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Review Paper

Risk of obstructive pulmonary diseases and occupational exposure to pesticides: a systematic review and meta-analysis

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ABSTRACT

Objective: This meta-analysis study was performed to examine the relationship between occupational exposure to pesticides and the risk of obstructive pulmonary diseases such as chronic obstructive pulmonary disease (COPD) and chronic bronchitis.
Study design: This is a systematic review and meta-analysis study.
Methods: PubMed and Scopus databases were searched for English-language publications. Eight cohort studies and one case–control study were included in the pooled analysis.
Results: These studies had a total of 101,353 participants from eleven different countries and were published between 2006 and 2018. The heterogeneity among the studies was high ($P < 0.001$, $I^2 = 68.7\%$). In a random-effects model meta-analysis, a pooled odds ratio (OR) analysis showed that there was a direct relationship between occupational exposure to the pesticides and obstructive pulmonary diseases (OR = 1.33, 95% confidence interval [CI]: 1.21–1.47). A positive significant relationship was also observed between exposure to the pesticides and risk of chronic bronchitis (OR = 1.27, 95% CI: 1.23–1.31). Also, there was a significant relationship between occupational exposure to the pesticides and an increased risk of COPD (OR = 1.44, 95% CI: 1.14–1.81). No evidence of publication bias was found among the studies according to the results of the Egger's test (P of bias = 0.157).
Conclusions: Findings of this study show that occupational exposure to pesticides can be associated with an increased risk of obstructive lung diseases including chronic bronchitis and COPD.

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Introduction

Chronic obstructive pulmonary disease (COPD) is a chronic disabling respiratory condition and is an increasing cause of mortality and morbidity worldwide. COPD is currently the fourth leading cause of death and is expected to become the third leading cause of death globally by 2030.[1–4] The prevalence of airway diseases has grown in recent decades despite therapeutic advances. Moreover, the prevalence of these diseases is downgraded as reported by epidemiological surveys.[5] In recent decades, many studies have reported a worldwide prevalence of obstructive lung diseases.[6–8] It is predicted that demographic changes will result in a remarkable increase in chronic obstructive airway diseases (OADs) in the future.[9] Each year, 210 million people suffer from chronic respiratory diseases.[10] Chronic bronchitis and emphysema result in irreversible airflow limitation.[11] Also, only in the USA, healthcare costs of COPD were estimated to be US$50 billion in 2010.[12]

Occupational exposures have played an important role in OADs.[13] A number of studies have shown that occupational exposure is a risk factor for some respiratory diseases, including chronic bronchitis and impairment of lung function.[14] Furthermore, occupational exposure increases the risk of reduced lung function[13] and is attributable to a 15–20% risk of COPD.[15–17] In addition, several studies in different occupational groups demonstrated a higher risk of COPD even after adjustment for cigarette smoking status as an important potential confounder.[18]

Since 1950, the use of pesticides has grown by over 50% and their toxicity has increased 10-fold.[19] Occupational exposure to pesticides occurs during their manufacturing, storage, transport and use,[20] thus is present in mixers, loaders, greenhouses, parks and especially on farms.[20] Pesticides can intoxicate the body after skin contact, ingestion or inhalation.[20] Inhalation may trigger diseases such as chronic bronchitis and emphysema.[21] Inhalation of pesticides at the worksite is commonplace.[14] Some studies have shown that farming and agricultural work are related to many respiratory problems,[22–24] and pesticides were identified as possible causing factors.[25] Harmful health effects related to occupational exposure to pesticides can have a major impact on public health because the agricultural sector employs more than 1.1 billion workers globally (about 34% of the working population worldwide).[26]

Some studies have reported inconsistent associations between obstructive pulmonary disorders (including COPD and chronic bronchitis) and occupational exposure to pesticides; a number of studies have reported a positive association,[21,27–33] while others reported no significant association.[20,26,34–38] To clarify this issue, we performed a systematic review and meta-analysis on the epidemiological evidence to examine the association between occupational exposure to pesticides and the risk of obstructive pulmonary diseases, such as COPD and chronic bronchitis.

Methods

We conducted a systematic review and meta-analysis of published studies according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline.[39]

Search strategy and terms

PubMed and Scopus databases were searched for English-language articles published between 4 August 1956 and 13 June 2018 by mixing two sets of keywords. The first set of keywords was used to identify publications containing terms connected to exposure and the second set contained terms connected to outcome/s:

1 (((((((((((((((((pesticide*[Title/Abstract]) OR herbicide*[Title/Abstract]) OR insecticide* [Title/Abstract]) OR fungicide* [Title/Abstract]) OR rodenticide* [Title/Abstract]) OR organophosphate* [Title/Abstract]) OR pyrethroid [Title/Abstract]) OR pyrethrin [Title/Abstract]) OR paraquat [Title/Abstract]) OR "chlorinated hydrocarbon*' [Title/Abstract]) OR rotenone [Title/Abstract]) OR rotenoid [Title/Abstract]) OR maneb [Title/Abstract]) OR carbamate [Title/Abstract]) OR DDT [Title/Abstract]) OR "dichlorodiphenyl-trichloroethane" [Title/Abstract]) OR permethrin [Title/Abstract])) AND

2 ((((((('Airway Obstruction" [MeSH]) OR "Bronchitis, Chronic" [MeSH]) OR "Pulmonary Emphysema" [MeSH]) OR "Pulmonary Disease, Chronic Obstructive" [MeSH]) OR COPD [Title/Abstract]) OR emphysema [Title/Abstract]) OR bronchitis [Title/Abstract]) OR "chronic obstructive pulmonary disease" [Title/Abstract]).

In addition, we also manually searched the reference lists of the retrieved review articles.

Eligibility criteria

Studies in the final analysis were included according to the following inclusion criteria:

(1) study design: cohort or case–control;
(2) studies that reported the role of occupational exposure to pesticides in risk of COPD or chronic bronchitis and in terms of the effect size (odds ratio [OR] and relative risk), confidence interval (CI) and any information to derive OR;
(3) studies not relying on biological monitoring data; and
(4) original reports.

Studies were excluded for the following reasons:

(1) information in the studies which could not be accessed or extracted;
(2) reviews, case reports, conferences, letters and animal studies;

(3) exposure to pesticides that was not occupational;
(4) studies that were not written in English language;
(5) studies that did not report the risk of outcome/s;
(6) studies with inadequate information in their abstracts; or
(7) cross-sectional studies.

Definitions

We included studies in which COPD was defined using lung function measurements or by physician diagnosis. COPD was defined by lung function measurements according to (1) a forced expiratory volume in 1 s over forced vital capacity [FEV_1/FVC] ratio less than 70% (known as the Global Initiative for Chronic Obstructive Lung Disease [GOLD] definition) or (2) the lower limit of normal (LLN) criterion, defined as FEV_1/FVC ratio less than the fifth percentile.

Chronic bronchitis was defined as a self-reported cough and (or) phlegm for at least 3 months during two consecutive years.[40]

Study selection

Titles and abstracts of all articles in the initial search were screened by two independent reviewers. When a title/abstract had inadequate information for the study selection, we evaluated the full text of the publication. Articles that did not meet the eligibility criteria were excluded by applying a screen form in a hierarchical way on the basis of population or exposure and outcome. Disagreements were settled by discussion among the reviewers. We also examined the reference lists of relevant review articles identified during this process. When the same institution or author reported two similar studies, we included only the more comprehensive study in the meta-analysis.

Data extraction and quality assessment of included studies

Two reviewers independently extracted data from the selected studies using a standard data extraction form. They separately extracted data containing first author, publication year, country, study design, smoking status, age range, gender and size of study population; type of occupational exposure; method of exposure assessment; definition of outcome/s; adjusted or crude; and ORs with 95% CIs. If an original study did not report an OR, we estimated the OR to two decimals. Also, the initially reported ORs were combined by STATA to extract an overall OR of interest when it was necessary. Any inconsistency in data extraction was settled by discussion with a third reviewer.

Quality of studies

The Newcastle–Ottawa Scale (NOS) was used by two reviewers to assess the quality of each included study. Selected studies were examined on eight items through three key scopes: (i) selection of cases and controls; (ii) comparability of the participants; and (iii) outcomes. This scale grants a maximum of nine points to each cohort or case–control study.[41] Studies conducted according to the NOS had nine or 7–8 points, which were considered as high- and medium-quality studies, respectively (NOS for included studies is shown in Table 1).

Statistical analyses

Subgroup analyses were conducted for the type of pesticides (including herbicides and insecticides), type of outcome (COPD or chronic bronchitis), control of confounders (adjusted and crude OR), diagnostic criteria of COPD (Global Initiative for Chronic Obstructive Lung Disease (GOLD) or LLN criteria) and exposure to pesticides (low or high).

Random-effects[42] and fixed-effects meta-analysis models were used to estimate the pooled OR (and 95% CI). Heterogeneity among the included studies was tested by the Cochran Q and the I^2 statistics ($I^2 = [Q\text{-df}]/Q \times 100\%$; $I^2 < 25\%$, no heterogeneity; $I^2 = 25–50\%$, moderate heterogeneity; $I^2 = 50–75\%$, large heterogeneity; $I^2 > 75\%$, extreme heterogeneity) with a significance set at $P < 0.1$ or $I^2 > 50\%$. In order to remove publication bias, we conducted the Egger's test ($P < 0.05$ considered representative of statistical significance). STATA (version 13.0; Stata Corporation, College Station, TX) and SPSS (version 23.0; SPSS, Inc., Chicago, IL) were used for statistical analyses of this quantitative meta-analysis.

Results

Study selection and characteristics

A flow diagram of the study selection process is presented in Fig. 1.

After removing duplicates, 491 studies were identified from the search. Subsequently, 447 studies were removed after screening for relevance based on the title and/or abstract. In total, 44 papers were identified for full-text review as potentially eligible. Among these 44 articles, 35 studies were excluded in the full-text screening for not having met the inclusion criteria. Finally, nine studies met the inclusion criteria and were included in the pooled analysis: eight cohort studies[26–28,31,33–35] and one case–control study[30] (Fig. 1). These studies were published between 2006 and 2018. The combined population size of the nine studies included 101,353 participants from 17 different countries (two from US, two from the Netherlands, one from Lebanon, one from Australia and the other studies from 12 different countries [Australia, Belgium, Estonia, France, Germany, Iceland, Italy, Norway, Spain, Sweden, Switzerland and the UK]).

The characteristics of included studies are summarised in Table 1.

Exposure was assessed using self-reported exposure, self-reported lifetime work history calendar, an interviewer-administered questionnaire, self-reported current job title at baseline or the ALOHA job exposure matrix.

Occupational exposure and risk of obstructive pulmonary diseases

The ORs of specific studies were pooled to examine the association between occupational exposure to all types of

Table 1 – Characteristics of the included studies that examined the association between occupational exposure to pesticides and obstructive pulmonary diseases.

Author/s [study name] (year)[ref]	Study design	Location	Sample size	Age (years)	Smoking status (%)	Occupational exposures	Method of assessment	COPD definition	Chronic bronchitis definition	Quality score	Adjustment for confounders
De Jong et al. [LifeLines] (2013)[26]	Cohort	The Netherlands	11,851	18–89	Never: 43 Past: 36 Current: 21	Insecticide Herbicide Pesticide	Self-reported current job title, JEM		Not measured		Sex, age, height, weight, ever smoking and pack-years smoked
De Jong et al. [Vlagtwedde-Vlaardingen] (2013)[26]	Cohort	The Netherlands	2364	35–79	Never: 32 Past: 32 Current: 36	Insecticide Herbicide Pesticide	Self-reported current job title, JEM		Not measured	8/9	Sex, age, height, weight, smoking and pack-years smoked
Alif et al. (2017)[31]	Cohort	Australia	1335	44.8 ± 0.8 (mean ± SD)	Never: 45.3 Past: 29.6 Current: 25.1	Insecticide Herbicide Pesticide	Self-reported lifetime work history calendar	FEV_1/FVC <0.7 FEV_1/FVC < LLN	Cough and phlegm >3 months		Sex, smoking, pack-years, childhood and adulthood socio-economic status, childhood and adulthood asthma, exposure to biological dust, mineral dust, gases/fumes,
Hoppin et al. (2007)[27]	Cohort	US	20,908	20 to <70	Never: 40 Past: 43 Current: 16	Insecticide Herbicide Pesticide	Self-reported questionnaire	Not measured	Physician's diagnosis		Age, sex, pack-years of smoking, state and up to three correlated pesticides
Stoecklin-Marois et al. (2015)[35]	Cohort	US	702	18–55	Never: 78.5 Past: 10.1 Current: 11.4	Pesticide	Self-reported	Not measured	Self-reported		Age, sex, smoking status
Pahwa et al. (2012)[28]	Cohort	Canada	8153	18 to <65	Never: 4.7 Past: 6.9 Current: 8.3	Insecticide Herbicide Pesticide Fungicide	Self-reported questionnaire	Not measured	Physician's diagnosis		Unadjusted
LeVan et al. (2006)[34]	Cohort	Singapore	52,325	45–74	Never: 41 Past: 13 Current: 46	Pesticide	Self-reported questionnaire	Not measured	Cough and phlegm >3 months		Unadjusted
Lytras et al. (2018)[33]	Cohort	12 countries[a]	3343	34.2–54.2 (mean age)	Ever smoker: 57.9 Never smoker: 42.1	Insecticide Herbicide Fungicide	Semiquantitative ALOHA+JEM	FEV_1/FVC < LLN	Not measured	8/9	Sex, age, pack-years of smoking, FEV_1/FVC ratio at baseline (% predicted), socio-economic status and early-life disadvantage score (including maternal smoking, maternal asthma, paternal asthma, childhood asthma [before the age of 10 years] and having a serious respiratory infection before the age of 5 years)

Salameh et al. (2006)[30]	Case–control	Lebanon	372	12–99	Never: 13.6 Past: 28.2 Current: 58.2	Pesticide	Self-administered questionnaire	Not measured	Cough >3 months	7/9	Smoking pack-years, number of smokers at home, sex, age, education, residency department, hospital, body mass index, allergy, nationality, working in a smoky and in a dusty environment, personal cardiac and family history of respiratory problem

ALOHA, XXX; COPD, chronic obstructive pulmonary disease; FEV_1/FVC, forced expiratory volume in 1 s over forced vital capacity ratio; JEM, job exposure matrix; LLN, lower limit of normal; SD, standard deviation.

[a] Australia, Belgium, Estonia, France, Germany, Iceland, Italy, Norway, Spain, Sweden, Switzerland and the UK.

pesticides and obstructive lung diseases. As shown in Fig. 2, a direct relationship was found between occupational exposure to pesticides and OPDs (OR = 1.33; 95% CI: 1.21–1.47) when all the ORs were combined with the random-effects model. Heterogeneity existed among the studies (P = 0.001, I^2 = 68.7%). We found no evidence of publication bias among the studies according to the results of the Egger's test (P of bias = 0.157). Also, an asymmetry funnel plot showed no evidence of publication bias (Fig. 3).

Subgroup analysis

Subgroup analysis by the type of the pesticide is shown in Table 2. By pooling these nine studies, the results of the meta-analysis showed an association between the type of the pesticides (herbicides [OR = 1.29; 95% CI: 1.20–1.40], insecticides [OR = 1.27; 95% CI: 1.20–1.34] and fungicides [OR = 1.26; 95% CI: 1.05–1.51]) and the risk of obstructive lung diseases.

In a subgroup analysis according to the adjusted and crude ORs, we observed that adjusted studies presented an increased risk of obstructive lung diseases (OR = 1.38; 95% CI: 1.19–1.60); in addition, crude studies showed a significant relationship (OR = 1.27; 95% CI: 1.18–1.37) [Table 2].

Publication bias of these results were assessed by the Egger's statistics and potential heterogeneity among studies were computed by the Higgins I^2 (Table 2).

Chronic bronchitis and occupational exposure to pesticides

The relationship between chronic bronchitis and occupational exposure to all pesticides is shown in Table 3. Moreover, it shows the association between COPD and any type of pesticide.

There was a positive significant relationship between exposure to pesticides and risk of chronic bronchitis (OR = 1.27; 95% CI: 1.23–1.31) [Table 3].

Subgroup analysis by occupational exposure to any type of pesticide is shown in Table 3. Also, subgroup analyses by the type of pesticides showed a significant relationship between an increased chronic bronchitis risk and occupational exposure to herbicides (OR = 1.28; 95% CI: 1.18–1.40) and insecticides (OR = 1.27; 95% CI: 1.20–1.35) [Table 3].

Publication bias of these results was assessed by the Egger's statistics and potential heterogeneity among the studies was also evaluated by the Higgins I^2 (Table 3).

COPD and occupational exposure to pesticides

Table 4 shows the relationship between COPD and occupational exposure to all pesticides. Furthermore, it presents the association between COPD and any type of pesticide.

There was an association between occupational exposure to the pesticides and an increased risk of COPD (OR = 1.44; 95% CI: 1.14–1.81). In subgroup analysis by the type of pesticide, a significant positive relationship was found between the risk of COPD and exposure to herbicides (OR = 1.34; 95% CI: 1.12–1.59) and insecticides (OR = 1.33; 95% CI: 1.05–1.70).

Subgroup analysis according to diagnostic criteria for COPD, GOLD (OR = 1.36; 95% CI: 1.08–1.71) and LLN (OR = 1.82;

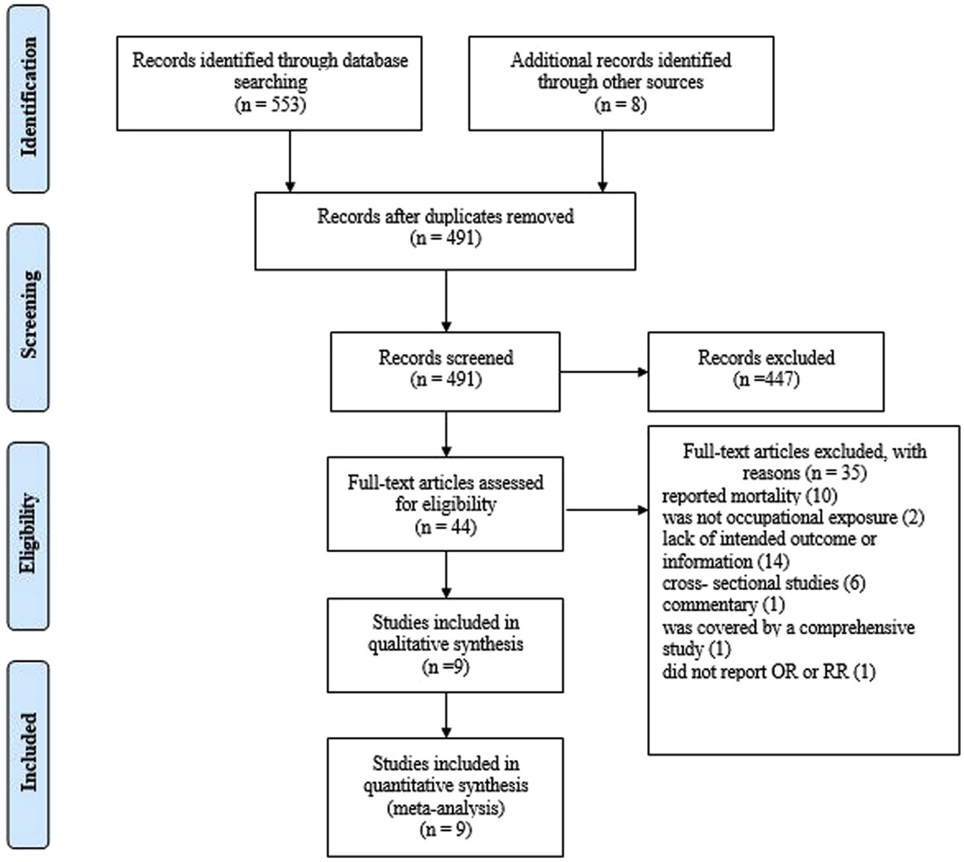

Fig. 1 – Flow diagram of the screening process and study selection. OR, odds ratio; RR, relative risk.

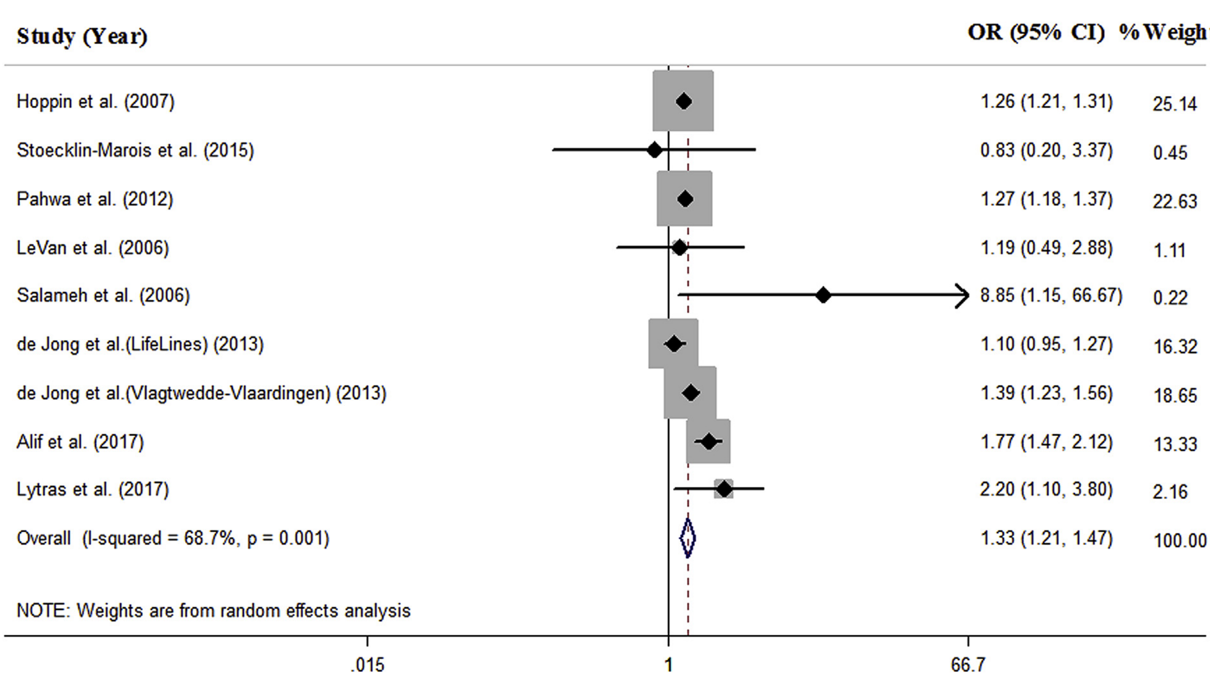

Fig. 2 – Association between occupational exposure to any type of the pesticides and obstructive lung diseases. CI, confidence interval; OR, odds ratio.

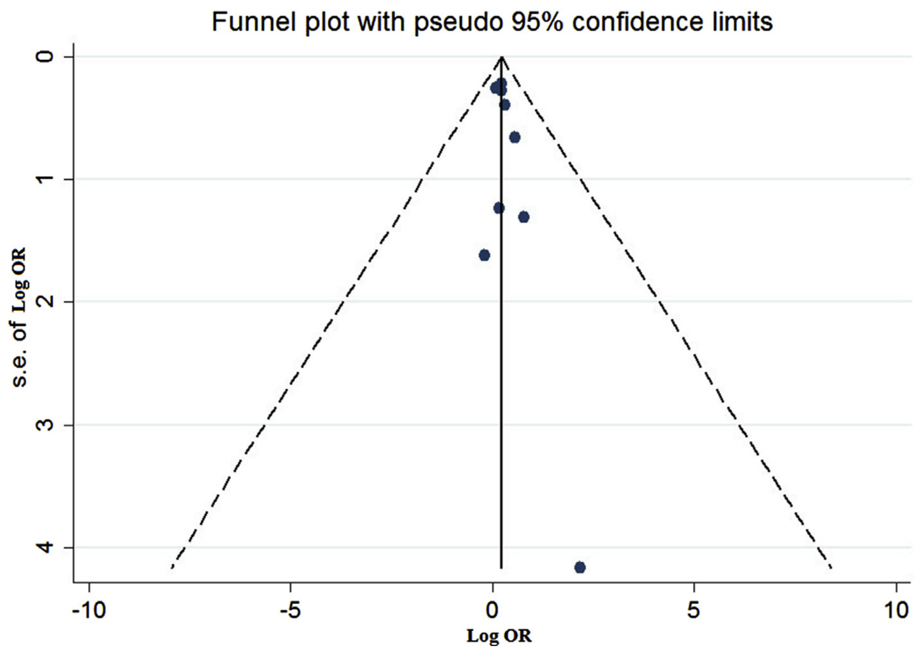

Fig. 3 – Funnel plot of the effect estimates (ln odds ratio [OR]) for the association between obstructive lung diseases and occupational exposure to the pesticides by the standard errors (s.e.) [Egger's statistics].

95% CI: 1.34–2.46) criteria, showed a significant association (Table 4).

Intensity of exposure is a major factor in chronic diseases such as COPD; thus, we performed subgroup analysis for the intensity of exposure. There was a significant relationship between a high exposure to insecticides (OR = 1.52; 95% CI: 1.22–1.89), pesticides (OR = 1.58; 95% CI: 1.26–1.97) and herbicides (OR = 1.72; 95% CI: 1.33–2.21) and an increased risk of COPD (Table 4).

The publication bias of these results was assessed by the Egger's statistics and the potential heterogeneity among the studies was also evaluated by the Higgins I^2 (Table 4).

Table 2 – Overall and subgroup analyses of the association between occupational exposure to pesticides and obstructive pulmonary diseases.

Subgroup analyses	No. of studies	Summary OR (95% CI)	I^2 (%)	Heterogeneity (*P*-value)	Model used	Publication bias (*P*-value)
Total studies	9	1.33 (1.21–1.47)	68.7	0.001	Random effects	0.157
Type of pesticide						
Insecticide	7	1.27 (1.20–1.34)	23.3	0.251	Fixed effects	0.056
Herbicide	7	1.29 (1.20–1.40)	26	0.230	Fixed effects	0.024
Fungicide	2	1.26 (1.05–1.51)	31.4	0.227	Fixed effects	_
Control of confounder						
Adjusted	7	1.38 (1.19–1.60)	76.4	0	Random effects	0.161
Unadjusted	2	1.27 (1.18–1.37)	0	0.886	Fixed effects	_

CI, confidence interval; OR, odds ratio.

Table 3 – Overall and subgroup analyses of the association between occupational exposure to pesticides and chronic bronchitis.

Subgroup analyses	No. of studies	Summary OR (95% CI)	I^2 (%)	Heterogeneity (*P*-value)	Model used	Publication bias (*P*-value)
Total studies	6	1.27 (1.23–1.31)	42.7	0.121	Fixed effects	0.425
Type of pesticide						
Insecticide	3	1.27 (1.20–1.35)	0	0.482	Fixed effects	0.017
Herbicide	3	1.28 (1.18–1.40)	0	0.398	Fixed effects	0.297

CI, confidence interval; OR, odds ratio.

Table 4 – Overall and subgroup analyses of the association between occupational exposure to pesticides and COPD.

Subgroup analyses	No. of studies	Summary OR (95% CI)	I^2 (%)	Heterogeneity (P-value)	Model used	Publication bias (P-value)
Total studies	4	1.44 (1.14–1.81)	80.4	0.002	Random effects	0.067
Type of pesticide						
Insecticide	4	1.33 (1.05–1.70)	52.6	0.097	Random effects	0.533
Herbicide	4	1.34 (1.12–1.59)	50.8	0.107	Fixed effects	0.051
COPD definition						
GOLD ($FEV_1/FVC < 0.7$)	3	1.36 (1.08–1.71)	80.9	0.005	Random effects	0.693
LLN	2	1.82 (1.34–2.46)	0	0.487	Fixed effects	_
Exposure						
Low						
Insect	3	0.93 (0.74–1.18)	0	0.430	Fixed effects	0.231
All pest	3	1.22 (0.83–1.80)	68.4	0.042	Random effects	0.072
Herb	3	1.24 (0.96–1.60)	0	0.477	Fixed effects	0.569
Fungi	1	1.50 (0.50–3.70)	_	_	_	_
High						
Insect	3	1.52 (1.22–1.89)	0	0.682	Fixed effects	0.159
All pest	3	1.58 (1.26–1.97)	0	0.737	Fixed effects	0.386
Herb	3	1.72 (1.33–2.21)	47.8	0.147	Fixed effects	0.073
Fungi	1	2 (0.70–4.60)	_	_	_	_

All Pest, all pesticides; CI, confidence interval; COPD, chronic obstructive pulmonary disease; FEV_1/FVC, forced expiratory volume in 1 s over forced vital capacity ratio; Fungi, fungicides; Herb, herbicides; Insect, insecticides; GOLD, Global Initiative for Chronic Obstructive Lung Disease; LLN, lower limit of normal; OR, odds ratio.

Evidence of statistical heterogeneity was not remarkable for insecticides, herbicides, fungicides, crude ORs or LLN criteria subgroups; however, a significant heterogeneity was found for pesticides, chronic bronchitis, COPD and GOLD criteria subgroups.

Discussion

The present study is the first systematic review and meta-analysis to investigate the relationship between occupational exposure to pesticides and risk of obstructive lung diseases in population-based studies.

The results of this review and meta-analysis showed a significant relationship between occupational exposure to pesticides and risk of obstructive lung diseases. In particular, a significant relationship was observed between occupational exposure to pesticides and obstructive lung diseases. Furthermore, a significant relationship was observed between exposure to insecticides and herbicides and the risk of obstructive lung diseases. These findings provide more support to the hypothesis that any occupational exposure to pesticides (insecticides or herbicides) can be associated with an increased risk of obstructive lung diseases. There are conflicting reports in the academic literature, with some supporting our findings[26,27,29–31,33,40] and others that found no increased risk.[20,26,32,34–38]

Unknown confounding exposures and risk factors might affect our findings. In subgrouping by adjusted and crude ORs, regarding the main potential risk factors such as sex, age, smoking, socio-economic status, family history and other occupational exposures to gas, dust or fumes (GDF), the findings of this study showed that despite a significantly increased risk in both adjusted and crude studies, the risk of adjusted studies is higher than that of crude studies.

Among the risk factors associated with COPD, smoking is the best studied and is a consistent finding in many studies.[42–44] Thus, all recent guidelines of COPD considered smoking to be the main risk factor for the development of the disease.[45,46] As the association between COPD and smoking is so powerful, it has frequently been viewed as a smoker's disease.[47] However, several epidemiological studies have gained enough evidence to suggest that non-smokers may also develop COPD; nearly one-quarter of diagnosed COPD cases in Japan (25.0%),[48] the UK (29.5%)[49] and the US (24.9%)[50] occur in non-smokers. These findings indicate that other factors might also be related to COPD.

Another important risk factor for COPD is the chronic exposure to occupational GDF.[51] The risk attributable to occupational exposure of GDF in COPD has been estimated at approximately 19%, and 31% for non-smokers.[52] Various occupational categories, such as farmers, mining workers, construction workers and other industries (e.g. metallic fumes like cadmium and aluminium), have been associated with an increased risk of COPD.[27,53–56] Joint exposure to both occupational factors and smoking has been found to markedly increase the risk of COPD.[57]

As a result, occupational exposure to pesticides was associated with an increased risk of COPD after adjustment for various risk factors. Therefore, exposure to pesticides is one of the main risk factors for COPD.

The results of the present study showed a significant relationship between the risk of chronic bronchitis and occupational exposure to pesticides. In subgroup analyses by the type of pesticide, we found a direct relationship between an increased risk of chronic bronchitis and occupational exposure to herbicides and insecticides. There are conflicting reports in the literature, with some supporting our results[27–33] and other studies that found no increased risk.[20,34–36,38]

The relation between risk of COPD and occupational exposure to pesticides showed a strong positive association. These results are supported by some scientific literature,[26,31,33] but some other studies did not confirm our findings.[26,32,37] Furthermore, occupational exposure to any type of the pesticide, including herbicides and insecticides, can be associated with an increased risk of COPD.

Occupational exposure to pesticides is associated with a direct risk of COPD according to the GOLD and LLN criteria; however, there was no statistically significant association between occupational exposure to pesticides and risk of COPD when considering the physician's diagnosis. These results demonstrate that spirometry measurement definitions of COPD are more reliable than a physician's diagnosis, which is subjective.

In general, the proportion of the population working in agriculture is increasing worldwide, especially in developing countries, where workers often use pesticides with inadequate protective equipment or training.[58] According to the results of the current study, there was a significant relationship between a high exposure to pesticides and increased risk of COPD, while exposure to low levels of pesticides may not increase the risk of COPD. Therefore, using interventions to reduce the exposure levels to these chemicals could contribute to lowering the global burden of COPD.

Strengths and limitations

The major strength of this study was reviewing a relatively large number of studies. In this study, publication bias was assessed using the Egger's test and funnel plots, and no clear trend of bias was observed. In addition, subgroup analysis was performed based on the type of pesticides, study design, obstructive lung diseases, criteria of COPD definition and OR. Moreover, this study aimed to assess the magnitude of the association between crude and adjusted OR with obstructive pulmonary diseases.

There are some limitations to this meta-analysis. First, only English-language studies were included in this study. Second, an analysis based on the duration of pesticide exposure was not possible as many of the included studies only assessed whether participants have been exposed to pesticides. Third, it was not possible to analyse the intensity of pesticide exposure because the included studies did not measure exposure intensity. Fourth, we were unable to carry out any subgroup analysis based on age, smoking status or other risk factors for obstructive lung diseases, which may have had an effect modification on the results because the included studies did not present data for stratification by age or smoking status. Fifth, we did not perform subgroup analyses by the exposure assessment method and could not be able to assess the studies based on this factor.

Conclusions

In summary, findings of the present study show that an increased risk of obstructive lung diseases, including COPD and chronic bronchitis, is associated with the occupational exposure to pesticides. In addition, the relationship between occupational exposure to pesticides and risk of obstructive lung diseases are influenced by adjusted or crude ORs and the design of the study. We also found that the relationship between exposure to pesticides and the risk of COPD is influenced by the criteria used for COPD diagnosis. This study contains significant implications for public health, as we found that occupational exposure to pesticides can be associated with the risk of obstructive lung diseases not only in the general population but also in people with high-risk occupations. This review emphasises the need for adequate ventilation and the provision of personal protective equipment in occupations where people are exposed to pesticides.

Author statements

Ethical approval

None.

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None.

Competing interests

The authors declare that they have no competing interests. The authors are only responsible for the writing and content of the paper.

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