Addiction

REVIEW

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Smoking and absence from work: systematic review and meta-analysis of occupational studies

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ABSTRACT

Aims This study aimed to assess the association between smoking and absenteeism in working adults. **Methods** A systematic review and meta-analysis was performed by electronic database searches in MEDLINE, EMBASE, CAB Abstracts, PubMed, Science Direct and National Health Service Economic Evaluation Database (February 2012). Longitudinal, prospective cohorts or retrospective cohorts were included in the review. Summary effect estimates were calculated using random-effects meta-analysis. Heterogeneity was assessed by I^2 and publication bias was investigated. **Results** A total of 29 longitudinal or cohort studies were included. Compared with non-smokers, current smokers had a 33% increase in risk of absenteeism [95% confidence interval (CI): 1.25–1.41; $I^2 = 62.7\%$; 17 studies]. Current smokers were absent for an average of 2.74 more days per year compared with non-smokers (95% CI: 1.54–3.95; $I^2 = 89.6\%$; 13 studies). Compared with never smokers, ex-smokers had a 14% increase in risk of absenteeism (95% CI: 1.08–1.21; $I^2 = 62.4\%$; eight studies); however, no increase in duration of absence could be detected. Current smokers also had a 19% increase in risk of absenteeism compared with ex-smokers (95% CI: 1.09–1.32, $P < 0.01$, eight studies). There was no evidence of publication bias. The total cost of absenteeism due to smoking in the United Kingdom was estimated to be £1.4 billion in 2011. **Conclusions** Quitting smoking appears to reduce absenteeism and result in substantial cost-savings for employers.

Keywords Absenteeism, meta-analysis, productivity loss, smoking, systematic review, work-place.

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INTRODUCTION

Smoking is responsible for cardiovascular, cerebrovascular, respiratory and other diseases, including cancer of the lungs and other organs [1], causing one in 10 adult deaths world-wide [2]. The risk of premature death is extremely high as a result of these smoking-related diseases. This poses a serious economic burden for many countries. The 50-year follow-up of the British male doctors cohort found that men born from 1900 to 1930 who smoked cigarettes died on average about 10 years younger than life-long non-smokers [3]. The World Bank estimates that tobacco use results in a global net economic loss of $200 billion (US$) per year attributable to health-care costs and lost productivity, of which smoking-related premature death and absenteeism in the work-force is a major contributing influence [2]. Large financial and social costs due to smoking come in the form of productivity loss as a result of death, absenteeism, sick leave or disability of the work-force. In the United States, the Centre for Disease Control and Prevention estimates between 2000–2004, cigarette smoking and tobacco exposure resulted in 443 000 premature deaths, equating to approximately 5.1 million years of potential life lost (YPLL) [4]. In the United Kingdom, approximately 50 million working days are lost each year due to smoking, valued at £2.5 billion (inflated to 2011 levels) [5]. A study of employers in Scotland found that the annual cost of employee smoking was estimated to be about £450 million from lost productivity due to absence from work, smoking breaks and fire damage [6]. The sheer scale of the finances suggests that decreases in smoking prevalence in the work-force may result in significant gains in productivity through reduced absenteeism. These costs may provide motivation for employers to support smoking cessation programmes, as potential near-term benefits may be gained by a reduction in absenteeism.

There is some evidence in published studies to suggest that smoking is associated with absenteeism [5,7–11]. However, the evidence has not been reviewed systematically or evaluated for publication bias and quality of the studies or synthesized in a meta-analysis. Thus, the aim of this study was to evaluate and quantify the relationship between smoking and absenteeism in the working population through a systematic review and meta-analysis of longitudinal and cohort studies. We adhered to Preferred Reporting Items For Systematic Reviews and Meta-Analyses (PRISMA) [12] and Meta-Analyses and Systematic Reviews of Observational Studies (MOOSE) [13] guidelines to ensure a high level of quality assurance with regards to selecting and extracting data.

METHODS

Search strategy

We conducted a comprehensive search of electronic databases: MEDLINE (1948–February 2012), EMBASE (1980–February 2012), PubMed (1950–February 2012), Science Direct (1950–February 2012) and the National Health Service (NHS) Economic Evaluation Database (1980–February 2012). Grey literature was searched for in CAB Abstracts (1910–February 2012), which includes all relevant conference proceedings. In addition, reference lists from included studies were checked for potential studies. Keywords relating to 'smoking' and 'absenteeism' were used to search for all relevant papers. These keywords were developed through group discussion and consensus (S.F.W., J.L.B., C.Q., S.A.) and piloted in each individual database before the formal search process. Where available in the database, medical subject headings (MeSH) were used to identify related terms.

Inclusion criteria

Studies meeting all the following key criteria were included in the review:

1. Study design: the designs included in the review were longitudinal studies, prospective cohorts or retrospective cohorts in order to evaluate temporal relationship between smoking and absenteeism.
2. Population: the studies including subjects who were full-time, part-time or self-employed adult wage earners in any occupation were included in the review.
3. Exposure: studies that established the primary exposure of smoking (cigarette, pipe, cigar) through one of the following methods were included: self-reported interview, self-reported survey, medical/employee records or validated biomarker such as cotinine or carbon monoxide.
4. Outcome: the primary outcomes of interest were the following measurements of absenteeism established through self-reported interview, medical/employee records or self-reported survey: duration of absence (days, hours, percentage of work time lost) or risk of absence (risk, odds, hazard).

Data extraction

Two authors (S.W. and J.L.B.) selected studies independently based on titles and abstracts. Titles were excluded on the basis of subject matter, while abstracts were excluded when inclusion criteria for study design or population were not met. Full-text papers were retrieved from the remaining studies. The full-text papers that were not written in English were translated using both a human translator (T.L.) and an electronic language translator. Full-text papers were screened and selected independently for inclusion by two reviewers (S.W. and J.L.B.; S.W. and C.Q.; or S.W. and S.A.) using a designed checklist based on eligibility criteria. The data extraction form was developed and piloted independently on five initial studies. Two reviewers (either S.W. and J.L.B.; or S.W. and S.A.) extracted the data from the studies independently using a standardized form, including data on study design, study population, location, sample size and reported results.

Quality assessment

To assess the methodological quality of selected studies, the Newcastle–Ottawa Scale (NOS) was used [14]. According to the NOS, studies were judged according to three domains: (i) selection of the study groups, (ii) comparability of the groups and (iii) ascertainment of the outcome of interest, with a maximum total score of 9. Two reviewers (either S.W. and J.L.B.; or S.W. and S.A.) assessed independently the quality of the included studies. Any disagreements were resolved by discussion and consensus.

Statistical analysis

The meta-analysis evaluated the following outcomes: (i) relative risk (RR) of absence and (ii) mean difference in days absent per year (annualized).

We used rate ratios and hazard ratios as estimates of relative risk ratios [15] and transformed odds ratios to risk ratios using the correction method [16]. Separate analyses were conducted to assess the effect of smoking by comparing current smokers versus non-smokers, ex-smokers versus never smokers and current smokers versus ex-smokers. Random-effects meta-analysis models were used to analyse the data from different studies and to account for differences in population characteristics, geography and time.

Primary and sensitivity analyses

Three meta-analyses were performed using the extracted data: relative risk of absence for current smokers versus non-smokers (model 1); mean difference in duration of absence for current smokers versus non-smokers (model 2); and relative risk of absence for ex-smokers versus never smokers (model 3). In addition, we performed indirect comparison meta-analysis using inverse variance weighting [17] to analyse the risk of absence between current smokers and ex-smokers to test for true effect of quitting smoking. Where available, we used adjusted RR estimates extracted from the studies opposed to unadjusted results to take into account additional study-level covariates. We were not able to perform a meta-analysis of the mean difference in duration of absence between ex-smokers and never smokers due to a limited number of studies that reported standard deviation parameters. Heterogeneity between the studies was assessed using the I^2 statistic [18].

Some studies in the meta-analysis had missing data for measures of dispersion [e.g. standard deviations or 95% confidence intervals (CI)]. For some of these studies ($n = 5$), it was possible to obtain the measure of dispersion from the P-values or using the exact t-statistic or F-statistic. For other studies ($n = 6$) with insufficient data to enable estimation of dispersion, we imputed a measure of dispersion by first running an initial model with only those studies that had a measure of dispersion available and then imputing a dispersion measure for the studies with insufficient data. However, to evaluate the impact of imputation of dispersion parameters, we conducted sensitivity analysis without the studies with imputed measures of dispersion.

Subgroup analyses and meta-regression

To explore reasons for heterogeneity, subgroup analyses were conducted using the above random effects models to evaluate effect size based on sex (male, female), work sector (private, public, unclassified), type of absence (short <4 weeks, long ≥4 weeks, undefined) and methodological quality of the study (based on the selection, comparability and ascertainment domains). To evaluate statistical significance of difference in effect size based on subgroups, we conducted random-effects meta-regression [19] for subgroups that appeared to have large differences in effect sizes.

Publication bias

Publication bias was assessed visually by funnel plot and statistically by Egger's test for asymmetry [20] based on the distribution of effect sizes against standard errors. The analyses were completed in STATA version 11 (Stata Corp, College Station, TX, USA).

RESULTS

Description of studies

The electronic database search yielded a total of 3080 studies (Fig. 1). After removing duplicates ($n = 993$) and excluding studies based on relevance of titles and abstracts ($n = 1906$), 181 full-text papers were retrieved for evaluation. After screening full-text papers for eligibility, 29 studies [21–49] were identified for inclusion in the systematic review. The most common reason for exclusion was non-cohort or non-longitudinal study design (56 studies excluded) or smoking status was not reported (54 studies excluded). Other reasons for exclusion included no definition of absenteeism (18 studies), duplicates of the same participants (eight studies), non-adult participants (seven studies), unavailable full-text papers (seven studies) and protocols only (two studies).

The study characteristics and study-effect estimates are presented in Table 1. The year of publication for the studies ranged from 1960 [39] to 2011 [46], with a median year of publication of 2003. Most studies were conducted in western countries, although three studies were from eastern Europe [32,33,37], two from Japan [36,41] and one study was from Israel [29].

Quality assessment

The quality scores on NOS ranged from the lowest score of three to the highest score of eight with a median of six (interquartile range: 5–7) (Table 1). All the included studies relied upon self-reported smoking status either through interview or survey. Lower scores were generally related to studies not taking into account confounding variables and/or having high attrition rates without providing descriptions of those lost.

Current smokers versus non-smokers

Risk of absenteeism

Seventeen studies [21,22,25–28,31,34–38,41–43,45,46] compared the risk of work absenteeism for current smokers, of which eight studies [25,26,28,38,41,42,45,46] compared the risk between current smokers and never smokers and nine studies [21,22,27,31,34–37,43] compared the risk between current smokers and non-smokers (including ex-smokers). The follow-up duration ranged from 3 months [27] to 144 months [31] with a median duration of 24 months. There were 71 516 workers in the sample, with an over-representation of men (50%) compared to women (40%). To test for the overall effect of current smoking, never smokers and non-smokers were combined in a single 'non-smoking' group. The pooled meta-analysis showed that current smokers were 33% more likely to take work absence than

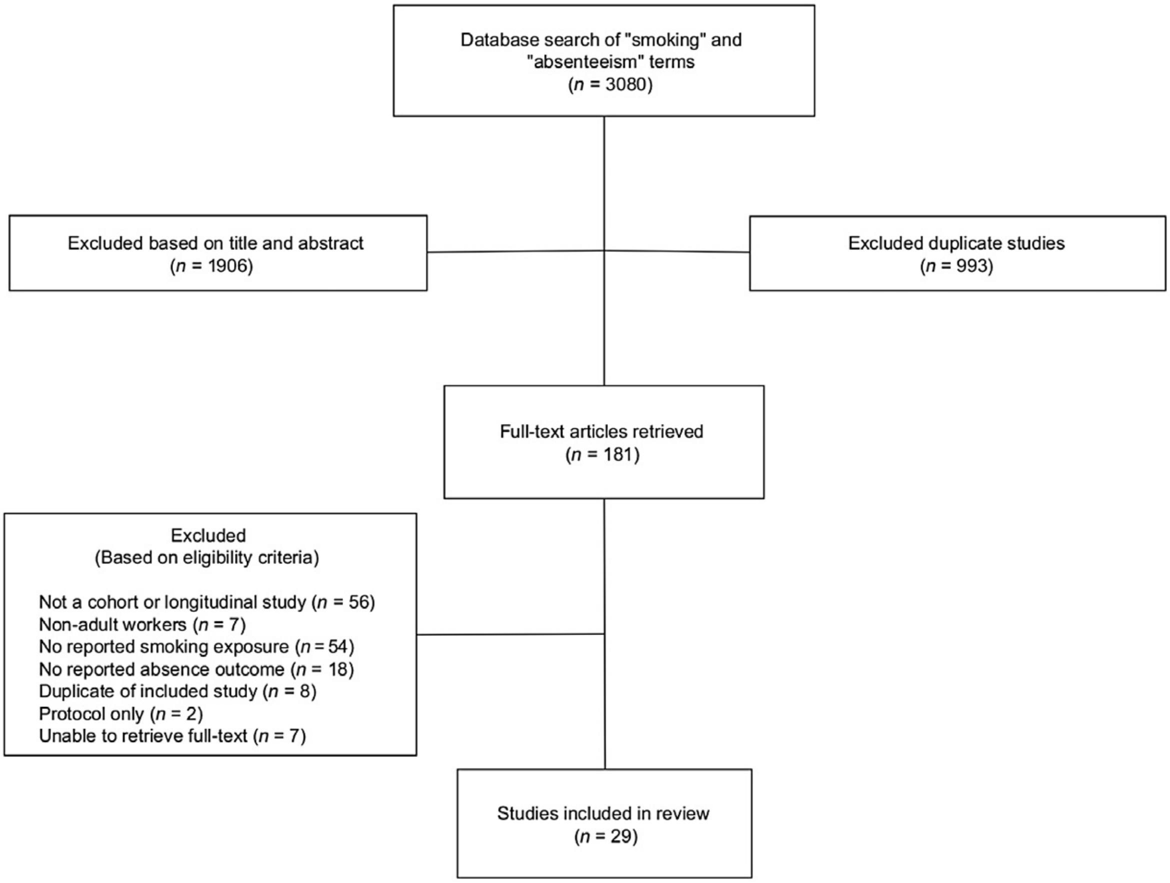

Figure 1 Search flow-chart and selection process

non-smokers (RR = 1.33, 95% CI: 1.25–1.41; I^2 = 62.7%; 17 studies; Fig. 2). When meta-analysis was stratified based on whether or not study-level covariates such as age, sex and life-style factors were adjusted for, the pooled estimates were similar to the overall relative risk (adjusted RR: 1.35 , 95% CI: 1.25–1.45; unadjusted RR: 1.25, 95% CI: 1.17–1.35).

In the subgroup of eight studies comparing the risk of absence between current and never smokers, we found almost identical results (RR = 1.36, 95% CI: 1.27 to 1.47; I^2 = 68%; eight studies) to the overall analysis comparing the risk between current and non-smokers.

Duration of absenteeism

Thirteen studies [23,24,29,30,32,33,37,39,40,44, 47–49] compared the duration of work absence between current smokers and non-smokers. There was a total of 30 978 workers in these studies. The follow-up duration ranged from 3 months [30] to 120 months [47] with a median of 24 months. The continuous outcomes of duration of absence were not adjusted for any additional study-level covariates in the extracted data. Most studies included in the meta-analysis of duration of absenteeism reported the results separately for men and women; hence, we performed both stratified (by gender) and overall meta-analysis. The overall mean annual difference in absence between current smokers and non-smokers was 2.74 days (95% CI: 1.54–3.95 days; I^2 = 89.6%; 13 studies; Fig. 3). In men, current smokers were absent, on average, 1.18 more days per year than non-smokers (95% CI: 0.51–1.84 days; I^2 = 28.4%; eight studies); whereas in women, the difference between current and non-smokers was not significant (days/year = 0.75; 95% CI: 0.63–2.12; I^2 = 69%; six studies). When the results from the meta-analysis were applied to the UK population with an adult smoking prevalence of 21% [50], employment rate of 70.5% (29.17 million) [51] and an average pay of £434 per week [51], we estimated that the total cost of absenteeism due to smoking was £1457 million (95% CI: £819–2100 million) in 2011.

Ex-smokers versus never smokers

Risk of absenteeism

Eight studies [25,26,28,38,41,42,45,46] compared the risk of absenteeism for ex-smokers and never smokers,

Table 1 Selected characteristics of studies included in the analysis of the relationship between smoking and absenteeism (29 studies).

						Relative risk of absence (95% confidence interval)		*Mean diff. (SDpooled) (days absent per year)*		
First author/year	*Location*	*Sample size*	*Start year/ duration (months)*	*Adjusted results (yes/no)*	*Sex (M/F/both)*	*Current versus non/never smoker*	*Ex versus never smoker*	*Current versus non-smoker*	*Ex versus never smoker*	*Quality score*
Alavinia 2000 [21]	Netherlands	5 867	2005/14	Yes	M	1.18 (1.07–1.30)	–	–	–	7
Andersen 2010 [22]	Denmark	5 096	2000/24	Yes	Both	1.50 (1.29–1.75)	–	–	–	8
Athanasou 1979 [23]	Australia	424	–/24	No	M	–	–	5.62 (2.32)	–	3
					F			0.24 (0.39)		
Batenburg 1990 [24]	New Zealand	892	1987/12	No	M	–	–	0.60 (0.35)	–	6
					F			0.75 (0.92)[b]		
Christensen 2007 [25]	Denmark	5 020	2000/18	Yes	M	1.55 (1.00–2.40)	1.36 (0.85–2.19)	–	–	7
					F	2.05 (1.36–3.08)	1.61 (1.07–2.42)			
De Backer 2006 [26]	Belgium	20 651	1994/12	Yes	M	1.32 (1.21–1.43)[a]	1.32 (1.21–1.43)[a]	–	–	6
					F	1.21 (1.08–1.36)[a]	1.21 (1.08–1.36)[a]			
Eriksen 2004 [27]	Norway	4 931	1999/3	Yes	Both	1.27 (1.04–1.53)[a]	–	–	–	7
Ferrario 2007 [28]	Italy	3 277	1992/24	Yes	Both	1.25 (1.09–1.43)[a]	1.06 (0.86–1.30)[a]	–	–	5
Green 1992 [29]	Israel	5 826	1985/24	No	M	–	–	1.30 (0.39)		6
					F			–0.47 (0.63)		
Halpern 2001 [30]	USA	292	–/3	No	Both	–	–	10.7 (2.16)	4.29 (1.47)	4
Holmberg 2010 [31]	Sweden	836	1990/144	Yes	Both	1.05 (0.53–2.08)[a]	–	–	–	5
Indulski 1967 [32]	Poland	2 874	1960/24	No	M	–	–	1.72 (0.92)[b]	–	4
					F			3.10 (0.92)[b]		
Jedrychowski 1976 [33]	Poland	197	1968/72	No	M	–	–	0.72 (0.92)[b]	0.42 (–)	5
Karlsson 2010 [34]	Sweden	341	2003/24	Yes	Both	0.79 (0.55–1.15)	–	–	–	6
Kivimäki 1997 [35]	Finland	763	1994/24	Yes	Both	1.02 (0.67–1.55)	–	–	–	6
Kondo 2006 [36]	Japan	529	1997/24	Yes	Both	1.85 (0.86–3.76)[a]	–	–	–	6
Kozak 1987 [37]	Czech Republic	675	1981/48	No	M	1.30 (1.00–1.57)[a]	–	–1.70 (4.46)	–	3
					F	1.24 (1.00–1.47)[a]		–3.50 (3.09)		
Laaksonen 2009 [38]	Finland	6 934	2000/47	Yes	M	1.69 (1.44–1.97)	1.11 (0.98–1.27)	–	–	8
					F	1.50 (1.40–1.60)	1.18 (1.12–1.25)			
Lowe 1960 [39]	UK	3 341	1957/12	No	M	–	–	1.33 (0.92)[b]	–	5
Lundborg 2007 [40]	Sweden	14 272	1988/12	No	Both	–	–	14.1 (1.28)	4.55 (1.20)	8
Morikawa 2004 [41]	Japan	2 504	1990/96	Yes	Both	1.43 (1.17–1.75)	1.39 (1.07–1.80)	–	–	6
Niedhammer 1998 [42]	France	12 555	1995/12	No	M	1.24 (1.10–1.38)	1.10 (1.00–1.20)	–	–	6
					F	1.26 (1.11–1.41)	1.03 (0.96–1.10)			
North 1993 [43]	UK	7 715	1985/20	Yes	M	1.61 (1.31–1.99)	–	–	–	6
					F	1.22 (0.97–1.44)				
Ryan 1992 [44]	USA	2 537	1986/14	No	Both	–	–	4.75 (0.92)[b]	–	5
Skillgate 2009 [45]	Sweden	6 532	1999/36	Yes	Both	1.80 (1.20–2.60)	1.80 (1.30–2.40)	–	–	8
Tsai 2011 [46]	USA	6 551	2005/48	Yes	Both	1.18 (0.95–1.44)[a]	1.08 (0.91–1.26)[a]	–	–	7
Tsai 2005 [47]	USA	2 203	1990/108	No	M	–	–	6.30 (3.21)	1.70 (–)	5
					F			11.0 (5.58)	0.20 (–)	
Tsai 2003 [48]	USA	2 550	1994/120	No	Both	–	–	2.90 (0.92)[b]	–	5
Van Tuinen 1986 [49]	USA	406	1983/20	No	Both	–	–	1.50 (0.76)	–	5

[a]Relative risk derived from odds ratio correction method [16]. [b]Proxy standard deviation obtained from meta-analysis of complete studies. M: male; F: female; –: unreported data.

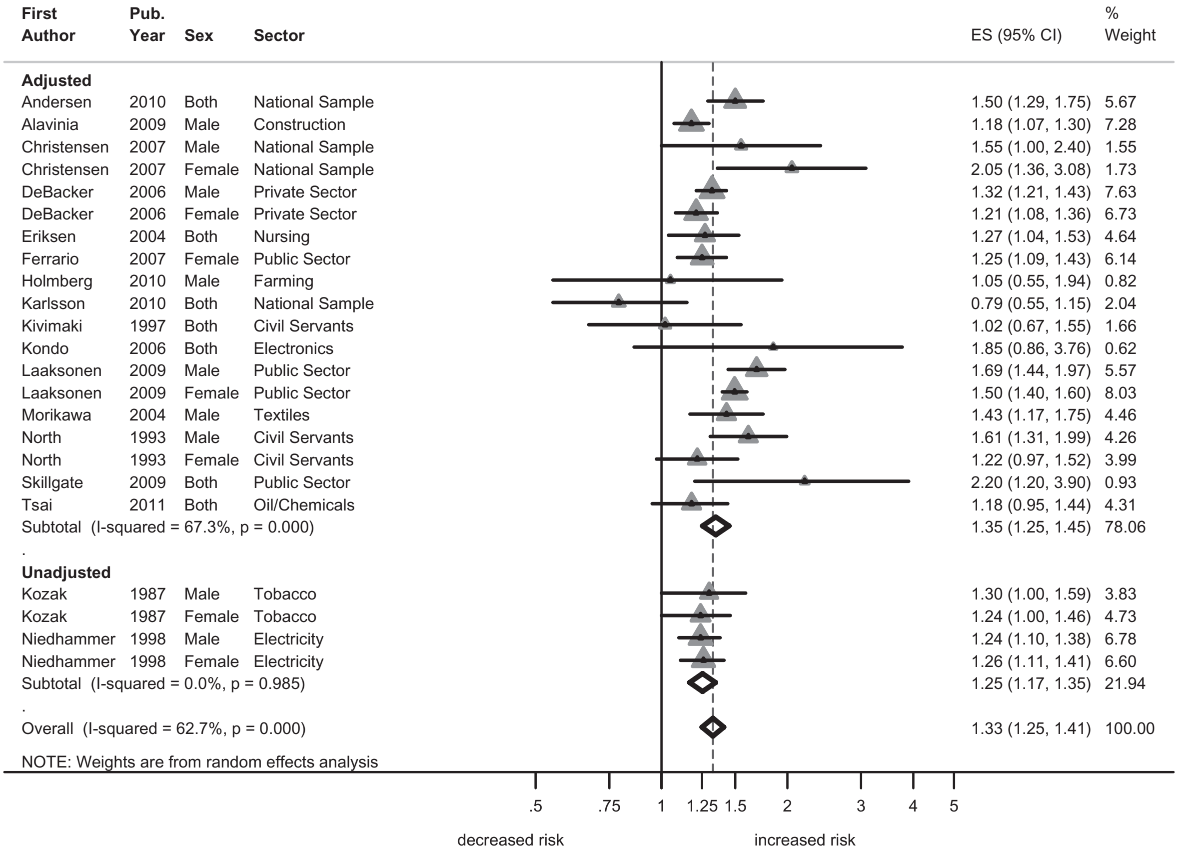

Figure 2 Pooled relative risk (RR) of absence from work and 95% confidence interval (CI) of current smokers compared to non-smokers (reference group) stratified by adjusted and unadjusted study-level characteristics (17 studies)

comprising a total pooled sample of 48 645 workers with an over-representation of men (59%) compared to women (41%). The duration of follow-up ranged from 12 months [26,42] to 96 months [41] with a median of 30 months. Overall, ex-smokers were 14% more likely to take work absence than never smokers (RR = 1.14, 95% CI: 1.08–1.21; $I^2 = 62.4\%$; eight studies; Fig. 4). The average risk of absenteeism (14%) for ex-smokers compared to never smokers was substantially less than the risk of absenteeism (33%) for current smokers compared non-smokers. The majority of the studies provided relative risks that were adjusted for additional study-level lifestyle covariates while only one study [42] provided crude effects.

Duration of absenteeism

Four studies [30,33,40,47] compared the duration of work absence between ex-smokers and never smokers. These studies provided incomplete measures of dispersion, and therefore meta-analysis could not be performed. The largest difference in work absence was reported by Lundborg [40], where ex-smokers took 4.55 more days off per year than never smokers, the difference being statistically significant after controlling for occupational and health covariates. The smallest difference in work absence was reported by Tsai *et al.* [47], where female ex-smokers took only 0.20 more days off per year than never smokers, but the difference was not statistically significant. Halpern *et al.* [30] found a statistically significant difference in duration of absenteeism between ex-smokers and never smokers, while Jedrychowski [33] did not find a statistically significant difference. Therefore, there was conflicting evidence that ex-smokers were significantly absent for longer than never smokers.

Current smokers versus ex-smokers

By using the meta-analyses comparing current smokers to never smokers (RR = 1.36, 95% CI: 1.27–1.47; $I^2 = 68\%$; eight studies) and ex-smokers to never smokers (RR = 1.14, 95% CI: 1.08–1.21; $I^2 = 62.4\%$; eight studies), we were able to conduct indirect comparison meta-analysis using an inverse variance weighting. We found that current smokers were 19% more likely be absent from work compared to ex-smokers (RR = 1.19, 95% CI: 1.09–1.32; eight studies; $P < 0.01$) suggesting that quitting smoking would reduce the risk of work absence.

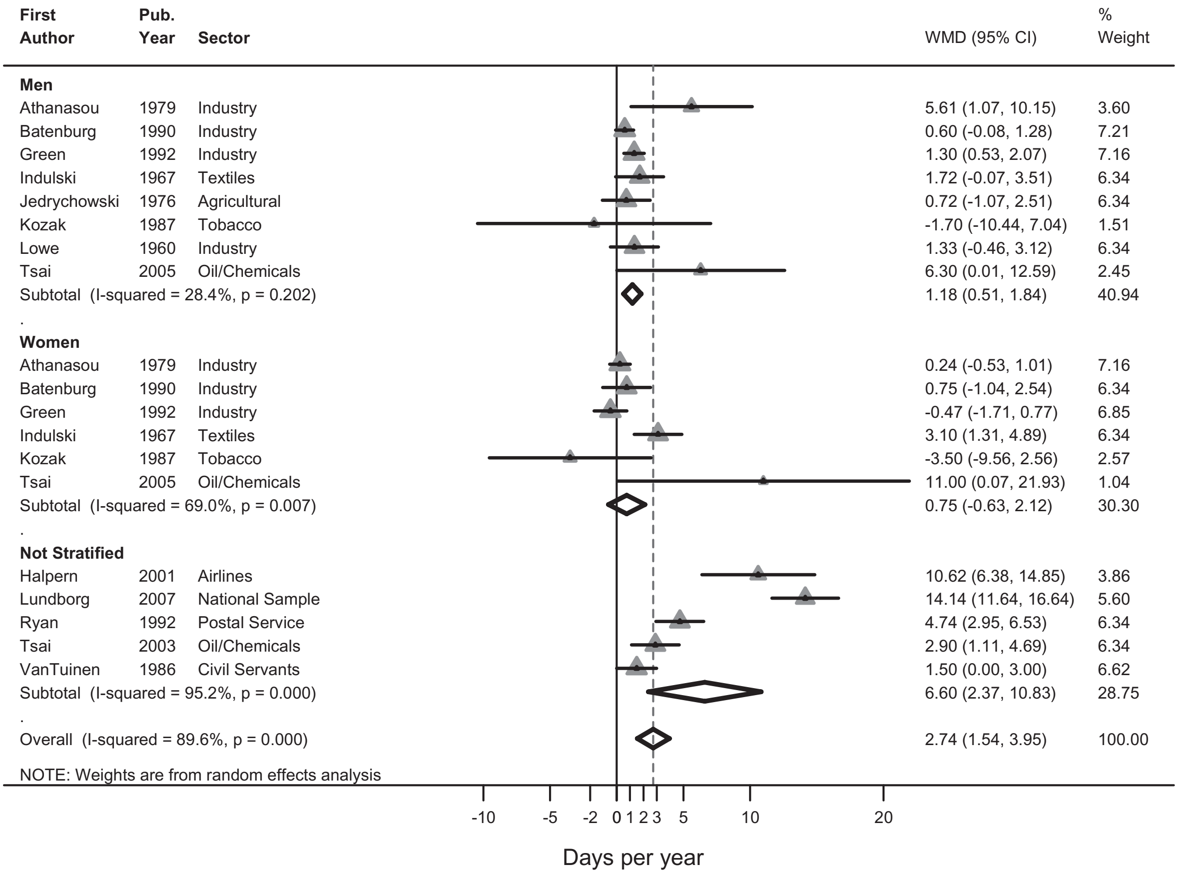

Figure 3 Pooled mean difference in absence (days per year) from work and 95% confidence interval (CI) of current smokers compared to non-smokers (reference group) stratified by sex (13 studies)

Subgroup analysis

Table 2 presents subgroup analyses using random-effects models for relative risk of absenteeism (model 1) and duration of absenteeism (model 2) in current versus non-smokers and relative risk of absenteeism in ex-smokers versus non-smokers (model 3). The analysis was stratified by sex, work sector and duration of absence. For subgroups based on sex, all three models showed only small, non-significant differences in pooled effects between males and females (model 1: meta-regression $P = 0.940$; model *2:* meta-regression $P = 0.431$; model 3: meta-regression $P = 0.906$). When studies were grouped by work sector, public sector workers on average were more at risk of being absent from work than private sector workers in both current and ex-smokers (model 1 and 3). However, the difference was not statistically significant in either model (model 1: meta-regression $P = 0.745$; model 3: meta-regression $P = 0.709$). In terms of duration, current smokers were on average more at risk of long-duration absence (≥4 weeks) than short-duration absence (<4 weeks) (model 1) but the difference was also not statistically significant (meta-regression $P = 0.632$).

The methodological quality of the studies had a marginal impact on the pooled effects of the meta-analyses when comparing the relative risk of absenteeism in current versus non-smokers (model 1) and ex-smokers versus non-smokers (model 3). However, the impact that methodological quality had on pooled effects was most apparent in model 2 when comparing the duration of absence between current and non-smokers. For the selection domain of the NOS, the average difference in pooled effects between studies with high scores and studies with low scores was 2.42 days per year (meta-regression $P = 0.406$). For the comparability domain, the average difference in pooled effects between studies with high scores and studies with low scores was 2.67 days per year (meta-regression $P = 0.401$). In terms of ascertainment domain, the average difference in pooled effects between studies with high scores and studies with low scores was 3.52 days per year (meta-regression $P = 0.133$). Overall, the analysis in model 2 showed that low-quality studies may have biased the average estimates downwards, as high-quality studies tended to demonstrate much stronger in average effect size.

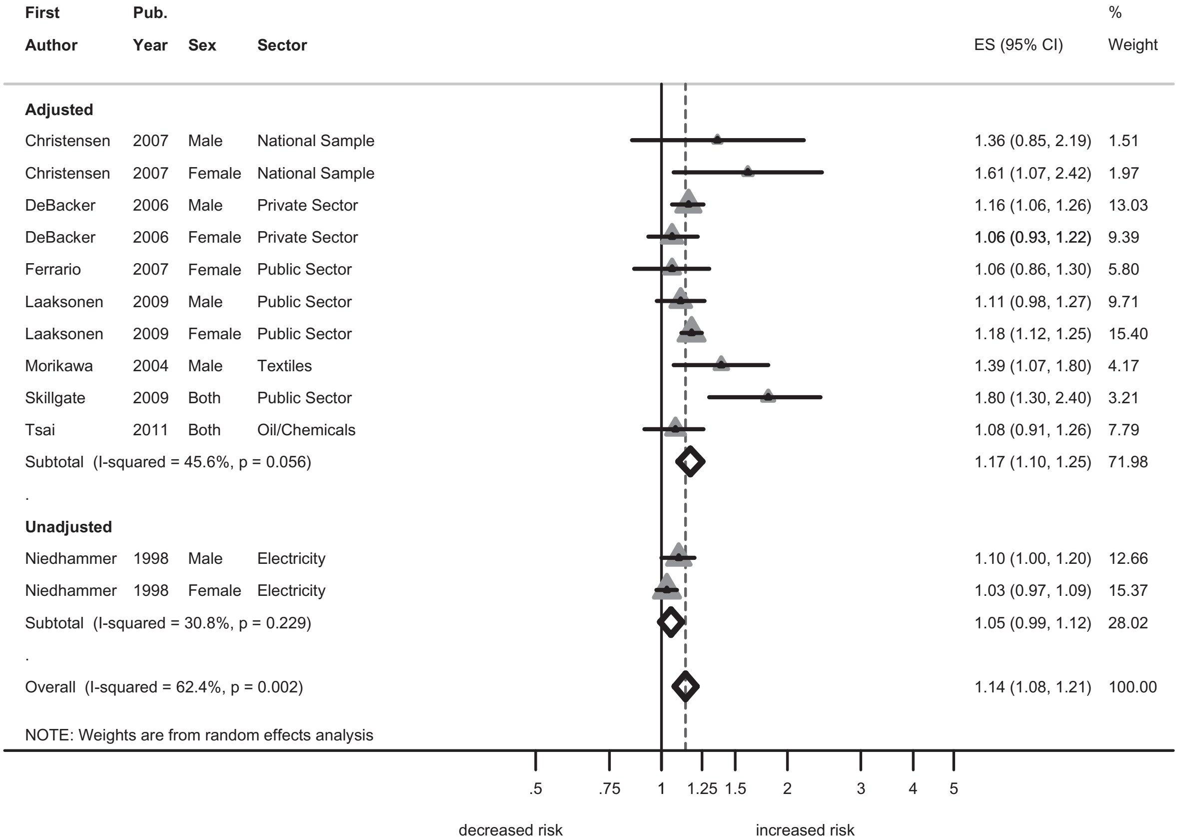

Figure 4 Pooled relative risk (RR) of absence from work and 95% confidence interval (CI) of ex-smokers compared to never smokers (reference group) stratified by adjusted and unadjusted study-level characteristics (eight studies)

Publication bias

No significant evidence of publication bias was found in the meta-analyses for the relative risk of absenteeism between current smokers and non-smokers [Fig. S1 (online Supporting Information); Egger's asymmetry test, $P = 0.951$]; the mean difference in absenteeism between current smokers and non-smokers [Fig. S2 (online Supporting Information); Egger's asymmetry test, $P = 0.132$]; and the relative risk of absenteeism between ex-smokers and never smokers [Fig. S3 (online Supporting Information); Egger's asymmetry test, $P = 0.104$].

Sensitivity analysis

The sensitivity analysis excluded excluding studies that did not report a measure of dispersion. The results (Table 2) show that imputation of measures of dispersion generally had marginal effects on the meta-analyses for the relative risk of absenteeism between current smokers and non-smokers (model 1) and ex-smokers and non-smokers (model 3). However, the model 2 comparing the mean difference of absence duration demonstrated that current smokers were absent 3.3 more days per year than non-smokers (compared to 2.74 days per year in the primary analysis), suggesting that data imputation procedures had a small impact weighting the estimate downwards, when in fact the mean difference in absence between current and non-smokers may have been even greater.

DISCUSSION

Summary of findings

There was consistent evidence from this systematic review and meta-analysis that smoking increased both the risk and duration of work absenteeism. This, to our knowledge, is the first systematic review assessing the impact of smoking on the risk and duration of absenteeism. In current smokers, the risk of work absenteeism was 33% greater than that of non-smokers. In terms of the duration of absence, current smokers were absent 2.74 days per year more than non-smokers. For ex-smokers compared to never smokers, the relative risk of absenteeism was 14% higher. For the mean duration of absence in ex-smokers compared to never smokers, there were only four studies available. The number of days absent per year ranged from 0.2 days to 4.5 days, but we were unable to pool the study effects due to incomplete

Table 2 Summary relative risk ratios from primary and stratified random-effects meta-analyses between smoking and absenteeism.

Stratification	*Pooled effect size*		*Heterogeneity*	
Model 1: current versus non-smokers	*Relative risk of absenteeism*	*95% CI*	*No. of studies*	I^2
Primary analysis	1.33	1.25,1.41	17	62.7%
Sex				
Male	1.36	1.24,1.49	9	62.2%
Female	1.32	1.19,1.45	7	70.4%
Non-stratified	1.26	1.05,1.52	7	63.6%
Work sector				
Private	1.25	1.20,1.31	7	0.0%
Public	1.41	1.27,1.57	6	62.8%
Unclassified	1.34	1.11,1.62	4	67.1%
Type of absence				
Short (<4 weeks)	1.33	1.16,1.52	4	91.2%
Long (≥4 weeks)	1.55	1.37,1.77	4	23.1%
Undefined	1.31	1.27,1.43	13	62.3%
Selection				
High (≥3)	1.42	1.29,1.56	6	66.2%
Low (<3)	1.27	1.19,1.36	11	43.2%
Comparability				
High (= 2)	1.33	1.23,1.45	13	70.7%
Low (<2)	1.30	1.21,1.38	4	6.1%
Ascertainment				
High	1.40	1.29,1.52	9	70.6%
Low	1.25	1.17,1.33	8	12.4%
Sensitivity analysis[a]	1.38	1.27,1.50	12	70.7%
Current versus never	1.36	1.27,1.47	8	68.0%
Model 2: current versus non-smokers	*Mean difference (days per year)*	*95% CI*	*No. of studies*	I^2
Primary analysis	2.74	1.54, 3.95	13	89.6%
Sex				
Male	1.18	0.51, 1.84	8	28.4%
Female	0.75	–0.63, 2.12	6	69.0%
Non-stratified	6.60	2.37, 10.83	5	95.2%
Selection				
High	4.48	–0.13, 9.09	3	97.2%
Low	2.06	0.99, 3.13	10	78.1%
Comparability				
High	4.83	–0.72, 10.37	2	98.1%
Low	2.16	1.17, 3.16	11	76.4%
Ascertainment				
High	5.04	1.52, 8.57	6	93.7%
Low	1.52	0.59, 2.45	7	76.8%
Sensitivity analysis[a]	3.30	1.51, 5.09	8	92.7%
Model 3: ex- versus never smokers	*Relative risk of absenteeism*	*95% CI*	*No. of studies*	I^2
Primary analysis	1.14	1.08, 1.21	8	62.4%
Sex				
Male	1.14	1.08, 1.21	5	0.0%
Female	1.11	1.01, 1.22	5	73.3%
Non-stratified	1.37	0.83, 2.26	2	88.0%
Work sector				
Private	1.10	1.03, 1.16	4	55.8%
Public	1.23	1.09, 1.39	4	45.6%
Unclassified	–	–	–	–
Selection				
High	1.14	1.04, 1.25	3	80.1%
Low	1.15	1.06, 1.24	5	21.8%
Comparability				
High	1.16	1.09, 1.24	6	45.7%
Low	1.10	0.99, 1.22	2	64.8%
Ascertainment				
High	1.17	1.08, 1.27	6	70.0%
Low	1.12	1.05, 1.20	2	0.0%
Sensitivity analysis[a]	1.18	1.10, 1.27	6	49.0%

[a]Only included studies with reported measures of dispersion. CI: confidence interval.

parameters. By comparing current smokers to ex-smokers indirectly, the relative risk of absenteeism was found to be 19% higher. Overall, our results were conservative in nature, as quality assessment and sensitivity analysis showed that low-quality studies and data imputations procedures weighted the pooled effect size downwards, suggesting that the strength of association between smoking and risk or duration of absenteeism may, in fact, be stronger.

Exploration of heterogeneity

Higher levels of heterogeneity were generally seen in the meta-analyses. The studies differed in time-periods, geographic location and population demographics. We explored additional reasons for heterogeneity by subgroups presented in Table 2. When workers were stratified by sex, the relative risk and duration of absenteeism due to smoking was similar in men and women. Public sector workers had, on average, a higher risk of absenteeism than private sector workers; however, the result was not statistically significant at the 5% level. The lack of significance could be due to a lack of power in the meta-regression analysis from a limited number of studies. A survey of 241 public and private sector organizations [52] found that absence was, on average, 2.5 days higher in the public sector than in the private sector. One of the reasons suggested was that public sector employees were in more challenging public-facing roles, such as social work, policing, teaching and nursing, where they often have to deal with people in difficult and emotionally charged situations, putting pressure on their time and resilience [53]. While our results were not statistically significant, there may be some indication to support the survey literature suggesting that public sector workers were, on average, more at risk of absence.

Compared to non-smokers, current smokers were, on average, at higher risk of taking longer durations of absence than shorter durations. However, this result was not statistically significant. This lack of statistical significance could be due to a lack of power in the meta-regression, as there were only four outcomes [21,28,38,43] that could be classified as short-duration and four outcomes [21,25,38,45] that could be classified as long-duration. In many of the included studies in the review, the reason for long-term absence was due consistently to chronic health problems, while the reasons for short-term absence varied from short-term illness to behavioural issues. Many of the smokers in the sample were persistent long-term smokers. Health problems related to smoking tend to be long-term and chronic conditions such as lung cancer, chronic obstructive pulmonary disease (COPD) and heart disease, where illness periods were longer and more frequent. This is supported further by a 19-year follow-up study in Finland, which estimated that the smoking resulted in 2.6 productive work-years lost per person due to smoking-related chronic health problems [54].

Implications

The results of this study suggest that smoking cessation in the work-place could potentially result in cost savings for employers from reduced absenteeism. Using the results of the meta-analyses, we showed that smoking may have cost employers £1.4 billion, on average, in 2011 from absenteeism in the work-place. This large economic impact of smoking on absenteeism suggests that there is potentially great value in work-place smoking cessation programmes. This view is supported in several cost-of-smoking studies [6,55–57]. Parrott *et al.* [6] estimated that the cost of employee-related absence in Scotland was £40 million per annum. Tsai *et al.* [47] estimated that the cost of employee absenteeism due to smoking in Taiwan cost employers US$184 million per annum.

Two systematic reviews have explored the impact of smoking cessation interventions in the work-place [58,59]. A review of 22 prospective studies on the impact of work environment on smoking cessation by Albertsen *et al.* [58] found that highly demanding jobs were associated with higher amount smoked, while social support at work were associated positively with cessation. In addition, a Cochrane Review by Cahill *et al.* of 51 quasi-randomized control trials evaluated work-place interventions and found strong evidence that interventions directed towards individual smokers (such as individual or group counselling and pharmacological treatment) increased the likelihood of quitting more than self-help or social support interventions alone [59]. In both these reviews, the general conclusion was that work-place interventions aided employees to quit smoking. However, the number of quitters was low due to a lack of participation and awareness of the programmes. In order to improve quit rates, it would be necessary to increase participation by providing easier access and raising awareness of successful forms of work-place smoking cessation interventions.

Limitations

There were some limitations of the systematic review. We did not find significant evidence of publication bias in any of the meta-analyses; however, some visual evidence of asymmetry was seen in the funnel plots. Asymmetry in the funnel plots could have been a result of poor methodological quality of the studies rather than publication bias.

Furthermore, only a limited number of studies had reported results by subgroups, thus limiting the power of our secondary analysis. As a result, meta-regression did not detect significant differences between gender subgroups, absence duration subgroups, work sector subgroups or quality assessment subgroups at the 5% level. This was most noticeable in quality assessment subgroups in model 3, where average pooled effects resulted in large differences but wide 95% confidence intervals.

There were also limitations in terms of the quality of evidence and design of studies identified in the systematic review. Cohort studies may be the best type of evidence in terms of observational studies, but some studies were subject to attrition bias and confounding. A few of the studies experienced higher attrition rates and lacked description of those lost to follow-up. Many of these studies were retrospective and limited to what information was collected at the time. Some multivariate models included many covariates and others included only a few.

Additionally, we computed relative risks from odds ratios in several studies for the analysis using a common transformation method; however, this is known to overstate significance levels when outcomes are common [60]. Finally, seven studies had old publication dates (1950–70) where we could not access full-text papers in print or electronic form. Several of these papers were in journals that have stopped circulation and we were not able to make contact with the study authors.

CONCLUSION

The systematic review found that smoking increases both the risk and duration of absenteeism. Current smokers were, on average, 33% more likely to be absent from work than non-smokers. When current smokers did take absence, they were absent on average 2.74 more days per year than non-smokers. Ex-smokers were also, on average, 14% more likely to be absent from work than never smokers. Using an indirect comparison, current smokers were on average 19% more likely to be absent from work than ex-smokers. The results of this systematic review imply that quitting smoking may reduce absenteeism and result in substantial cost-savings for employers. Future research is also needed into quantifying the efficacy and cost-effectiveness of work-place smoking cessation programmes.

Declarations of interest

None.

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Supporting information

Additional Supporting Information may be found in the online version of this article:

Figure S1 Funnel plot of the log relative risk of absence and corresponding standard error between current smokers and non-smokers

Figure S2 Funnel plot of the mean difference of absence and corresponding standard error between current smokers and non-smokers

Figure S3 Funnel plot of the log relative risk of absence and corresponding standard error between ex-smokers and never smokers