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Systematic review: Chronic obstructive pulmonary disease and work-related outcomes

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Abstract

Background Several studies have assessed the impact of chronic obstructive pulmonary disease (COPD) on work ability and work productivity, however this relationship is poorly understood.

Aims To undertake a systematic review to assess the effects of COPD on employment, absenteeism and presenteeism.

Methods A comprehensive search using CINAHL, Embase, MEDLINE and The Cochrane Library, was conducted to include epidemiological studies from 1937 to August 2017. One reviewer screened all citations. Shortlisted full-text articles were independently assessed by a second reviewer. Data were extracted by one reviewer with a random sample of papers (45%) checked by a second reviewer.

Results Forty-four studies were included; the majority of evidence was from cross-sectional studies, and some cohort studies. COPD patients had lower employment rates than those without COPD. Among those in work, most studies showed patients with COPD took more time off work than those without and reported poorer work performance (presenteeism), although evidence for this association was weaker. The influence of disease severity on these outcomes was unclear, however it appeared that increasing severity of airflow obstruction was associated with reduced likelihood of being employed. A number of methodological limitations were found amongst the evidence, including the lack of adjustment for important confounders.

Conclusions Future studies are required which assess the impact of COPD on presenteeism using validated presenteeism instruments and consistent reporting methods. Robust studies are now needed to identify modifiable factors associated with these poorer working outcomes to inform future interventions aimed at improving work productivity among those with COPD.

Key words: Chronic obstructive pulmonary disease; employment; absenteeism; sickness absence; presenteeism; work performance; work productivity; systematic review

Introduction

Chronic obstructive pulmonary disease (COPD) is a progressive lung disease characterised by airflow obstruction and increasing breathlessness.¹ It is the fourth leading cause of death worldwide^{2;3} and is associated with high healthcare utilisation costs; costing the UK National Health Service (NHS) more than £800 million annually.⁴ However the additional societal costs attributable to the condition, mainly deriving from lower work productivity, are even greater, with estimates ranging from £1.1 billion and £2.7 billion annually.^{4;5} In the UK, an estimated 44% of the COPD population are below retirement age, and around one quarter are not in work due to their COPD.⁵ For those who are in employment, an estimated 5% of sickness absence is due to COPD.⁵

A number of studies have indicated that patients with COPD have lower employment rates compared to those without COPD,⁶⁻⁸ and this appears to be more marked amongst those with more severe disease.⁸ Furthermore, COPD may also be responsible for increased absenteeism⁹ and presenteeism¹⁰ (poor work performance when at work).

However, studies examining the effect of COPD on employment and work productivity are not always consistent, and have been conducted in a variety of settings and populations. There are no previous comprehensive reviews of the evidence in this area. The aim of this review was to summarise the findings of these studies and to identify the key disease related factors that are associated with poorer working outcomes among those with COPD. This will inform the development of future interventions to help improve work productivity within this population.

Methods

We undertook a systematic review to evaluate the evidence on the relationship between COPD and employment, absenteeism and presenteeism. Cohort or cross-sectional studies of COPD patients from any setting, which measured employment, absenteeism or presenteeism among COPD patients compared with participants without COPD were sought. To ensure that the effect of disease severity was considered, only studies where a standardised measure of disease severity or impact of symptoms was used were considered. A comprehensive search was conducted using CINAHL, Embase, MEDLINE and The Cochrane Library electronic databases to identify relevant studies published from 1937 until August 2017. The combination of keywords used were: (“chronic obstructive pulmonary disease” or “COPD” or “chronic obstructive airways disease” or “chronic obstructive lung disease” or “emphysema” or “chronic bronchitis”) and (“employment” or “employed” or “absenteeism” or “day off” “sickness absence” or “sick leave” or “presenteeism” or “work productivity” or “work performance” or “occupational health”). MeSH terms and text words were used. All relevant epidemiological studies were included. Citation lists were scanned to identify additional relevant articles. Non-English language articles were excluded.

One reviewer (KR) screened all titles and abstracts and relevant full-text articles. The shortlisted citations were independently assessed by another reviewer (RJ). The first reviewer extracted the data using an agreed data extraction form. For a random sample of 45% of papers, a second reviewer checked data extraction. Outcome measures of interest included: objective or subjectively reported employment, absenteeism (including mean number of days or hours off work; proportion of patients reporting time off work) and presenteeism (including mean presenteeism score; number of hours affected by

presenteeism; proportion of patients reporting presenteeism). Due to the various definitions we used a known definition of presenteeism for the purpose of this review: “the problem of workers being on the job, but, because of illness or other medical conditions, not fully functioning”¹¹; therefore studies measuring the impact of COPD on work performance or working limitations were included, irrespective of whether a validated presenteeism tool was used. Articles that did not compare those with COPD to those without COPD or assess the effect of disease severity on one of the three outcomes measures were excluded. For studies that did not report data in the text or tables, estimates were extracted from graphs or calculated using the available data (i.e. proportions).

The methodological quality of the included studies was assessed by the first reviewer, with a random sample of 45% of papers, checked by the second reviewer using an adaptation of the Cochrane risk of bias method¹² and a combination of questions from Crombie¹³ and the Critical Appraisal Skills Programme (CASP) cohort tool¹⁴; which was piloted and adjusted as necessary (see supplementary table S2 for quality assessment criteria). Risk of bias was classified as high, low or unclear.

Results

Of 3108 citations (after excluding duplicate citations), 44 relevant studies met the inclusion criteria. The effect of COPD on employment was assessed in 20 studies^{6-8;15-31}; 35 assessed absenteeism,^{9;10;15-20;22;28-53} and 21 presenteeism.^{9;10;15-17;22;28;29;31;32;37-41;45;46;48;50-52}

Table 1 summarises the main characteristics and findings for higher quality studies that used spirometry to diagnose COPD or measure airflow obstruction and also adjusted for important confounders within their analyses (full details of all studies in supplementary tables S1 to S8).

Two cohort studies^{23;27} and 5 cross-sectional studies^{6-8;24;30} compared employment rates among those with and without COPD. Two cross-sectional studies compared early retirement rates in those with COPD³⁰ and chronic bronchitis²⁰ to those without COPD³⁰ and asthma.²⁰ Four cross-sectional studies assessed employment rates,^{16;22;29} retirement rates,^{16;22;29} unemployment rates^{16;22;29} and the inability to work³¹ among those with various respiratory conditions.

The cohort studies, based on the Health and Retirement Study in the USA²⁷ and the National Patient Registry in Denmark,²³ collected data over 16 and 12 years, respectively. (Note: Snider et al's²⁷ analysis described as longitudinal, however it is unclear how timeframe was accounted for within the analysis). Among the 10 cross-sectional studies, 5 were general population samples,^{6-8;24;31} 4 primary/secondary care populations,^{16;22;29;30} and one was a smaller study consisting of a subgroup of people identified from a general population

sample, comparing those with chronic bronchitis symptoms with people who reported asthma symptoms.²⁰

Consistently across 6 studies, patients with COPD had significantly lower employment rates than those without COPD,^{6-8;23;27;30} or those with asthma⁶ and other chronic conditions⁶; with odds ratios (ORs) ranging from 0.4 (95% confidence intervals (CI): 0.2 – 0.7) (COPD compared to no chronic conditions)⁶ to 0.8 (0.7 – 1.00) (COPD compared to no COPD).⁷ Furthermore, once out of work, COPD patients were less likely to re-join the workforce compared to those with no chronic conditions (OR: 2.92; 95% CI: 1.35 – 6.29).⁶ Similar patterns were reported in an age-group adjusted analysis of serial cross-sections of the general US population²⁴; employment rates were consistently lower among those with self-reported COPD compared to those without (49.7% vs. 59.7% during 1980-82 and 57.5% vs. 64.6% in 1994-96).

Two further cross-sectional studies showed that those with COPD and chronic bronchitis had higher rates of early retirement, compared with those without COPD³⁰ and those who had asthma symptoms.²⁰

The final four cross-sectional studies compared COPD with other respiratory conditions. A general population study (n=8855), found that those with self-reported emphysema had higher unemployment (62.9%) compared to those with chronic bronchitis (18.4%) and asthma (25.2%), with a higher proportion also attributing this to their lung condition (27.4% vs. 0.6% and 4.8% respectively).³¹ The remaining three studies were part of a series based on the same protocol carried out in India,¹⁶ Taiwan²² and Thailand²⁹. Study samples included

approximately 1000 people, recruited from various health settings, and found lower employment rates and higher early retirement rates in those with COPD compared to those with asthma, allergic rhinitis and rhinosinusitis (no statistical tests reported).^{16;22;29}

Eleven studies (2 cohort and 9 cross-sectional) assessed the relationship between COPD disease severity and employment.^{7;8;15;17-19;21;25;26;28;30} The two cohort studies (with 1 year follow-ups) were based on COPD patients (n=244¹⁹; n=212¹⁸) in northern Sweden and both found higher likelihood of early retirement with increasing airflow obstruction (p<0.01), but neither adjusted for important confounders.^{18;19}

Among 7 cross-sectional studies assessing effects of airflow obstruction, only 3 found a statistically significant inverse relationship with employment,^{8;21;28} including one high quality study, from the USA which adjusted for a range of confounders.⁸ Another cross-sectional study, based on a large (n=2139) primary/secondary care population with COPD, indicated trends of lower employment and higher early retirement with increasing airflow obstruction, however no statistical tests were reported.³⁰ The remaining studies showed no association and were of varying quality.

Three studies assessed other measures of disease severity: symptoms score¹⁵ (breathlessness, coughing, infection, mucous production and wheezing), modified Medical Research Council (mMRC) score^{17;26} and the body-mass index, airflow obstruction, dyspnoea and exercise capacity (BODE) index.²⁶ All showed lower employment rates with increasing severity, including one study which adjusted for all relevant confounders.²⁶

Twenty-three studies assessed sickness absence.^{9;16;20;22;29-32;35;37-40;42-45;47;49-53} Thirteen measured absenteeism^{9;30;32;37-40;42;43;47;49;50;53} and two assessed disability days^{32;35} (sick leave covered by insurance programmes⁵⁴) in people with COPD compared to those without. Eight studies compared absenteeism in people with COPD to those with other respiratory diseases^{16;20;29;31;44;51-53} and one in people with or without airflow limitation.⁴⁵ The majority were large studies in workplaces,^{9;32;35;42;43;45;50} the general population,^{31;37-40;44;49;53} primary care⁴⁷ or a combination of primary and secondary care.^{16;22;29;30;51;52}

Two large retrospective matched cohort studies (up to 12 months follow-up), from US workplaces measured disability days (short-term,^{32;35} long-term^{32;35} and a combination of the two³⁵), and found a significantly increased risk of disability in those with COPD compared to those without. Data on disability days were extracted from the employee's company database, however the definitions lacked clarity.

Five studies^{20;30;31;42;44} reported the proportion of COPD patients affected by sickness absence and one⁴⁵ reported the proportion of those with absenteeism who had airflow limitation. All used self-reported absenteeism and recall periods varied from two weeks³¹ to six years.⁴² The cohort study found higher absenteeism among people with, compared to those without COPD over six years (95.5% vs. 82.4%).⁴² Of the three cross-sectional studies, two found that a greater proportion of people with COPD or airflow limitation reported absenteeism (over 12 months) compared to those without.^{30;45} Two further studies found higher absenteeism among those with asthma compared to those with COPD, but neither adjusted for confounding.^{19;43}

Nine cross-sectional studies assessed whether work time missed over one-week differed among those with, from those without COPD (n=4) or with other respiratory diseases (n=5). Whilst two found no significant difference,^{38;39} the two larger studies (n=60389³⁷; n=58378⁴⁰) found significantly higher absenteeism rates in those with COPD compared to those without (4.3% vs. 2.6%, p<0.001³⁷; 8.71% vs. 6.93%, p=0.0008⁴⁰) in adjusted analyses. The remaining five studies (from the same series) found greater absenteeism in those with rhinosinusitis compared to people with COPD (no statistical tests reported).^{16;22;29;51;52}

Four of the five cross-sectional studies that compared the risk of absenteeism in those with COPD or airflow limitation with those without, had similar trends. The remaining Canadian study found no significant difference between those with and without COPD.⁴⁹ However, there was a lack of adjustment for important potential confounders.

Ten studies (4 cohort^{32;35;42;43}, 6 cross-sectional^{30;31;38;39;47;50}) compared the amount of time off work among people with and without COPD. Three of the cohort studies^{35;42;43} (occupational) found that people with COPD had more time off work whilst the fourth³² found this in only one of the two time periods assessed. The largest of these studies matched for a number of important factors, and had an 8 year follow-up (mean days off work per month 1.0 in those with vs. 0.6 without COPD; incident rate ratio=1.53).⁴³ The remaining cross-sectional studies demonstrated similar patterns, although five of the six^{31;38;39;47;50} did not adjust for some important confounders.

The mean number of days off among patients with COPD ranged from 1.6 (projected) to 12.0 (calculated) days over 12 months.^{31;43} However, the latter (1 day per month/per

patient) may provide a more reliable estimate as in this cohort study COPD diagnosis and sickness absence rates were taken from medical reports and the company database, respectively.⁴³

The relationship between disease severity and absenteeism was assessed in fifteen studies^{10;15;17-19;28;30;33;34;36;37;41;45;46;48}; of which two cohort^{18;19} and three cross-sectional studies^{28;33;46} found no associations, even after adjusting for a range of confounders in two of the studies.^{33;46} Two large and one smaller cross-sectional study did show a positive association ($p < 0.05$) between airflow obstruction and sickness absence, however none adjusted for confounders.^{34;36;48} Another two studies found a similar pattern but reported no statistical tests.^{30;45}

Five large and one smaller cross sectional study investigated the impact of other measures of disease severity: the COPD Assessment Test (CAT) score,⁴¹ symptom score,¹⁵ mMRC/MRC score^{10;17;46} and perceived disease severity.³⁷ Three studies^{15;41;46} found greater symptoms were associated with an increased risk of sickness absence after adjusting for a number of confounders (MRC 4 and 5 vs. MRC 1: OR=13.83; 95% CI 3.78 – 50.56⁴⁶). One found greater perceived disease severity was associated with a higher rate of sickness absence (adjusted $p < 0.001$).³⁷ Two further studies, although not statistically significant, indicated that increased breathlessness was associated with greater absenteeism.^{10;17}

Fourteen cross-sectional studies assessed the effect of COPD on work performance. Studies were drawn from workplaces,^{9;32;45;50} primary/secondary care^{16;22;29;51;52} or the general population.^{31;37-40}

The assessment of presenteeism varied widely between studies. Nine large cross-sectional studies used the Work Productivity and Activity Impairment (WPAI) questionnaire; of which three were based in the USA³⁷⁻³⁹ and six in Asia.^{16;22;29;40;51;52} Four large general population based studies found that people with COPD were significantly more likely to report presenteeism compared to those without COPD ($p < 0.001$), after adjusting for confounders. The remaining five Asian studies (same series) found poorer presenteeism scores among those with asthma, allergic rhinitis and rhinosinusitis compared to those with COPD (no statistical data reported).^{16;22;29;51;52}

Two cross-sectional studies used the World Health Organization Health and Work Performance Questionnaire (WHO-HPQ).^{9;50} Although both found no significant association, one suggested COPD patients might be at increased risk of presenteeism.⁹

A serial cross-sectional study based in a large US company obtained data over two time periods using two presenteeism questionnaires: the Work Limitation Questionnaire (WLQ) and the Health and Work Productivity-One Survey (HWP-1).³² The study found that presenteeism was greater among those with COPD compared to matched cases who did not have COPD at the 1st time point ($p \leq 0.05$), although no significant association was seen at the other time point.

One cross-sectional study based on an employed Japanese population of 1378 people, consisting of a smaller sample of people with airflow limitation ($n=98$), assessed the impact of airflow limitation on perceived quantity and quality of work,⁴⁵ and found that after adjusting for a number of confounders, those with moderate to severe airflow limitation

were approximately twice as likely to report lower work quality (adjusted OR=2.04; 95% CI 1.12 – 3.71) and quantity scores (adjusted OR=2.19; 95% CI 1.21 – 4.00) compared to those with no airflow limitation.

The final cross-sectional study was based on a US general population survey (n=8855) and found that those with self-reported emphysema (43.5%) were more affected at work due to their condition compared to those who reported asthma (19.1%) and chronic bronchitis (3.4%).³¹

Nine studies assessed the relationship between disease severity and presenteeism.^{10;15;17;28;37;41;45;46;48} Disease severity was measured using various methods: degree of airflow obstruction^{28;45;46;48} (n=4), CAT score⁴¹ (n=1), symptom score¹⁵ (n=1), breathlessness^{10;17;46} (n=3) and perceived disease severity.³⁷

An association between severity of airflow obstruction and work performance were indicated in three studies (no adjustment for confounding),^{28;45;48} but not the fourth.⁴⁶ Significant associations were found between poorer work performance and greater CAT scores⁴¹ (CAT score 30-40 vs. CAT score 0-9: adjusted coefficient: 1.68; 95% CI 1.39 – 1.97), symptoms¹⁵ (always vs. do not always experience a symptom: adjusted coefficient= 0.06; 95% CI 0.04 – 0.08) and breathlessness^{17;46} (MRC score 4 and 5 vs. MRC score 1: adjusted OR=18.11; 95% CI 2.93 – 112.11⁴⁶). The last study, assessed perceived level of disease severity, and found a significant positive association with presenteeism (adjusted mean % presenteeism: 22.7% (mild), 27.3% (moderate) and 35.3% (severe); p<0.001).³⁷

Discussion

Although the prevalence of employment among COPD patients varied from 13.3% to 69.2%,^{8;22} there was clear and consistent evidence across settings and populations that employment rates among patients with COPD were lower compared to those without. This was observed in a 16 year cohort study,²⁷ a large matched retrospective cohort study²³ as well as five large cross sectional studies.^{6-8;24;30} Supporting these findings was some weaker evidence that as disease severity increased patients were less likely to be in paid employment.

Despite the inconsistencies in recall periods (1 week to 6 years) and wide variation in the period of data collection (1964 to 2013) strong evidence from 1 cohort study⁴³ in addition to some evidence from other cohort studies^{32;35;42} demonstrated that patients with COPD took more time off work compared to those without. Five cross-sectional studies with some methodological weaknesses also supported these results.^{30;38;39;47;50} A reliable estimate of the extent of absenteeism was that COPD patients took an average of 12 days off over 12 months compared to 7.2 days in those without COPD.⁴³ Furthermore, when measuring disability-related work loss, there was clear evidence from a cohort study that COPD patients were approximately twice as likely to have a short term disability and more than 4 times as likely to have long term disability compared to those without COPD.³⁵

The evidence for associations between disease severity (measured by airflow obstruction) and absenteeism was inconsistent, and comparison of study findings was difficult due to methodological weaknesses (e.g. small sample sizes, lack of adjustment for confounders), differences in measures of disease severity, and measures of absenteeism. There was

however, increasing evidence from adjusted analyses that absenteeism was worse among people with greater symptoms.

For presenteeism, there was weak evidence that patients with COPD had poorer work performance than those without, with some inconsistency in findings. Due to the various scales used to measure presenteeism it was difficult to quantify these differences. Some of the inconsistencies may be attributable to gender and age differences between samples.³²

There was conflicting evidence on the effect of disease severity on work performance, in particular the relationship with airflow obstruction. Similar to the data on absenteeism, analyses using other measures of disease severity did show significant associations with work performance; of which the majority were adjusted for the effect of confounding.

There were some well-conducted observational studies included in this review, which either matched or adjusted for a range of important covariates. However, adjustment for confounders or important confounders was an identified problem among many studies, making it difficult to interpret the reported effect sizes. Additionally, some studies did not go beyond descriptive statistics and hence, reported no effect size. Many studies also displayed limited external validity.

This is the first comprehensive systematic review, assessing the effect of COPD on work-related outcomes. However, the review had some limitations. Firstly, it was restricted to publications in English. Only one reviewer screened all citations from the electronic databases. A standardised tool was not available to evaluate the methodological strength of the evidence. However, to our knowledge, there is currently no gold-standard tool to assess bias within cross-sectional studies. There was high heterogeneity between the studies, making it difficult to compare and synthesise the results.

Two other reviews have been published^{55;56}; despite the differences in the methodology of these compared to the current review, the main results were broadly similar. However, Patel et al's⁵⁶ study focused on studies within the USA, and little was discussed on the effects of COPD disease severity on work outcomes in Chaker et al's study.⁵⁵

Due to the methodological weaknesses found within the current literature, the following are required for future studies: prospective studies with matched controls or better control of confounders; use of validated scales; methods of data collection to minimise recall error (e.g. routine data on sickness absence, or data from company records) and robust methods in diagnosing lung disease (i.e. spirometry data). Future studies should measure work performance using an agreed and standardised questionnaire and recall periods, to allow comparisons between studies.

Whilst the effect of airflow obstruction on outcomes was unclear, we did find associations between other measures of disease severity and employment, absenteeism and presenteeism.^{15;26;41;46} This supports findings from other literature that other measures, such as extent of breathlessness, may be more important for assessing severity in relation to impact on outcomes in patients with COPD.

Poorer employment and work productivity among people with COPD may be partly attributable to their work conditions or to poor disease management. It is important to raise awareness among employers and for better liaison between the workplace and the employees' health providers. Employers could provide support by ensuring access to smoking cessation programmes and time for employees to attend relevant self-

management programmes.¹ They could also support employees by undertaking workplace risk assessments and adjusting their work tasks to reduce the risk of triggering exacerbations.⁵⁷ By promoting the health of employees with chronic disease, employers will not only benefit the patient, but also improve work productivity in their workforce.

This review highlighted the lack of strong evidence on the effect of COPD on presenteeism, and suggests that the presence of symptoms rather than airflow obstruction impact on outcomes. Longitudinal studies, using standardised instruments and sufficient data to adjust for confounders, are required to confirm these observations. There is also a need to understand how to support COPD patients to remain in work and improve their work productivity. In order to inform interventions, we need to understand which modifiable aspects of the disease, personal or work characteristics contribute to the burden of COPD on work. Such interventions are needed to benefit both the physical and mental health and wellbeing of patients, as well as to benefit society.

Key points:

- Patients with chronic obstructive pulmonary disease have lower employment rates and take more time off work compared to those without COPD.
- There is conflicting evidence about the effects of airflow obstruction on work-related outcomes, however there is evidence that symptoms are important; longitudinal studies are needed to confirm this.
- Better understanding of the modifiable factors associated with lower employment rates and poorer work productivity are needed to help design effective interventions.

- Further research is required, particularly prospective studies which account for relevant confounders, use robust methods in diagnosing COPD, measure absenteeism and presenteeism using agreed and standardised questionnaires and recall periods, and allow comparison of data between studies.

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Author, country	Study design, setting, study period	Characteristics of participants	Study results			Comments	
Cross-sectional studies							
Ding et al (2017a) ⁴¹ China, Europe and USA	Cross-sectional Primary and secondary care COPD population 2010 and 2013	N=2166 Mean age (years) (SD): 65.1 (10.7) Sex (male) (%): 66.6 FEV₁ % predicted: 61.9	<u>COPD Assessment Test (CAT) score</u> 0 – 9 score: 10 – 19 score: 20 – 29 score: 30 – 40 score: Coefficient (95% CI): P value:	<u>Work time missed (%)</u> 0.1(1.1%) 3.3 (13.9%) 9.4 (23.4%) 8.4 (24.3%) 0.445 (0.169 – 0.720) 0.002	<u>Presenteeism score (%)</u> 6.9 (9.2%) 19.5 (15.7%) 33.8 (18.8%) 51.7 (21.8%) 1.68 (1.392 – 1.967) <0.001	Adjusted for: age, BMI, smoking status and history, physician confirmed diagnosis of depression, anxiety and serious cardiovascular conditions. Presenteeism definition unclear (e.g. due to COPD or general health).	
Rai et al (2017a) ²⁶ UK	Cross-sectional Primary care COPD population 2012 – 2014	N=608 Age (years) (n, %): 38 – 49: 68 (11.2) 50 – 59: 253 (41.6) 60 – 64: 287 (47.2) Sex (male) (%): 56.4 FEV₁ % predicted: unknown	OR (95% CI) for the likelihood of being in paid employment according to disease severity P for trend:	<u>Modified BODE index score quartiles</u> 1: 1.0 (reference) 2: 0.84 (0.48 – 1.47) 3: 0.38 (0.19 – 0.74) 4: 0.10 (0.03 – 0.33) <0.01	<u>mMRC score</u> 0 – 1: 1.0 (reference) 2: 1.18 (0.64 – 2.18) 3: 0.23 (0.08 – 0.62) 4: 0.36 (0.15 – 0.85) 0.60	<u>Airflow obstruction (postbronchodilator FEV₁ % predicted)</u> >65: 1.0 (reference) 50-65: 0.84 (0.40 – 1.77) 34-49: 0.80 (0.38 – 1.71) ≤35: 0.41 (0.16 – 1.03)	Adjusted for age, sex, smoking status, education, number of comorbidities, disease severity (BODE index score/components of the BODE index) and occupational exposures to vapours, gases, dusts and fumes.
Rai et al (2017b) ⁴⁶ UK	Cross-sectional Primary care COPD population 2012 – 2014	N=348 Age (years) (n, %): 38 – 49: 38 (10.9) 50 – 59: 122 (35.1) 60 – 64: 88 (25.3) ≥65: 100 (28.7) Sex (male) (%): 62.4 FEV₁ % predicted: unknown	<u>Airflow obstruction according to GOLD staging</u> Mild: Moderate: Severe and very severe: <u>MRC dyspnoea score</u> 1: 2: 3: 4 and 5:	<u>Likelihood of high absenteeism according to disease severity, OR (95% CI)</u> 1.00 (reference) 1.00 (0.39-2.58) 1.84 (0.54 – 6.27) 1.00 (reference) 0.46 (0.12 – 1.78) 2.65 (0.72 – 6.24) 13.83 (3.78 – 50.56)	<u>Likelihood of poor work performance according to disease severity, OR (95% CI)</u> 1.00 (reference) 1.08 (0.40 – 2.90) 1.03 (0.26 – 4.09) 1.00 (reference) 0.83 (0.28 – 2.48) 2.65 (0.88 – 7.95) 18.11 (2.93 – 112.21)	Adjusted for age, sex, smoking status, social deprivation, number of comorbidities, GOLD stage, MRC score, usual working hours (absenteeism analysis only), occupational exposures to vapours, gases, dusts and fumes (presenteeism analysis only) and length of current employment (presenteeism analysis only)	

Author, country	Study design, setting, study period	Characteristics of participants	Study results				Comments	
Cross-sectional studies								
Onoue et al (2016) ⁴⁵ Japan	Cross-sectional Employed population 2012 - 2013	N=1378 (n=98 with airflow limitation) Characteristics not reported for whole sample (split into 3 categories according to airflow limitation). See supplementary tables for details.	<u>Sick leave according to airflow limitation, n (%)</u>	<u>No airflow limitation (AL)</u>	<u>Mild AL</u>	<u>Moderate to severe AL</u>		
			OR (95% CI): P value:	Reference -	15 (41.7%) 1.36 (0.67-2.76) 0.40	20 (54.1%) 2.69 (1.33-5.44) 0.006	High proportion of males in those with AL. Those with certain comorbidities excluded from the study. Sick leave based on 12 month recall period. Adjusted for age, sex, BMI, smoking status, hypertension, hyperglycaemia, dyslipidaemia, sleep duration, work hours per day, smoking environment at workplace	
Montes de Oca et al (2011) ⁷ Latin America	Cross-sectional Population based survey 2003 - 2004	N=5314 (n=759 COPDs) Characteristics not reported for whole sample (split by COPD diagnosis and work status). See supplementary tables for details.	<u>Employment in those with COPD vs. no COPD</u>	<u>Work for pay, n (%)</u>	<u>Mean+SE months for pay (adjusted for survey design)</u>	<u>Mean+SE days for pay (adjusted for survey design)</u>	<u>Mean+SE hours for pay (adjusted for survey design)</u>	<u>Health problems stop person from working, n (%)</u>
			Adjusted OR (95% CI): P value:	317 (41.8%) 2602 (57.1%) 0.83 (0.69 – 1.00) 0.054	10.5 ± 0.17 10.9 ± 0.06 -	5.85 ± 0.08 5.71 ± 0.03 -	8.97 ± 0.17 8.75 ± 0.06 -	27 (3.6%) 196 (4.3%) -
			<u>Employment according to disease severity</u>	<u>GOLD stage 1</u>	<u>GOLD stage 2</u>	<u>GOLD stage 3 and 4</u>	<u>Mean FEV1 % predicted + SE</u>	
			Employed: Not employed: P value (adjusted for survey design):	194 (61.2%) 257 (58.1%) 0.29	106 (33.4%) 150 (33.9%)	17 (5.4%) 35 (7.9%)	78.7 ± 1.2 79.7 ± 1.2 0.55	
Boot et al (2004) ³³ The Netherlands	Cross-sectional Primary care COPD/asthma population	N=189 (assessed subset of 71) Mean age (years) (SD): COPD sick leave: 47.8 (9.5); COPD no sick leave: 54.0 (6.3) Male (%): COPD sick leave: 67; COPD no sick leave: 62 FEV₁% predicted: unknown	<u>Sickness absence in past 12 months according to disease severity</u>	<u>Mild, n (%)</u>	<u>Moderate (IIa), n (%)</u>	<u>Moderate (IIb), n (%)</u>	<u>Severe, n (%)</u>	
			No sick leave: Sick leave: P value:	3 (12.0%) 9 (19.0%) >0.05	17 (65.0%) 21 (48.0%)	4 (15.0%) 15 (33.0%)	2 (8.0%) 0 (0%)	Small sample size, fewer females and fewer patients with severe disease. Although various methods used to recruit, little detail on how many participants were approached by healthcare professional. Although answer to sick leave is yes/no, recall period is 12 months. Adjusted for a range of confounders. Limited information on COPD severity classification.

Author, country	Study design, setting, study period	Characteristics of participants	Study results	Comments
Cross-sectional studies				
Sin et al (2002) ⁸ USA	Cross-sectional General population based survey 1966 – 1970	N=12436 (n=1073 COPDs) Mean age (years) (SD): 37.9 (13.2) (overall population) Male (%): 46.5 COPD: 58.5 Non-COPD: 47.4 FEV₁% predicted: unknown	<u>Working in past 2 weeks (%)</u> COPD: 69.21% No COPD: 77.24% Reduction in probability of being in work (95% CI): -3.9% (-1.3 to -6.4) P value: 0.032 <u>% reduction in employment according to airflow obstruction compared to those without significant airflow obstruction:</u> 3.4% P for linear trend: <0.01 <u>FEV₁ % predicted >80% (mild)</u> <u>FEV₁ % predicted 30% - 80% (moderate)</u> <u>FEV₁ % predicted <30% (severe)</u> 3.9% 14.4%	Although COPD diagnosis was based on self-report, disease severity was based on GOLD criteria. Did not adjust for co-morbidities.

Abbreviations: BODE index, body-mass index, airflow obstruction, dyspnoea and exercise capacity index; CAT, COPD Assessment Test; CI, confidence interval; COPD, chronic obstructive pulmonary disease; FEV₁, forced expiratory volume in 1 second; GOLD, Global Initiative for Chronic Obstructive Lung Disease; mMRC score, modified Medical Research Council score; OR, odds ratio; SD, standard deviation; SE, standard error.