age (years) | Prevalence (%) |
|-----------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------|-----------------------------|-----------------|-------------|----------------|
| Lundbäck et al  | OLIN longitudinal population-based study, 3rd survey of the 1st cohort, sample taken of survey respondents. | Clinical examination: 47.6% (1986–1987), 50.6% (1993–1994) 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       | 8.1           |
| Montnémery et al | 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 | Population-based survey, Malmö In 2000, questionnaire sent to 5179 randomly selected people; aged 20–59 years. Total respondents: 3692; 52.1% female. Smokers: overall, 28.4%; M, 28.0%, F, 28.1%. | Self-report of chronic bronchitis, emphysema, or COPD | 3692                        | 3692            | 20–59       | 3.6           |
| Nihlen et al     | 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                        | 4280            | 20–59       | 4.3           |
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

Total respondents: 18,087 (62\%). Focus of study was impact of nonresponse.

Questionnaire asked about physician-diagnosed CBE/COPD

A cross-sectional study by postal survey in Western Sweden. Random sample of 30,000 from population registry in Sweden, aged 16–75 years.

UK

Faulconer and de Lusignan

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

UK

Murtagh et al

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.
| Reference      | Study design                                                                 | Population                                                                 | Method                                      | Population (n) | Age (years) | Prevalence (%) |
|----------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------|---------------------------------------------|----------------|-------------|----------------|
| Nacul et al    | 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  | 3.1, 1.10       |
|                |                                                                              |                                                                            |                                             |                | 45–54       | 2.19           |
|                |                                                                              |                                                                            |                                             |                | 55–64       | 5.48           |
|                |                                                                              |                                                                            |                                             |                | 65–74       | 7.29           |
|                |                                                                              |                                                                            |                                             |                | ≥75         | 7.89           |
| Shahab et al   | 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 sampling design 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 | 8215          | >35         | 13.3           |
|                |                                                                              |                                                                            |                                             |                | ≥35         | 1.1            |
| Soriano et al  | 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            | 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         | 4.0            |
|                |                                                                              |                                                                            |                                             |                | 18–44       | 3.5            |
|                |                                                                              |                                                                            |                                             |                | 45–64       | 4.8            |
|                |                                                                              |                                                                            |                                             |                | 65–74       | 6.9            |
|                |                                                                              |                                                                            |                                             |                | ≥75         | 6.8            |
| Study                                                                 | Population Details                                                                 | Self-reported Chronic Bronchitis | Mean Age | CI          |
|----------------------------------------------------------------------|------------------------------------------------------------------------------------|----------------------------------|----------|-------------|
| Bhattacharyya (1997–2006)                                           | 313,982 adults. Mean age: 45.2 years.                                              | 313,982                          | Mean 45.2| 4.8         |
| Bhattacharyya (1998–2006)                                           | 851,581 adults; 21.8% female (M:F ratio, 0.93:1). Mean age: 35.7 years.           | 851,581                          | Mean 35.7| 4.5         |
| Celli et al (1998–1994) NHANES III                                  | 9838 subjects, aged 30–80 years, of Caucasian, non-Hispanic white, non-Hispanic black, or Mexican American origin with a satisfactory spirometry test. | 9838                             | 30–80    | 7.73        |
|                                                                     |                                                                                     |                                  | 30–34    | 4.93        |
|                                                                     |                                                                                     |                                  | 35–39    | 3.95        |
|                                                                     |                                                                                     |                                  | 40–44    | 6.56        |
|                                                                     |                                                                                     |                                  | 45–49    | 7.11        |
|                                                                     |                                                                                     |                                  | 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 Ia 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       |
| Reference        | Study design                                                                 |
|------------------|-------------------------------------------------------------------------------|
| Chamberlain et al | 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. |
| ARIC study       | 10,333 adults; aged 45–64 years. 2,047 black (59.5% female); 8,286 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     | Data from NHANES III in a working population (1988–1994). Included questionnaire, laboratory examination, and lung-function testing. 9823 subjects aged 30–75 years. 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 |
| Study                        | Data Source                                                                 | Sample Size | Age Range | Prevalence |
|-----------------------------|-----------------------------------------------------------------------------|-------------|------------|------------|
| Hnizdo et al<sup>11</sup>   | 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. | Physician-diagnosed chronic bronchitis | 9823 | 30–75 | 4.5 |
| Hnizdo et al<sup>6</sup>    | 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. | Airflow obstruction (FEV<sub>1</sub>/FVC < 75% and FEV<sub>1</sub> < 80% predicted) | 9428 | 30–75 | Caucasian: 10.7 African-American: 7.5 Mexican-American: 3.9 |
| Jackson and Hubbard<sup>12</sup> | 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<sub>1</sub>/FVC < 70% and FEV<sub>1</sub> < 80% predicted) | 3874 | 50–90 | 7.1 |
| Jordan and Mann<sup>13</sup> | 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 |
| Reference            | Study design                                                                 | Population                                                                 | Method                          | Population (n) | Age (years) | Prevalence (%) |
|----------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------|---------------------------------|----------------|-------------|----------------|
| Lipton et al[14]     | 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[7]     | 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. FEV₁ predicted, 95.3%; FEV₁/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             |
|                      |                                                                              |                                                                           |                                 |                | ≥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          |
|                      |                                                                              |                                                                           |                                 |                | ≥25         | 6.57           |
|                      |                                                                              |                                                                           |                                 |                | 25–44       | 2.29           |
|                      |                                                                              |                                                                           |                                 |                | 45–54       | 7.24           |
|                      |                                                                              |                                                                           |                                 |                | 55–64       | 14.05          |
|                      |                                                                              |                                                                           |                                 |                | 65–74       | 20.66          |
|                      |                                                                              |                                                                           |                                 |                | ≥75         | 22.93          |
| Study | Population | Methods | Sample Size | GOLD Stage |Mean Age |Reference |
|-------|------------|---------|-------------|------------|---------|----------|
| Mannino et al. (1991–1994) | NHANES III, phase 2 (1991–1994) | 6600 noninstitutionalized adults aged 25 years with spirometry data. | 6600 | Gold stage I | 25 | 4.7 |
| Mannino et al. (1971–1975) | 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. | 5542 | Gold stage I | 25–74 | 16.1 |
| Methvin et al. (study period not reported) | Survey including questionnaire and spirometry (BOLD study) | 508 noninstitutionalized adults aged ≥ 40 years with completed questionnaires, and pre- and postbronchodilator spirometry; 59.5% female. | 508 | Gold stage I | 25–39 | 7.9 |
| O’Malley et al. (2000–2002) | Medicare claims database analysis | 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. | 509,613 | ICD-9 codes | ≥ 65 | 17.9 |
| Pleis and Barnes (2000–2003) | Retrospective study of data from the NHIS (2000–2003). | 127,596 civilian noninstitutionalized adults from NHIS; 51.0%–51.8% female. | 127,596 | Self-reported COPD or CBE | NR | White: 6 American Indian or Alaska native: 6.5 White and American Indian or Alaska native: 13.1 |
| Reference     | Study design                                                                 | Population | Method                      | Population (n) | Age (years) | Prevalence (%) |
|---------------|------------------------------------------------------------------------------|------------|-----------------------------|----------------|-------------|----------------|
| Schneider et al<sup>118</sup> | 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<sup>119</sup> | 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 | 4.7 |
| Tinkelman et al<sup>119</sup> | 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 | 45–54 | 0.96 |
| Vaz Fragoso et al<sup>17</sup> | 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<sub>5</sub>) GOLD stage I or higher (LMS-LLN<sub>5</sub>) | 3502 | 40–80 | 7.1 |
| Vaz Fragoso et al<sup>17</sup> | 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<sub>5</sub>) GOLD stage I or higher (LMS-LLN<sub>5</sub>) | 3502 | 40–64 | 15.6 |
| Wilson et al<sup>120</sup> | 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<sup>13</sup> | 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 (4544 never-smokers; 5732 ever-smokers) | 10,276 | 30–80 | 16.50 |
| Celli et al<sup>13</sup> | 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 (4544 never-smokers; 5732 ever-smokers) | 10,276 | 30–80 | 16.50 |
| Celli et al<sup>13</sup> | 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 (4544 never-smokers; 5732 ever-smokers) | 10,276 | 30–80 | 16.50 |
| Celli et al<sup>13</sup> | 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 (4544 never-smokers; 5732 ever-smokers) | 10,276 | 30–80 | 16.50 |
| Study | Participants | Methods | Results |
|-------|--------------|---------|---------|
| Oiar et al<sup>21</sup> | 3955 subjects screened for a work-related medical evaluation (1980–2008), including questionnaire, evaluation, chest radiographs, and lung-function tests. Mean age: 64.1 years. 1038 nonsmokers or <20 pack-years smokers; 74.9% FEV<sub>1</sub> predicted. | Spirometry: GOLD stage I or higher. Self-reported COPD, chronic bronchitis, emphysema, or asthma | Overall: 37.0
Smokers: 43.5
Smokers: 18.0 |

Abbreviations: ATS, American Thoracic Society; ATS/ERS-LLN<sub>5</sub>, 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<sub>1</sub>, 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<sub>5</sub>, 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; NHS, 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.
