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REVIEW ARTICLE

Prevalence and risk factors of work-related asthma among healthcare workers: a systematic review and meta-analysis

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ABSTRACT

Background: Work-related asthma (WRA) is a significant occupational health concern, and healthcare workers (HCWs) are routinely exposed to respiratory hazards such as disinfectants, cleaning agents, and aerosolized medications. Despite this, the overall burden of asthma and the contribution of specific work-related tasks among HCWs have not been clearly quantified. This study aimed to estimate the pooled prevalence of asthma among HCWs and to summarize key occupational exposures and risk factors associated with WRA.

Methods: A systematic review and meta-analysis were conducted following Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. PubMed, Scopus, and Web of Science were searched for observational studies published up to December 2025. Cross-sectional or cohort studies reporting asthma prevalence and/or occupational exposures among HCWs were included. Pooled prevalence estimates were calculated using random-effects models. Heterogeneity was assessed using the I^2 statistic, and publication bias was evaluated using Doi plots and the Luis Furuya–Kanamori index.

Results: Eight cross-sectional studies involving 16,019 HCWs were included. The pooled prevalence of asthma among HCWs was 10% (95% confidence interval: 8%–13%), with substantial heterogeneity (I^2 = 95.7%). High proportions of HCWs reported exposure to asthma-related tasks, including cleaning or disinfecting surfaces (58%), use of chemicals or solvents on patients (32%), administering aerosolized medications (24%), and sterilizing medical instruments (15%). Identified risk factors included exposure to disinfectants such as quaternary ammonium compounds, bleach, and orthophthalaldehyde, as well as atopy, female sex, obesity, smoking, and certain job tasks.

Conclusion: Asthma is common among HCWs and is strongly associated with routine cleaning and disinfection activities. These findings highlight the need for enhanced occupational surveillance and targeted preventive strategies in healthcare settings.

Keywords: Work-related asthma, healthcare workers, occupational exposure, disinfectants, systematic review, meta-analysis.

Introduction

Asthma is among the most common chronic respiratory diseases worldwide. In 2017, approximately 273 million people (3.6% of the global population) were estimated to have asthma, making it the second most prevalent chronic respiratory illness [1]. It also causes substantial mortality (~500,000 deaths in 2017) [1]. Notably, occupational factors contribute significantly: an estimated 16.0% of adult asthma is directly attributable to workplace exposures, and another ~21.5% represents

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work-exacerbated asthma [1]. In other words, work-related asthma (WRA) – including both new‐onset (occupational) asthma and preexisting asthma worsened by work – affects a large fraction of working-age adults [1]. Persons with WRA have more symptomatic days, greater healthcare use, and poorer quality of life than those with non- WRA [2]. If unrecognized, WRA can progress to severe, difficult-to-control disease [1,2]. Thus, WRA is a common, preventable occupational disease with significant individual and socio-economic impact.

Healthcare workers (HCWs) represent a sizable occupational group that faces unique respiratory hazards. In many countries, the healthcare and social assistance sector has among the highest asthma prevalence of all industries [2]. For example, a U.S. survey found that ~10.7% of workers in health care or social assistance reported current asthma – higher than most other industries – and 12.4% of healthcare support staff reported asthma [2]. This elevated burden reflects workplace exposures common in healthcare settings. HCWs routinely handle cleaning and disinfecting chemicals, sterilants, powdered latex products, aerosolized medications, and other substances that can trigger or worsen asthma. Indeed, workers exposed to cleaning/disinfectant products [e.g. bleach, ammonia, quaternary ammonium compounds (QAC)], powdered latex gloves, and aerosolized drug therapies have roughly double the risk of developing new-onset asthma [2]. One study estimated that almost half of adult asthma could be caused or aggravated by work exposures [2].

Multiple epidemiologic studies have confirmed the link between these HCW tasks and asthma. For instance, evidence from Patel et al. [3] indicates that the prevalence of physician-diagnosed asthma, work-exacerbated asthma, and new-onset asthma among HCW has shown little change over time, with a substantial proportion also reporting bronchial hyperresponsiveness (BHR) symptoms. Importantly, new-onset asthma has been strongly linked to workplace exposures, particularly surface cleaning activities and the use of disinfectants, including orthophthalaldehyde, bleach, QAC, and spray products. These findings are consistent with many other studies.

These patterns underscore the potential burden of WRA in healthcare. Unmitigated, asthma in HCWs can reduce workforce health and productivity, leading to sick leave or workforce shortages. It also poses risks to patient care if symptomatic workers continue in exposure settings. Despite this, the exact prevalence of WRA among HCWs and the magnitude of various risk factors have not been clearly quantified. Existing data are fragmented across local surveys and industry reports. Moreover, evolving practices (e.g., new disinfectants introduced during infection-control campaigns) may change exposure profiles, making up-to-date synthesis essential.

To address these gaps, we conducted a systematic review and meta-analysis focusing on healthcare settings. Our objectives were to estimate the pooled prevalence of asthma among HCWs worldwide and to identify key occupational risk factors associated with its occurrence. By pooling evidence from diverse studies, we aim to provide robust estimates of how common asthma is in HCWs and which tasks or exposures are most important. This work is important for clinicians, industrial hygienists, and policy-makers: quantifying the burden of HCW asthma and its determinants can guide targeted prevention (such as safer cleaning alternatives and protective practices) and encourage routine occupational surveillance in healthcare. The primary aims were to (1) determine the overall prevalence of asthma among HCWs; (2) quantify the prevalence of specific occupational activities (e.g., cleaning, sterilizing, and aerosol administration) linked to asthma; and (3) summarize evidence on risk predictors (demographic, personal, and work-related) for new-onset or exacerbated asthma in HCWs.

Methods

This systematic review and meta-analysis were conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement guidelines [4].

Literature search and keywords

A comprehensive and systematic literature search was conducted in PubMed, Scopus, and Web of Science to identify relevant studies published up to December 2025. The search strategy was developed to capture studies assessing asthma prevalence and occupational risk factors among HCWs. The following search terms were used across the databases:

(asthma OR asthmatic) AND (Occupation OR “healthcare worker” OR “health care worker” OR “HCWs” OR “health care workers” OR “healthcare personnel” OR “health care personnel” OR “medical staff” OR “hospital staff” OR “healthcare professionals” OR “health care professionals”).

No restrictions were applied regarding geographic location. Reference lists of all included articles and relevant reviews were manually screened to identify additional eligible studies not captured by the electronic search.

Eligibility criteria

Studies were considered eligible for inclusion if they met the following criteria:

1. Observational studies, including cross-sectional or cohort designs.
2. HCWs (e.g., nurses, physicians, respiratory therapists, technicians, or other hospital staff) working in any healthcare setting.
3. Studies reporting the prevalence of asthma, WRA, new-onset asthma, work-exacerbated asthma,

or asthma-related respiratory symptoms, and/or occupational risk factors associated with asthma.

Exclusion criteria were:

1. Non-original publications, such as reviews, editorials, commentaries, protocols, theses, conference abstracts, or case reports.
2. Studies conducted in non-healthcare occupational groups or studies involving mixed occupational populations without extractable data specific to HCWs.
3. Studies with insufficient or unclear data on asthma prevalence or occupational risk factors.

Study selection and data extraction

After removal of duplicate records, all identified citations were uploaded into the Rayyan software for blinded screening [5]. Two reviewers independently screened titles and abstracts based on the predefined eligibility criteria. Full-text articles were retrieved and reviewed for studies deemed potentially relevant. Any disagreements between reviewers were resolved through discussion and consensus.

Data extraction was independently performed by two authors using a standardized electronic data extraction form. The following information was collected from each included study:

- Study characteristics: first author, year of publication, country, study design, healthcare setting, and sample size.
- Participant characteristics: mean age or age category, and sex distribution.
- Outcomes: prevalence of asthma and tasks contributing to asthma development (e.g.,

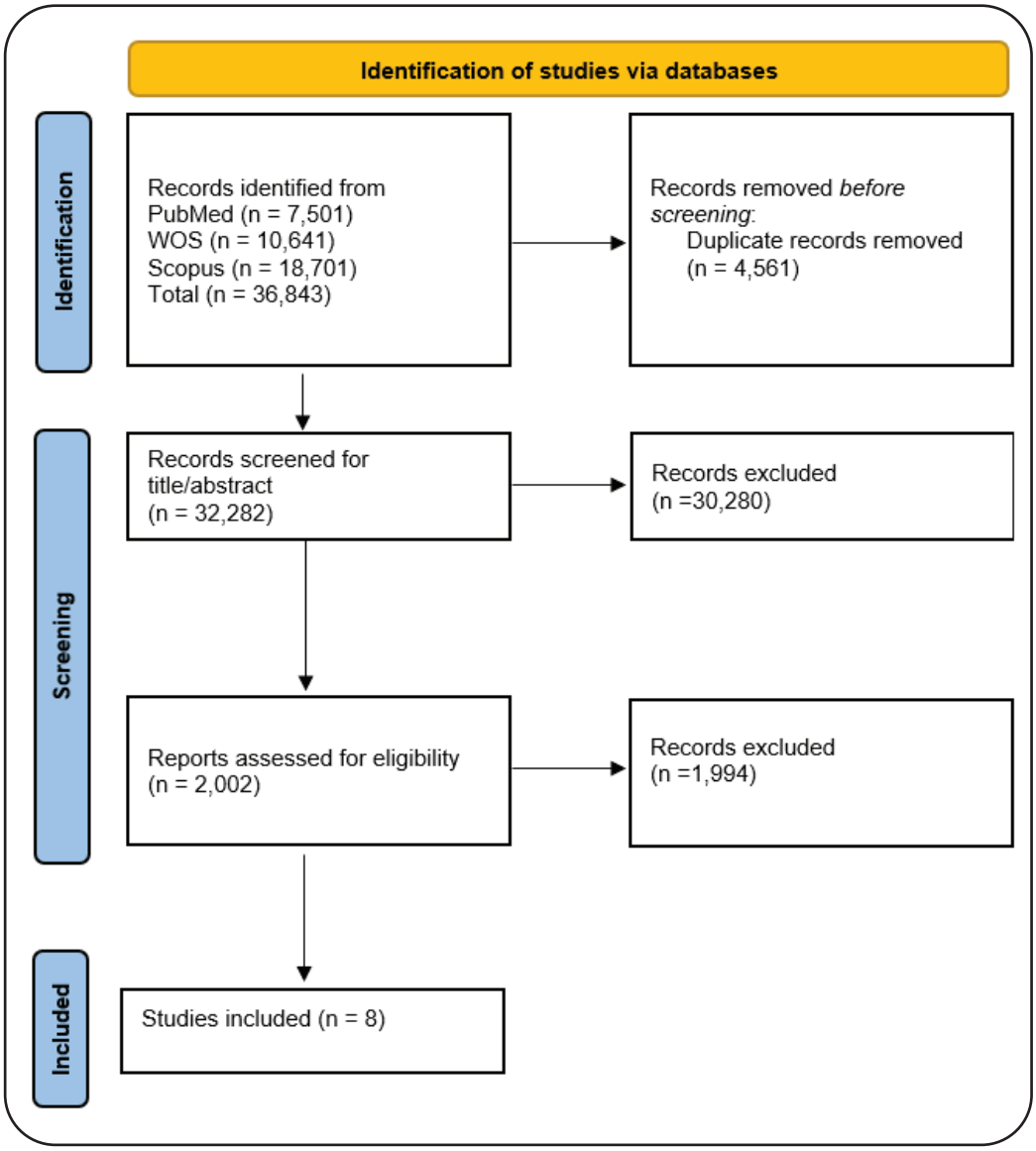


Figure 1. *PRISMA flowchart of study selection.*

sterilizing or disinfecting medical instruments, administering aerosolized medications to patients).

- Occupational exposures and risk factors: cleaning and disinfection tasks, exposure to specific agents (e.g., disinfectants, sterilants, latex, and aerosolized medications), and reported predictors of asthma or respiratory symptoms.

Risk of bias assessment

The methodological quality of the included cross-sectional studies was independently assessed by two

Table 1. *Summary of the included study characteristics.*

Study (Author, year)	Sample size (n)	Age, mean (SD)/range n (%)	Sex, males n (%)	Design	Population	Key finding
Kurth et al. 2017 [6]	347	21–37: 89 (25.7) 38–49: 90 (25.9) 50–561: 94 (27.1) 57–73: 74 (21.3)	76 (21.9)	Cross-sectional study	Workers employed at the VA Medical Center, USA.	Work-related exposures and job tasks were found to be associated with current asthma and asthma-like symptoms; however, additional studies are required to clarify the temporal relationship between these occupational exposures and the development of asthma and asthma-like symptoms.
Caridi et al. 2019 [7]	2,030	48.6 (11.4)	487 (24)	Cross-sectional study	Nine healthcare occupations in New York City	Work tasks, particularly cleaning fixed surfaces, showed a stronger association with asthma-related outcomes than employment in the healthcare profession itself.
Amakusa et al. 2025 [8]	556	39.6 (13.7)	126 (22.7)	Cross-sectional study	Gamagori City Hospital, Japan	Laryngeal abnormal sensation significantly worsens symptoms such as cough, negatively affects quality of life, and is independently linked to asthma, GERD, and mood disturbances.
Patel et al. 2024 [3]	2,421	48.8 (17.7)	569 (16.8)	Cross-sectional study	Texas sample of physicians, nurses, respiratory/ occupational therapists, and nurse aides	The prevalence of asthma appears to be stable compared to that of 2003; however, the associations between NOA and surface-cleaning exposures persisted, while those related to instrument cleaning declined.
Ibrahim et al. 2025 [9]	4,791	48.85 (12.46)	796 (16.6)	Cross-sectional study	French HCWs from the CONSTANCES general-population cohort	In a large cohort of HCWs, four distinct disinfectants and cleaning product exposure patterns were identified, highlighting the heterogeneity of healthcare occupations
Kurai et al. 2015 [10]	4,634	40.4 (11.35)	257 (5.5)	Cross-sectional study	Hospitals, clinics, and health care centers in Tottori and Shimane, Japan.	Duration of employment, bed-making activities, latex allergy, obesity, and smoking may be associated with an increased risk of wheeze among nursing professionals.
Mwanga et al. 2022 [11]	697	41.7 (14.1)	160 (23)	Cross-sectional study	HCWs from South Africa and Tanzania.	HCWs in both hospitals showed similar prevalences of work-related respiratory symptoms, and sensitization to ortho-phthalaldehyde and natural rubber latex appears to contribute to allergic airway inflammation in this population.
Gonzalez et al. 2013 [12]	543	0–29: 112 (20.8) 30–39: 145 (26.9) 40–49: 160 (29.7) 50+: 122 (22.6)	59 (11.1)	Cross-sectional study	Members aged 18–65 years, working for at least 6 months in seven French healthcare settings.	The greatest risk was linked to tasks that required manually diluting disinfectants, indicating potential exposure to repeated spikes of concentrated products, which are known strong respiratory irritants.

reviewers using the Newcastle–Ottawa Scale (NOS) adapted for cross-sectional studies [13]. The assessment focused on sample representativeness, adequacy of sample size, ascertainment of asthma outcomes, and control for potential confounding factors. Discrepancies in quality assessment were resolved through consensus.

Statistical analysis

All statistical analyses were performed using RStudio with the "meta" package [14]. Prevalence estimates from individual studies were pooled using a random-effects model to account for anticipated between-study heterogeneity. Pooled results were reported as prevalence estimates with corresponding 95% confidence intervals (CIs). Statistical heterogeneity was evaluated using Cochran's Q test and quantified by the I^2 statistic, with I^2 values ≥50% or p-values <0.10 indicating substantial heterogeneity [15].

Publication bias was assessed using the Doi plot and the Luis Furuya–Kanamori (LFK) asymmetry index. An LFK index within ± 1 was considered indicative of no asymmetry, values between ± 1 and ± 2 suggested minor asymmetry, and values exceeding ± 2 indicated major asymmetry [16]. Publication bias analyses and Doi plots were generated using the MetaXL add-in for Microsoft Excel [17].

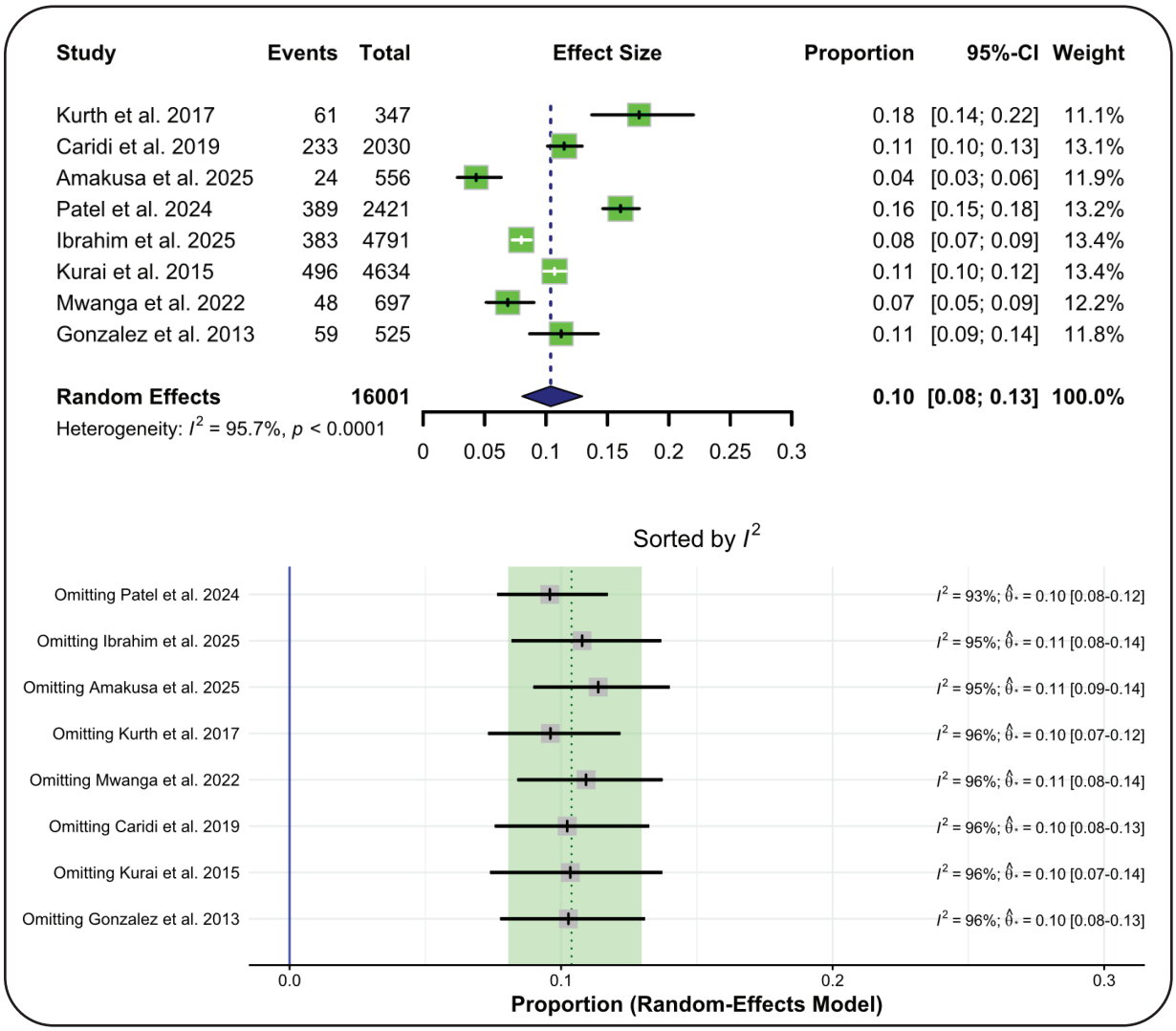
Sensitivity analysis

Sensitivity analyses were conducted using a leave-one-out approach, whereby each study was sequentially removed to assess its influence on the pooled prevalence estimates and to explore potential sources of heterogeneity.

Results

Literature search

The electronic database search yielded 36,843 records. After removal of duplicates, 32,282 records were screened by title and abstract, and 2,002 articles



Figue 2. *A) Prevalence of asthma among HCWs, B) Leave-one-out analysis.*

were selected for full-text assessment. Following a detailed eligibility evaluation, eight cross-sectional studies were included in the systematic review and meta-analysis. The study selection process is illustrated in the PRISMA flow diagram, as shown in Figure 1.

Study and population characteristics

The included studies collectively enrolled a total of 16,019 HCWs from diverse healthcare settings in various countries, including the USA, Japan, France, South Africa, and Tanzania [6,9,8,3,11,7,10,12]. Sample sizes varied considerably, ranging from 347 to 4,791 participants. The participants were drawn from hospitals, clinics, and specialized healthcare centers, with a predominant focus on nurses, physicians, respiratory therapists, and other healthcare staff. Age data were available for all studies, with average ages ranging from 39.6 to 48.85 years, and participants typically fell between the ages of 20–60 years. The proportion of male participants varied across studies, from 5.5% in the study by Kurai et al. [10] to 24% in Caridi et al. [7]. In terms of workplace exposures, studies consistently identified a higher prevalence of respiratory issues in HCWs involved in cleaning and disinfection tasks, especially those exposed to QAC, latex, and orthophthalaldehyde. Several studies, such as those by Caridi et al. [7] and Gonzalez et al. [12], highlighted the significance of work tasks, specifically cleaning tasks, in exacerbating asthma and respiratory symptoms. Gender distribution showed a predominance of female participants across most studies. The studies and population characteristics are represented in Table 1.

Quality assessment

The methodological quality of the included cross-sectional studies was assessed using the NOS. As shown in **Supplementary Table 1**, the overall scores of the studies ranged from 6 to 8 out of 9, reflecting variability in study design and reporting. All studies performed well in terms of outcome assessment and statistical analysis, with many demonstrating robust methods for evaluating asthma outcomes and applying appropriate statistical tests. However, some studies had limitations in handling non-respondents. Comparability, which reflects the control for confounding factors, was adequately addressed in several studies. Overall, the majority of studies were rated as moderate to high quality, indicating strong reliability in the evidence base for this review.

Meta-analysis

Asthma prevalence among HCWs

The pooled prevalence of asthma among HCWs was 0.10 (95% CI: 0.08–0.13), with high heterogeneity (I^2 = 95.7%, p < 0.0001), as shown in Figure 2A. Sensitivity analysis was conducted to assess the robustness of the findings, and it showed that excluding any individual study did not resolve the observed heterogeneity, as indicated by Figure 2B. The publication bias assessment using DOI plots yielded an LFK index of −0.09, suggesting no asymmetry, as shown in Figure 3.

HCWs administering aerosolized medications

The pooled prevalence of HCWs performing the task of administering aerosolized medications to patients was 0.24 (95% CI: 0.07–0.47), with high heterogeneity (I^2 = 99.6%, p < 0.0001), as shown in Figure 4A. Sensitivity analysis was conducted to assess the robustness of the findings, and it showed that excluding any individual study did not resolve the observed heterogeneity, as shown in Figure 4B.

HCWs using chemicals, adhesives, antiseptics, alcohols, or solvents on patients

The pooled prevalence of HCWs using chemicals, adhesives, antiseptics, alcohols, or solvents on patients was 0.32 (95% CI: 0.30–0.34), with no heterogeneity (I^2 = 0%, p = 0.95), as shown in Figure 5A.

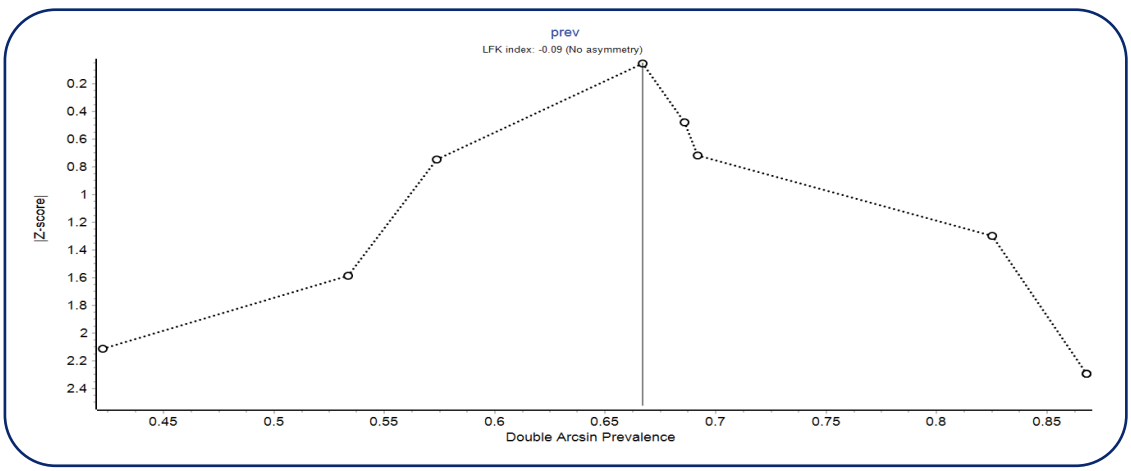


Figure 3. *Doi plot and LFK index for the prevalence of asthma among HCWs.*

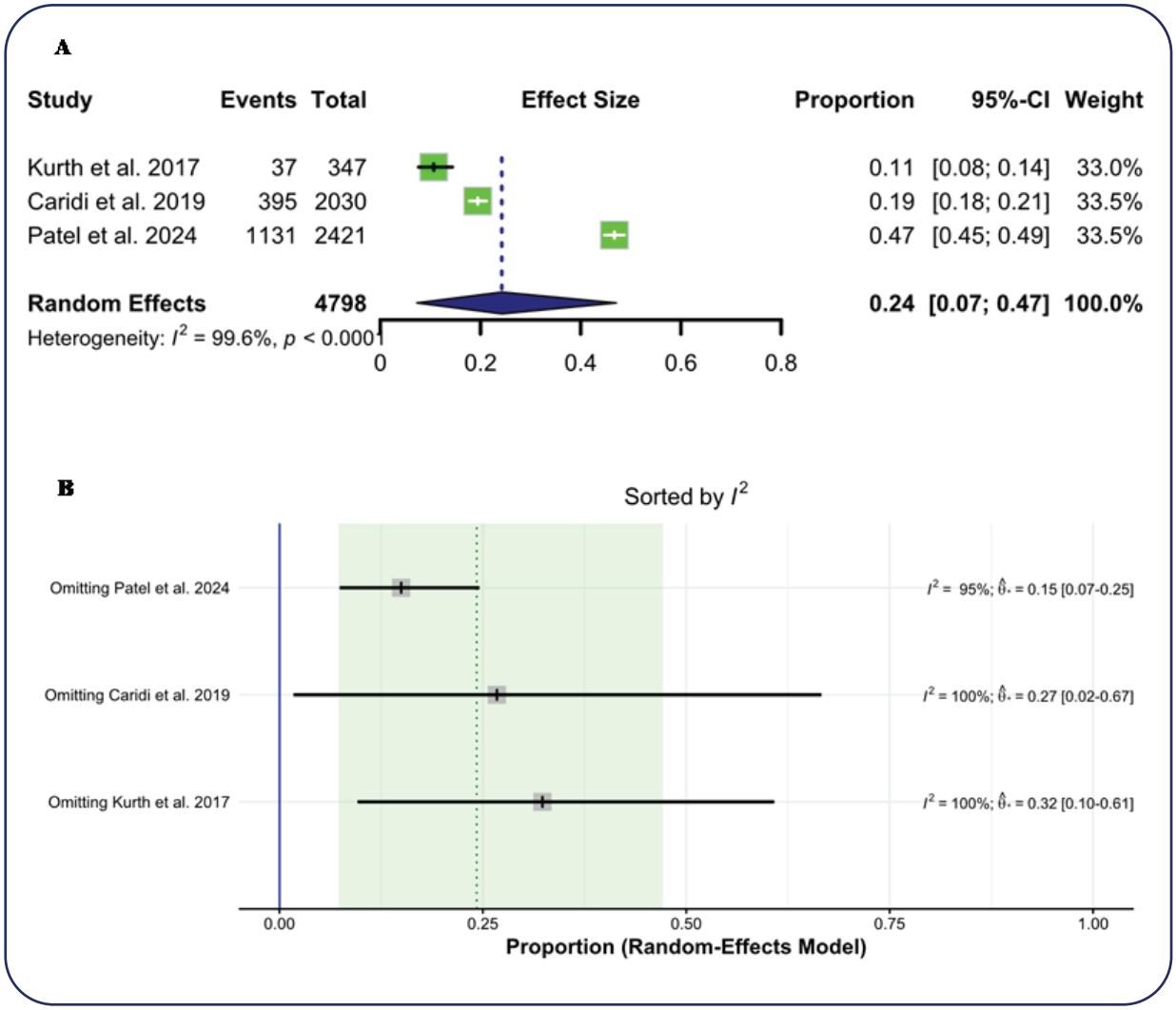


Figure 4. *A) Prevalence of HCWs administering aerosolized medications to patients, B) leave-one-out analysis.*

HCWs cleaning or disinfecting equipment, environmental, or fixed surfaces

The pooled prevalence of HCWs involved in cleaning or disinfecting equipment, environmental, or fixed surfaces was 0.58 (95% CI: 0.45-0.70), with high heterogeneity (I^2 = 94.8%, p < 0.0001), as shown in Figure 5B.

HCWs sterilizing or disinfecting medical instruments

The pooled prevalence of HCWs involved in sterilizing or disinfecting medical instruments was 0.15 (95% CI: 0.05-0.29), with high heterogeneity (I^2 = 99.1%, p < 0.0001), as shown in Figure 6A. Sensitivity analysis was conducted to assess the robustness of the findings, and it showed that excluding any individual study did not resolve the observed heterogeneity, as shown in Figure 6B.

Risk factors and predictors of asthma and its symptoms

In Patel et al. [3], the unadjusted models showed that new-onset asthma (NOA) was significantly associated with age (OR = 1.03, 95% CI: 1.02-1.04), atopy (OR = 2.47, 95% CI: 1.57-3.88), and job seniority, with the odds of NOA increasing with advancing age (ORs ranging from 5.48-11.39). Additionally, BHR symptoms were more likely among females (OR = 1.68, 95% CI: 1.28-2.20) and those with atopy (OR = 6.75, 95% CI: 5.00-9.11). Regarding cleaning tasks and products, exposure to orthophtalaldehyde (OPA), bleach, QAC, and sprays used for surface cleaning was significantly associated with NOA, even after adjusting for demographic factors, with the use of OPA for instrument cleaning remaining significantly associated with NOA (OR = 1.77, 95% CI: 1.15-2.72). Interestingly, latex glove use was inversely associated with NOA in more recent years.

In Gonzalez et al. [12], unadjusted analyses found that registered nurses and auxiliary nurses had significantly higher odds of physician-diagnosed asthma, particularly in association with QAC exposure and cleaning tasks. Among these, manual dilution of disinfectants had the highest odds ratio (OR) for asthma risk (OR = 4.58, 95%

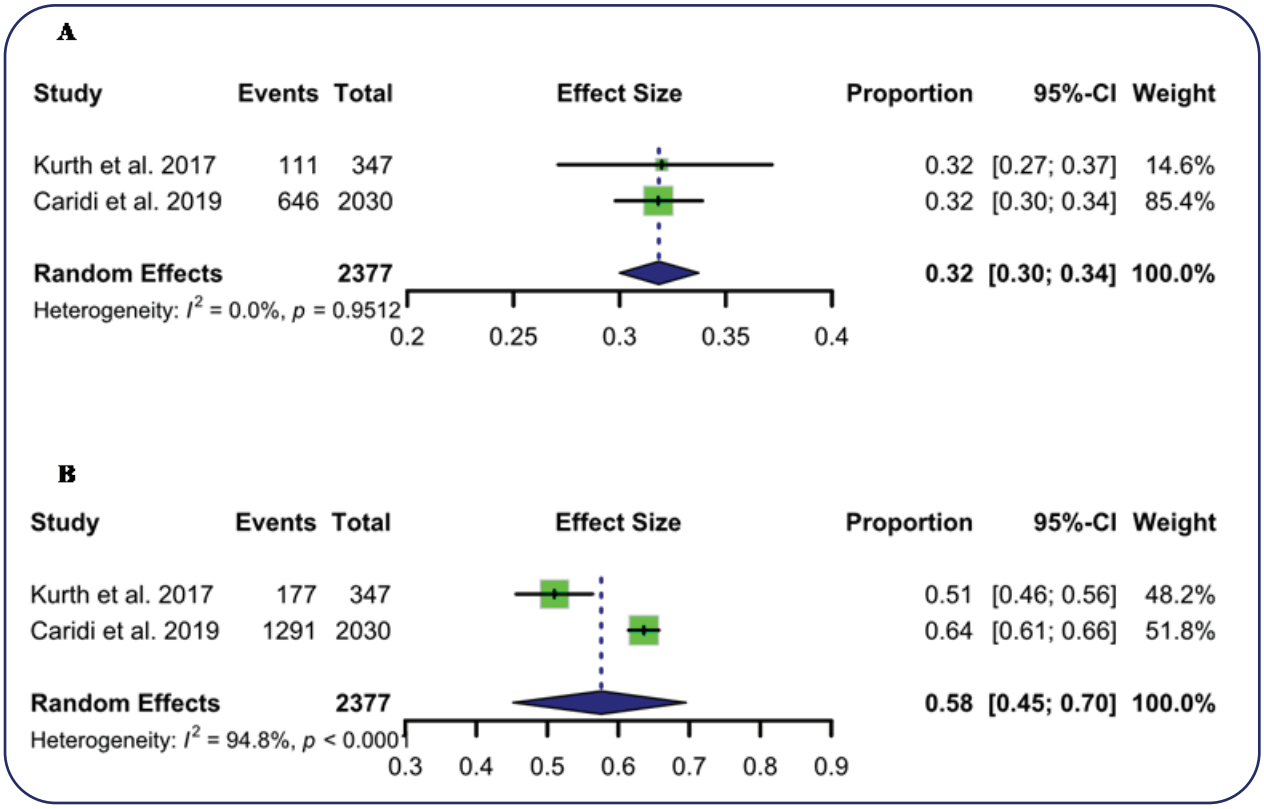


Figure 5. *A) Prevalence of healthcare workers using chemicals, adhesives, antiseptics, alcohols, or solvents on patients, B) Prevalence of healthcare workers cleaning or disinfecting equipment, environmental, or fixed surfaces.*

CI: 1.87-11.21). Additionally, atopy and Body mass index ≥ 25 were significantly associated with asthma, while job seniority in healthcare was inversely associated with the risk of new-onset asthma, showing a decreased risk for workers with more than 20 years of seniority.

Lastly, Kurai et al. [10] identified several factors associated with the prevalence of wheeze among nursing professionals, including employment duration, shift work, and bed-making tasks. Obesity and latex allergy were significant predictors of wheeze among female nursing professionals. Furthermore, current smoking was significantly associated with an increased likelihood of wheeze, with both male and female smokers showing significantly elevated odds compared to non-smokers.

Discussion

Our meta-analysis combined data on over 16,000 HCWs worldwide. We estimated the overall prevalence of asthma among HCWs to be roughly 10%. We also quantified how common various occupational tasks are among HCWs. For example, about 58% of HCWs reported involvement in cleaning or disinfecting equipment and surfaces, whereas 24% performed aerosolized medication administration and 15% handled instrument sterilization. In addition, roughly 32% reported using chemicals or solvents on. Because of differences in study design and populations, most pooled estimates showed very high statistical heterogeneity (I^2 often >90%).

The substantial I^2 values indicate that prevalence estimates varied widely across studies. Several factors likely contribute. Included studies spanned different regions and time periods, with variable asthma definitions (e.g., self-reported physician-diagnosed versus symptom-based questionnaires) and diagnostic rigor. Populations differed in age and gender balance (most were predominantly female), and job categories ranged from nurses and technicians to support staff. Exposure assessment varied: some studies relied on self-reported tasks or job-exposure matrices, others on administrative records. Regional differences in cleaning practices and chemicals (for example, use of QAC *vs.* other disinfectants) and ventilation standards could also influence asthma rates. These methodological and contextual variations likely underlie the observed heterogeneity. We conducted leave-one-out sensitivity checks, which showed that no single study drove the overall results, suggesting that the pooled estimates are robust but reflecting genuine diversity.

In our review, HCWs' self-reported exposures were very common (over half cleaned surfaces), in agreement with surveillance data showing bleach as one of the top triggers in healthcare-related asthma cases [18]. A

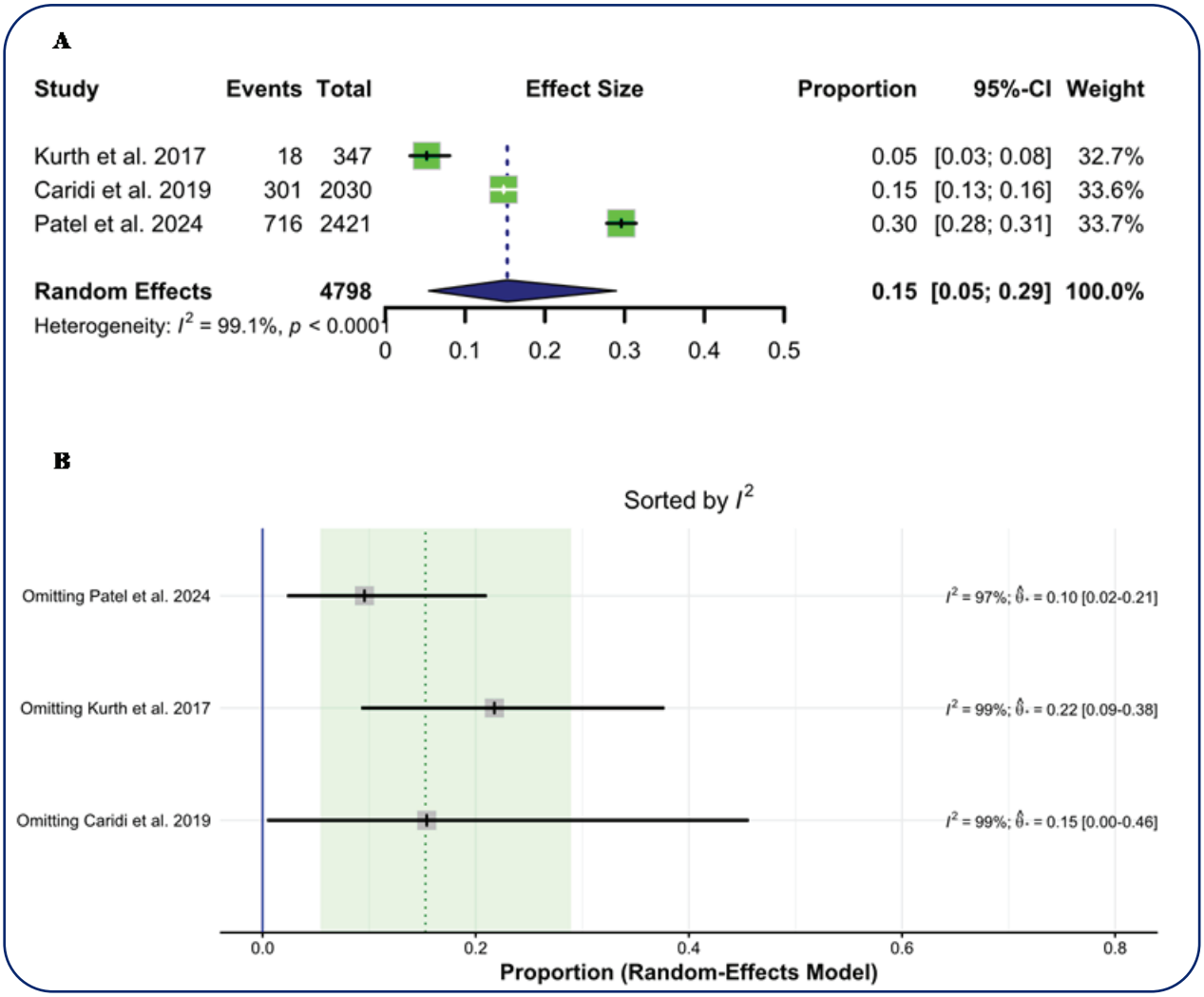


Figure 6. *A) Prevalence of healthcare workers sterilizing or disinfecting medical instruments, B) Leave-one-out analysis.*

recent U.S. survey found that regular surface cleaning or disinfectant use (bleach/quats, OPA, sprays) among HCWs was associated with approximately twofold higher odds of self-reported new-onset asthma [3]. In short, our prevalence estimates and identified high-risk tasks echo this prior evidence.

Our results also align with international guidance on WRA. The World Health Organization highlights that cleaning and disinfection agents raise asthma risk substantially – for example, nurses exposed to general cleaning disinfectants have been shown to have ~67% higher asthma risk, and bleach/glutaraldehyde each roughly doubles the risk [19]. We similarly found that a large proportion of HCWs engage with exactly these hazardous agents. The American Thoracic Society has long emphasized that about 16% of adult asthma is attributable to workplace exposures and over 20% of adults with asthma experience work-related exacerbations [20,21].

These findings have clear implications for occupational health in healthcare. The high asthma burden suggests that hospitals and clinics should treat asthma among staff as an important health priority. First, routine screening and surveillance may be warranted. Centers for Disease Control and Prevention/National Institute for Occupational Safety and Health recommends that healthcare employers consider medical surveillance plans for asthma, including periodic questionnaires and spirometry for workers handling known respiratory hazards [22]. Second, and most critically, interventions should follow the Hierarchy of Controls. NIOSH guidance emphasizes eliminating or substituting the hazards when possible [22]. In the healthcare context, this could mean replacing bleach and glutaraldehyde with less-toxic disinfectants (for example, hydrogen peroxide or alcohol-based agents where effective), or using closed systems to apply sterilants instead of open spraying. Engineering controls-such as improved general ventilation, local exhaust hoods

for cleaning tasks, or automated cleaning machines-should be prioritized over reliance on respirators [19,22]. Administrative controls (training, limiting duration of exposure, safe work practices) are also important. Personal Protective Equipment (masks or respirators) should be considered only as a last line of defense, as noted by NIOSH [22]. Many hospitals have begun "green cleaning" initiatives or standardized disinfectant use to reduce the use of hazardous chemicals. The fact that 58% of HCWs engage in high-risk cleaning suggests that such preventive measures could have a large impact on workforce health.

A strength of our study is the comprehensive pooling of many studies across multiple continents, yielding a large sample (N > 16,000). We used rigorous methods (PRISMA, NOS assessment) and found that most included studies were moderate-to-high quality, with robust outcome measures. Nevertheless, important limitations exist. All included data were from cross-sectional studies, which means we cannot confirm causality or capture incidence rates. The pooled prevalence combines both pre-existing and new-onset asthma (including work-exacerbated cases), so we cannot distinguish those subtypes. Because of the cross-sectional design, reverse causation is possible (e.g., symptomatic workers may avoid certain tasks, or sick worker bias). The reliance on self-reported asthma diagnoses or symptoms could lead to misclassification. Despite our attempt to be inclusive, the pooled data may not be fully representative: most studies came from a handful of countries (e.g., the US, Europe, and a few from Africa/Asia), and some healthcare roles (e.g., administrative staff) were underrepresented. These factors may limit generalizability to all global HCWs. Moreover, the pooled analyses incorporated outcomes with differing clinical definitions and levels of diagnostic specificity, including ever asthma, current asthma, physician-diagnosed asthma, wheeze, and laryngeal hypersensitivity. Although these outcomes broadly reflect respiratory or airway health, they are not clinically equivalent and may represent distinct pathophysiological entities, symptom profiles, or temporal disease states. Consequently, combining these measures may have introduced conceptual heterogeneity and may limit the interpretability and comparability of the pooled estimates. The findings should therefore be interpreted as reflecting broader respiratory health associations rather than a single uniform asthma outcome.

Our study highlights gaps that future work should address. Longitudinal cohort studies of HCWs would be especially valuable to track new-onset occupational asthma over time and better infer causality. Such studies could incorporate quantitative exposure measurements (e.g., personal air sampling of disinfectant vapors or real-time task monitoring) rather than relying solely on job title or self-report. More research is also needed on the effectiveness of specific interventions: for example, trials comparing traditional bleach cleaning versus safer alternatives in hospitals, or evaluating the impact of ventilation upgrades on HCW asthma rates. Implementation research should test whether routine surveillance programs or training initiatives actually reduce disease burden. Further, studies in low- and middle-income country settings are sparse; expanding data in those regions would assess whether risk patterns differ under varying resource conditions. Finally, economic analyses of HCW asthma (productivity losses, healthcare costs) could inform policy by quantifying the benefits of prevention.

Conclusion

This systematic review and meta-analysis demonstrate that asthma affects approximately 1 in 10 HCWs worldwide, underscoring a substantial and preventable occupational health burden. A large proportion of HCWs are routinely exposed to high-risk tasks, particularly cleaning, disinfection, and chemical use, which are consistently associated with asthma and respiratory symptoms. These findings reinforce existing international recommendations emphasizing exposure reduction through substitution of hazardous agents, engineering controls, and occupational health surveillance. Future longitudinal studies incorporating quantitative exposure assessment are needed to clarify causal pathways and evaluate the effectiveness of preventive interventions aimed at reducing WRA in healthcare settings.

List of Abbreviations

CDC	Centers for Disease Control and Prevention
GERD	Gastroesophageal Reflux Disease
NIOSH	National Institute for Occupational Safety and Health
PPE	Personal Protective Equipment

Conflict of interest

The authors declare that they have no conflict of interest regarding the publication of this article.

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None.

Consent for publication

Not applicable.

Human Ethics and consent to participate statement

Our manuscript was not applied to human beings and thus requires no ethical approval.

Ethics approval and consent to participate

Not applicable.

Availability of data and materials

All data generated or analyzed during this study are included in this published article [and its supplementary material file].

Authors' contributions

The authors meet the criteria for authorship as recommended by the International Committee of Medical Journal Editors (ICMJE).

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Supplementary Table 1. *Quality assessment of the included studies using NOS.*

Study ID	Selection				Comparability	Outcome		Total (out of 9)
	Representativeness of the sample	Sample size	Ascertainment of exposure	Non-respondents	The subjects in different outcome groups are comparable, based on the study designs or analysis, confounding factors are controlled	Assessment of outcome	Statistical test	
Amakusa et al. [12]	★	★	★	★	★	★★	★	8
Caridi et al. [15]	★	★	–	★	★	★	★	6
Gonzalez et al.[17]	★	★	★	★	★	★★	★	8
Ibrahim et al. [11]	★	★	★	★	★	★★	★	8
Kurai et al. [16]	★	★	★	–	★	★★	★	7
Kurth et al. [10]	★	★	★	–	★	★★	★	7
Mwanga et al. [14]	★	★	★	★	★	★★	★	8
Patel et al. [13]	★	★	★	★	★	★★	★	8