Supplementary materials

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Methodology

Outcome clustering

Studies were categorized into groups based on the specific intervention assessed: four groups for disinfectants (chlorine-based products, glutaraldehyde, peracetic acid (PAA), acetic acid (AA), and hydrogen peroxide (HP), and quaternary ammonium compounds (QACs)); two groups for application methods (use of spray and general disinfection tasks (GDTs), defined as any other disinfection-related activities except spraying, such as wiping, mopping, disinfection of patient rooms, furniture surfaces, equipment, and preparation and dilution of products); and one group for mitigation measures (indoor ventilation and personal protective equipment (PPE)), which were included for completeness.

Health outcomes reported in the included studies were grouped into clusters based on their shared physiological pathways, clinical manifestations, and relevance to occupational exposure. This approach was necessary to streamline the meta-analytic process, minimize heterogeneity within outcome categories, and facilitate meaningful comparisons between studies. Below, the rationale for each outcome cluster is detailed:

Condition	Included outcomes	Theoretical basis	Relevance to disinfectant exposure
Respiratory Conditions	New-onset asthma, poorer asthma control, asthma exacerbations, undiagnosed/untreated asthma, wheeze, cough, phlegm, shortness of breath, breathlessness, throat irritation, difficulty breathing	The respiratory system is the primary target of airborne chemical exposures in occupational settings, particularly from disinfectants. Inhalation of irritants or sensitizers can trigger airway inflammation, bronchial hyperresponsiveness, and obstruction, which manifest as asthma, wheezing, coughing, and other related symptoms.	Chlorine-based products and other disinfectants are known to release volatile compounds that irritate the respiratory mucosa, leading to both acute and chronic respiratory conditions. This grouping captures both disease outcomes (e.g., asthma) and symptomatology (e.g., wheeze, cough) to reflect the full spectrum of respiratory effects.
Ocular-Nasal Conditions	Eye irritation, nasal irritation, sneezing, nasal obstruction,	The conjunctivae and nasal mucosa are highly sensitive to chemical irritants, making them common sites of	Many disinfectants, including chlorine-based products, release fumes or vapors that can irritate the eyes and nasal

	nasal catarrh, ocular-nasal symptoms	inflammation and irritation following exposure to airborne disinfectants. These symptoms are often the first indicators of exposure to volatile compounds.	passages, causing tearing, redness, nasal congestion, and sneezing. These effects often co-occur, justifying their grouping under a single category.
Skin Conditions	Skin disorders, eczema, rashes, allergic skin reactions.	The skin is a common site of occupational exposure during disinfection tasks, especially when proper protective measures (e.g., gloves) are not used. Direct contact with disinfectants can lead to skin irritation or allergic dermatitis.	Both chlorine-based and non-chlorine-based disinfectants can act as irritants or allergens, leading to conditions such as eczema or contact dermatitis. Grouping these outcomes together reflects the shared mechanism of dermal exposure and reaction.
Neurological Conditions	Headache	Neurological symptoms, such as headaches, can result from systemic absorption of chemical vapors or indirect effects of irritant exposures (e.g., stress or discomfort caused by respiratory or ocular symptoms).	Headaches are frequently reported by workers exposed to volatile compounds released by disinfectants. Though less directly related to specific mechanisms of exposure than other clusters, they are an important indicator of occupational discomfort and systemic effects.
Gastrointestinal Conditions	Nausea	Inhalation of volatile compounds from disinfectants can irritate the gastrointestinal mucosa or trigger systemic effects, leading to nausea. Nausea may also result from the aversive	Nausea is a commonly reported symptom among healthcare workers exposed to chemical disinfectants and reflects the broader systemic effects of occupational exposure.

		odors of disinfectants, particularly in poorly ventilated environments.	
Immunological Conditions	Allergic reactions.	Allergic reactions occur as hypersensitivity responses triggered by exposure to sensitizing agents in disinfectants. These reactions often manifest systemically or as localized skin conditions (in that case, they are reported as skin conditions).	Certain disinfectants, such as quaternary ammonium compounds (QACs) or glutaraldehyde, are known allergens that can provoke immune responses in sensitive individuals. This grouping reflects the broader immunological effects of disinfectant exposure beyond localized reactions.

The clustering of outcomes was guided by:

- Physiological pathways: Outcomes within the same cluster share common exposure routes or biological mechanisms (e.g., inhalation for respiratory and ocular-nasal conditions, direct contact for skin conditions).
- Clinical presentation: Clustering reflects common patterns of symptoms or conditions that healthcare workers experience during occupational exposure, facilitating meaningful interpretation of results.
- Consistency across studies: Grouping similar outcomes ensures comparability across studies with diverse reporting practices, enabling consistent meta-analysis.
- Reduction of heterogeneity: By consolidating related outcomes, the grouping minimizes heterogeneity within clusters, improving the validity of pooled estimates in the meta-analysis.

Single pair-wise comparison

For studies reporting multiple outcomes or subgroups within the same population, a statistical approach was applied to combine these groups into a single pair-wise comparison to avoid unit-of-analysis errors. This method ensures that each study contributes only one effect size to the overall

meta-analysis. The process involved calculating a pooled effect estimate for the multiple groups or outcomes using inverse-variance weighting. Specifically, the log-transformed effect sizes (e.g., odds ratios) and their corresponding standard errors were extracted for each group. The combined log-effect size was calculated as the weighted average of the individual log-effect sizes, with weights proportional to the inverse of the squared standard errors. The combined standard error was then derived from the total inverse variance, ensuring that the pooled estimate reflected the precision of the individual groups. The pooled log-effect size was back-transformed to the original scale (e.g., odds ratio) for interpretation, and 95% confidence intervals were calculated to represent the uncertainty around the combined estimate.

GRADE

The Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) approach (The GRADE Working Group, 2013) was applied systematically to assess the certainty of evidence across all interventions and comparisons included in this review. This methodology evaluates the quality of evidence by considering five key domains: risk of bias, inconsistency, indirectness, imprecision, and publication bias. Each domain was assessed to determine its influence on the confidence in the pooled results.

The assessment of risk of bias focused on the methodological quality of the included studies. Variability in study design, reliance on self-reported outcomes, and the potential for bias inherent to cross-sectional designs were carefully evaluated. A hybrid tool, combining elements from the Scottish Intercollegiate Guidelines Network (SIGN) and the Critical Appraisal Skills Program (CASP), was used to categorize the risk of bias as high, low, or unclear.

To evaluate inconsistency, we examined the variability in effect estimates across the included studies. The Higgins I^2 statistic was employed to quantify the extent of heterogeneity. When the I^2 value was below 50%, inconsistency was deemed minimal, and no downgrades were applied. However, if the I^2 value exceeded 50%, it was considered indicative of significant heterogeneity, resulting in a downgrade of the certainty of evidence.

The indirectness domain assessed the relevance of the evidence to the research questions posed in this review. Studies were evaluated to confirm alignment with the population of interest (healthcare workers), the specific exposures (disinfectants and their application methods), and the outcomes of interest (respiratory conditions and other health effects). Studies directly addressing these aspects were not downgraded, while those with mismatches in relevance were penalized accordingly.

Imprecision was assessed by analyzing the confidence intervals (CIs) around the pooled effect estimates. Wide confidence intervals that crossed the null value (1.0) indicated uncertainty in the results, leading to a downgrade in certainty. Additionally, imprecision was influenced by the number of included studies and the total sample size, with small study pools contributing to less confidence in the findings.

Publication bias was evaluated through a combination of funnel plot analysis and Egger's test for asymmetry. Where no evidence of significant publication bias was detected (Egger's test p-value ≥ 0.05), no downgrades were applied. For derived comparisons, such as relative odds ratios (RORs), publication bias assessments were not applicable, as these comparisons relied on pooled estimates from prior meta-analyses rather than individual study-level data.

Based on the evaluation across these domains, the certainty of evidence was categorized into four levels: high, moderate, low, or very low. High-certainty evidence reflected strong confidence in the findings, while moderate-certainty evidence indicated some limitations in one domain. Evidence was classified as low or very low when significant concerns were identified across two or more domains.

Special considerations were applied to relative comparisons, such as RORs. These comparisons used pooled odds ratios (ORs) from individual meta-analyses to derive estimates, and heterogeneity and publication bias metrics were not calculated. Certainty for RORs was primarily influenced by the methodological quality of the underlying studies and the precision of the pooled estimates. In instances where confidence intervals for RORs included both harm and benefit, downgrades were applied for imprecision.

To enhance the clarity of conclusions, narrative statements were crafted according to GRADE recommendations. For high-certainty evidence, definitive terms such as 'is,' 'does,' 'has,' or 'will' were used to reflect very strong confidence in the findings. For moderate-certainty evidence, terms such as "probably" or "likely" were used to reflect reasonably strong confidence. Low-certainty evidence was conveyed using phrases like "may" or "the evidence suggests," while findings with very low certainty were described as "very uncertain." This phrasing allowed readers to clearly understand the strength of the evidence supporting each conclusion.

Figure S1. Alluvial plot displaying the clustering of studies based on the intervention or exposure assessed and the associated health outcomes. Each study is linked to specific interventions or exposures, which are then connected to various health outcomes.

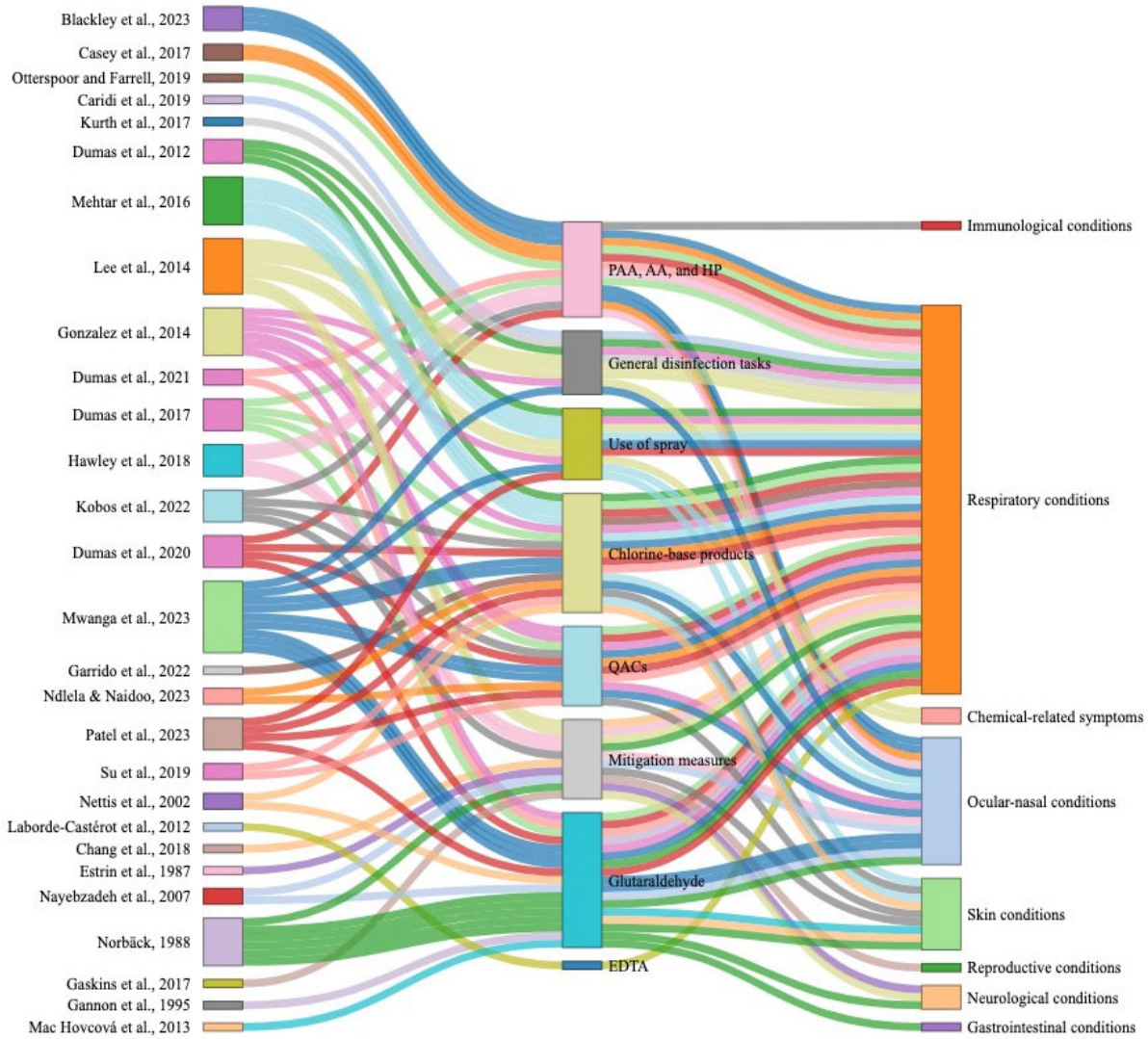


Table S1. Search strategy

Database	Search string
PubMed	1: "health personnel"[Mesh] OR ("health personnel"[tiab:~3] OR "healthcare personnel"[tiab:~3] OR "health provider"[tiab:~3] OR "health providers"[tiab:~3] OR "healthcare provider"[tiab:~3] OR "healthcare providers"[tiab:~3] OR "health worker"[tiab:~3] OR "health workers"[tiab:~3] OR "healthcare worker"[tiab:~3] OR "healthcare workers"[tiab:~3] OR "health professional"[tiab:~3] OR "health professionals"[tiab:~3] OR "healthcare professional"[tiab:~3] OR "healthcare professionals"[tiab:~3] OR "healthcare assistant"[tiab] OR "healthcare assistants"[tiab] OR "health assistant"[tiab:~3] OR "health assistants"[tiab:~3] OR paramedic*[tiab] OR nurse*[tiab] OR "Nursing Assistant"[tiab] OR "Nursing Auxiliaries"[tiab] OR "Nursing Auxiliary"[tiab] OR Anesthesiologist*[tiab] OR anesthetist*[tiab] OR Caregiver*[tiab] OR Carer*[tiab] OR "Care Givers"[tiab] OR "Care Giver"[tiab] OR "Case Manager"[tiab] OR "Case Managers"[tiab] OR Coroner*[tiab] OR "Medical Examiner"[tiab] OR "Medical Examiners"[tiab] OR surgeon*[tiab] OR "Emergency dispatcher"[tiab] OR "Emergency dispatchers"[tiab] OR "Infection Control Practitioner"[tiab] OR "Infection Control Practitioners"[tiab] OR "Laboratory Personnel"[tiab] OR "Laboratory Scientists"[tiab] OR "Laboratory Scientist"[tiab] OR "Medical Technologists"[tiab] OR "Medical Technologist"[tiab] OR "Laboratory Technicians"[tiab] OR "Laboratory Technician"[tiab] OR "Laboratory Assistants"[tiab] OR "Laboratory Assistant"[tiab] OR "Medical Staff"[tiab] OR "Medical Staffs"[tiab] OR Physician*[tiab] OR "hospital personnel"[tiab] OR doctor*[tiab] OR Pediatrician*[tiab] OR Neonatologist*[tiab] OR Pulmonologist*[tiab] OR Surgeon*[tiab] OR cleaning-worker*[tiab] OR cleaner*[tiab]) 2: ("Disinfectants"[Mesh:noExp] OR "Disinfectants"[Pharmacological Action] OR disinfect*[tiab] OR detergents[tiab] OR sterili*[tiab] OR decontaminat*[tiab]) AND (chlorine-dioxide*[tiab] OR hypochlorite*[tiab] OR Chlorine-based[tiab] OR hypochlorous-acid*[tiab] OR bleach*[tiab] OR chlorine-product*[tiab] OR Chlorin*[tiab] OR sodium-dichloroisocyanurate*[tiab] OR Chloramine-T[tiab] OR High-level-disinfectant*[tiab] OR benzalkonium-chloride[tiab])

	3: (("Disinfectants"[Mesh:noExp] OR "Disinfectants"[Pharmacological Action] OR disinfect*[tiab] OR detergent*[tiab] OR sterili*[tiab] OR decontaminat*[tiab]) AND (spray*[tiab] OR Aerosol*[tiab] OR airway*[tiab] OR vapour* OR airborn*[tiab])) 4: #1 AND (#2 OR #3) 5: (adverse*[tw] OR safe[tw] OR safety[tw] OR side-effect*[tw] OR undesirable-effect*[tw] OR toxicity[tw] OR tolerability[tw] OR reaction*[tw] OR hazard*[tiab]) OR "Chemical Safety"[Mesh] OR "Safety Management"[Mesh] OR irritant*[tw] OR irritat*[tw] OR allerg*[tw] OR exposure*[tw] OR exposed[tw] OR increased-risk*[tw] OR health-problem*[tw]) 6: #4 AND #5 7: "Letter"[Publication Type] OR "Editorial"[Publication Type] OR "comment"[Publication Type] 8: ("Animals"[Mesh] NOT ("Animals"[Mesh] AND "Humans"[Mesh])) 9: #6 not (#7 OR #8)
Scopus	1: (TITLE-ABS-KEY (((health*) w/3 (personnel OR provider* OR worker* OR professional* OR assistant*)) OR paramedic* OR nurse* OR nursing-assistant* OR nursing-auxilliar* OR Anesthesiologist* OR anesthetist* OR Caregiver* OR Carer* OR "Care Givers" OR "Care Giver" OR Case-Manager* OR Coroner* OR Medical- Examiner* OR Emergency-dispatcher* OR Infection-Control-Practitioner* OR Laboratory-Personnel OR Laboratory-Scientist* OR Medical-Technologist* OR Laboratory-Technician* OR Lab-technician* OR Laboratory-Assistant* OR Medical-Staff OR Physician* OR "hospital personnel" OR doctor* OR Pediatrician* OR Neonatologist* OR Pulmonologist* OR Surgeon* OR cleaning-worker* OR cleaner* OR ((hospital) w/5 (staff)))) AND 2: (TITLE-ABS-KEY (((disinfect* OR detergent* OR sterili* OR decontaminat* OR chlorine OR cleaning) AND (spray* OR aerosol* OR airway* OR vapour* OR airborn*))) OR 3: TITLE-ABS-KEY (((disinfect* OR detergent* OR sterili* OR decontaminat* OR (surface W/3 clean*)) AND (chlorine-dioxide* OR hypochlorite* OR chlorine-based OR hypochlorous-acid* OR bleach* OR chlorine-product* OR

	chlorin* OR sodium-dichloroisocyanurate* OR chloramine-t OR high-level-disinfectant* OR benzalkonium-chloride)))) AND 4: (TITLE-ABS-KEY (adverse* OR safe OR safety OR side-effect* OR undesirable-effect* OR toxicity OR tolerability OR hazard* OR irritant* OR irritat* OR allerg* OR exposure* OR exposed OR increased-risk* OR health-problem*)) #1 AND (#2 OR #3) AND #4 (TITLE-ABS-KEY ((((health*) W/3 (personnel OR provider* OR worker* OR professional* OR assistant*)) OR paramedic* OR nurse* OR nursing-assistant* OR nursing-auxilliar* OR anesthesiologist* OR anesthetist* OR caregiver* OR carer* OR "Care Givers" OR "Care Giver" OR case-manager* OR coroner* OR medical- AND examiner* OR emergency-dispatcher* OR infection-control-practitioner* OR laboratory-personnel OR laboratory-scientist* OR medical-technologist* OR laboratory-technician* OR lab-technician* OR laboratory-assistant* OR medical-staff OR physician* OR "hospital personnel" OR doctor* OR pediatrician* OR neonatologist* OR pulmonologist* OR surgeon* OR cleaning-worker* OR cleaner* OR ((hospital) W/5 (staff)))) AND TITLE-ABS-KEY ((((disinfect* OR detergent* OR sterili* OR decontaminat* OR chlorine OR cleaning) AND (spray* OR aerosol* OR airway* OR vapour* OR airborn*)))) OR TITLE-ABS-KEY (((disinfect* OR detergent* OR sterili* OR decontaminat* OR (surface W/3 clean*)) AND (chlorine-dioxide* OR hypochlorite* OR chlorine-based OR hypochlorous-acid* OR bleach* OR chlorine-product* OR chlorin* OR sodium-dichloroisocyanurate* OR chloramine-t OR high-level-disinfectant* OR benzalkonium-chloride))) AND TITLE-ABS-KEY ((adverse* OR safe OR safety OR side-effect* OR undesirable-effect* OR toxicity OR tolerability OR hazard* OR irritant* OR irritat* OR allerg* OR exposure* OR exposed OR increased-risk* OR health-problem*)))
Embase	1: health care personnel'/exp OR (((health*) NEAR/3 (personnel OR provider* OR worker* OR professional* OR assistant*)) OR paramedic* OR nurse* OR nursing-assistant* OR nursing-auxilliar* OR Anesthesiologist* OR anesthetist* OR Caregiver* OR Carer* OR "Care Givers" OR "Care Giver" OR Case-Manager* OR Coroner* OR Medical- Examiner* OR Emergency-dispatcher* OR Infection-Control-Practitioner* OR Laboratory-Personnel OR Laboratory-Scientist* OR Medical-Technologist* OR Laboratory-Technician* OR Lab-technician* OR Laboratory-

	Assistant* OR Medical-Staff OR Physician* OR "hospital personnel" OR doctor* OR Pediatrician* OR Neonatologist* OR Pulmonologist* OR Surgeon* OR cleaning-worker* OR cleaner* OR ((hospital) NEAR/5 (staff))):ti,ab,kw,de 2: ('disinfectant agent'/exp AND ('chlorine dioxide'/exp OR 'chloramine derivative'/exp OR 'hypochlorite sodium'/exp OR 'chlorine derivative'/exp)) OR ((disinfect* OR detergent* OR sterili* OR decontaminat* OR (surface NEAR/3 clean*)) AND (chlorine-dioxide* OR hypochlorite* OR Chlorine-based OR hypochlorous-acid* OR bleach* OR chlorine-product* OR Chlorin* OR sodium-dichloroisocyanurate* OR Chloramine-T OR High-level-disinfectant* OR benzalkonium-chloride)):ti,ab 3: ('disinfectant agent'/exp AND 'aerosol'/exp) OR ((disinfect* OR detergent* OR sterili* OR decontaminat* OR chlorine OR cleaning) AND (spray* OR aerosol* OR airway* OR vapour* OR airborn*)):ti,ab 4: #1 AND (#2 OR #3) 5: adverse event'/exp OR 'chemical safety'/exp OR 'product safety'/exp OR (adverse* OR safe OR safety OR side-effect* OR undesirable-effect* OR toxicity OR tolerability OR hazard* OR irritant* OR irritat* OR allerg* OR exposure* OR exposed OR increased-risk* OR health-problem*):ti,ab 6: #4 AND #5 7: ([animals]/lim NOT ([animals]/lim AND [humans]/lim)) 8: [letter]/lim OR [conference abstract]/lim OR [conference paper]/lim OR [conference review]/lim OR [editorial]/lim OR [note]/lim 9: #6 NOT (#7 OR #8)

Table S2. Eligibility criteria

Category	Inclusion	Exclusion
Participants/population	Healthcare workers (HCWs) or workers exposed to chemical disinfectant products in occupational settings, such as hospitals, clinics, or laboratories.	HCWs or other frontline workers not exposed to chemical disinfectant products in occupational settings (e.g., administrative staff, security personnel).
Exposure(s)	- Occupational exposure to chlorine-based disinfectants. - Exposure to non-chlorine-based disinfectants (e.g., hydrogen peroxide, quaternary ammonium compounds, alcohol-based disinfectants, peracetic acid, acetic acid). - Comparisons between disinfectant types (chlorine-based vs. non-chlorine-based) or between disinfectants and no exposure. - Studies solely assessing non-chlorine-based disinfectants or different application methods (e.g., spraying, wiping, mopping).	- Studies with no occupational exposure to disinfectants or lacking clear differentiation between disinfectant types or application methods.
Comparator(s)/control	- HCWs exposed to chlorine-based disinfectants versus non-chlorine-based disinfectants. - HCWs exposed to disinfectants versus no disinfectants. - HCWs exposed to different application methods (e.g., spraying, wiping, mopping).	- Groups with elevated risks due to non-occupational exposures (e.g., smoking, pollution). - Studies not reporting clear comparator groups or exposure details.

Outcome	- Respiratory: asthma, COPD, or other obstructive diseases. - Skin: dermatitis, burning, allergic reactions. - Eye: pain, irritation, vision issues. - Reproductive: pregnancy-related outcomes (e.g., preterm birth, pregnancy loss). - Exposure markers: airborne gas levels.	- Medical conditions not linked to disinfectant exposure (e.g., unrelated chronic illnesses). - Outcomes not linked to occupational exposure or disinfection practices.
Study design	Case reports, case series, cohort studies, case-control studies, cross-sectional studies, experimental studies, and observational studies.	Qualitative studies, studies with only abstracts, conference papers/posters, reviews, letters, editorials.

Table S3. Data extraction template for included studies

Authors, Year, study design	Risk of bias	Study objective	Type of recruitment, population	Sex, age	Sample size	Exposure (category), assessment	Outcome (cluster) assessment	Adjustment confounding
Authors, year of publication, Type of study conducted	Results of bias assessment	Main aim or objective of the study	How participants were recruited for the study (e.g., random sampling, convenience sampling, volunteers from a specific population).	The demographics of the participants, including the percentage of male and female participants and their age range or mean age.	The total number of participants in the study.	The methods used to measure or assess the exposure of interest (e.g., self-reported questionnaires, direct measurements, use of specific equipment).	The methods used to measure the outcomes of interest (e.g., clinical evaluations, laboratory tests, surveys).	Any confounding variables that the study adjusted for in its analysis (e.g., age, sex, smoking status, socioeconomic status).

Table S4. Risk of bias instrument

Major risk of bias domains	Risk	Criteria
1. Recruitment procedure & follow-up (in cohort studies): For cohort studies HINT: We are looking for selection bias: - Was the cohort representative of a defined population? # - Was everybody included who should have been included? # PRELIMINARY RULING: If the cohort recruitment is based on a convenient/ self-reported sampling OR if response is <10%, the study will be excluded from analysis.	Low	▪ Cohort recruitment was acceptable. # ▪ Baseline response level is acceptable (50% or more) OR is <50% and >30%, but substantial differential selection could be excluded (e. g. by a non-responder analysis). ▪ Loss to follow-up is below 20% in total and not different between the two groups (up to 10% difference). *
	High	▪ Cohort recruitment was not acceptable. # ▪ Response not reported/ not calculable. ▪ Total loss to follow-up is larger than acceptable (20% or more) * OR drop out differs between the groups by more than 10%* OR the reasons for drop out considerably differ between exposed and non-exposed groups. *
For case-control studies HINT: We are looking for selection bias: - Were the cases and control subjects representative of the same defined population ("study base"; geographically and/or temporally)? #	Low	▪ Case selection and recruitment were acceptable. # ▪ Control subjects' selection and recruitment were acceptable. # ▪ Non-response was less than 50% for cases and/or control subjects OR it was >50% and <70%, but substantial differential selection of cases and control subjects could be excluded (e.g., by a non-responder analysis) *

- Was there an established reliable system for selecting all the cases? # - The same exclusion criteria are used for both cases and controls. # - Comparison is made between participants and non-participants to establish their similarities or differences. # PRELIMINARY RULING: If the recruitment is based on a convenient/ self-reported sampling OR if response is <10%, the study will be excluded from analysis.	High	▪ Case selection and recruitment were not acceptable. # ▪ Control subjects' selection and recruitment were not acceptable. # ▪ Non-response was >70% for cases or control subjects OR it was >50% and<70%, but substantial differential selection of cases and control subjects could not be excluded. * ▪ Response not reported/ not calculable
For cross-sectional studies HINT: We are looking for selection bias: - Was the study population representative of a defined population? # - Was everybody included who should have been included? # PRELIMINARY RULING: If the recruitment is based on a convenient/ self-reported sampling OR if response is <10%, the study will be excluded from analysis.	Low	▪ Recruitment of the study population was acceptable. # ▪ Non-response was less than 50% OR it was >50% and <70%, but substantial differential selection of the study population could be excluded (e.g., by a non-responder analysis). *
	High	▪ Recruitment of the study population was not acceptable. # ▪ Non-response was >70% OR it was >50% and <70%, but substantial differential selection of the ▪ study population could not be excluded. * ▪ Response not reported/ not calculable.
2. Exposure definition and measurement	Low	▪ Exposure definition included at least basic job characteristics (e.g., job tasks, length of employment).

		▪ Exposure was accurately measured to minimize bias: use of external validation, validated questionnaire or exposure is connected to a task) # ▪ Adequate comparison group of non-exposed workers (e.g., office workers) included.
	High	▪ Exposure does not cover basic job characteristics. ▪ Exposure was not accurately measured (e.g., use of JEM only) # ▪ Different methods were used to measure exposure in different groups/ cases and control subjects (in case-control studies). ▪ No adequate comparison group of non-exposed workers included
	Unclear	▪ Not reported
3. Outcome, Source and validation	Low	▪ Outcome was accurately/ objectively measured to minimize bias ▪ Measurement methods were similar in the different groups. #
	High	▪ Outcome was not accurately or subjectively measured (e.g., self-reported physician diagnosis or questionnaire). # ▪ Measurement methods were different in the groups.
	Unclear	▪ Not reported

4. Confounding and effect modification	Low	▪ If risk estimators were calculated, major confounding factors (at least age, sex, atopy) were considered. ▪ If only prevalence or incidence was assessed, at least sex & age (at least mean values for the study population) are described.
	High	▪ Major confounding factors or effect modifiers were not considered.
	Unclear	▪ Not reported
5. Analysis method: methods to reduce research specific bias	Low	▪ Authors used adequate statistical models to reduce bias (e.g., standardization, matching, adjustment in multivariate model, stratification, propensity scoring). § For prevalences, matching/stratification may not be required as long as a good description of the age structure and immunization status of the population is given.
	High	▪ Authors did not use adequate statistical models to reduce bias.
	Unclear	▪ Not reported
6. Chronology	Low	▪ Incident diseases were included. # ▪ Temporal relation may be established (exposure precedes the outcome). #
	High	▪ Prevalent diseases were included OR prevalent diseases of baseline were not excluded (in cohort studies). # ▪ Temporal relation cannot be established.
	Unclear	▪ Not reported

Minor risk of bias domains	Risk	Criteria
7. Blinding of assessors	Low	▪ Assessors were blinded
	High	▪ Assessors were not blinded
	Unclear	▪ Not reported
8. Funding	Low	▪ Grant/ non-profit-organizations* ▪ Study was clearly not affected by sponsors. *
	High	▪ Sponsoring organization participated in data analysis. ▪ Study was probably affected by sponsors.
	Unclear	▪ Industry, combined industry grant*, unclear if study was affected by ▪ sponsors. ▪ Not reported.
9. Conflict of interest	Low	▪ Reported not having conflict of interest or clear from report/ communication that study was not affected by author(s) affiliation. *
	High	▪ Conflict of interest exists (at least one author). *
	Unclear	▪ Not reported.

Overall Assessment General rule for rating	Low	▪ low risk in all major domains

Table S5. Quantitative data extracted from included studies

Chlorine-base products						
Study	**Specific product**	**Health outcome**	**Health condition clusters**	**OR (95% CI)**	**p-value**	**Sample size**
Dumas et al., 2017	Bleach	Poorer asthma control	Respiratory	1.55 (1.14-2.1)	0.02	1884
Dumas et al., 2012	Bleach			2.11 (0.88-5.03)	>0.05	212
Gonzalez et al., 2014	Bleach	New-onset asthma	Respiratory	2.08 (0.86-5.0)	0.1	543
Garrido et al., 2022	Bleach	Respiratory symptoms	Respiratory	2.46 (1.01-6.89)	>0.05	307
Kobos et al., 2022	Bleach	Skin Disorder	Skin	1.79 (1.14-2.8)	0.05	559
Mehtar et al., 2016	Chlorine 0,05%	Respiratory conditions	Respiratory	32.95 (22.0-49.0)	<0.001	1550
Mehtar et al., 2016	Chlorine 0,05%	Eye conditions	Ocular-nasal	30.95 (21.0-43.0)	<0.001	1550
Mehtar et al., 2016	Chlorine 0,05%	Skin conditions	Skin	22.95 (15.0-32.0)	<0.001	1550
Mwanga et al., 2023	Bleach	WRONS*	Ocular-nasal	1.12 (0.7-1.78)	>0.05	697
Mwanga et al., 2023	Bleach	WRONS**	Ocular-nasal	0.69 (0.34-1.42)	>0.05	697
Mwanga et al., 2023	Bleach	WRONS***	Ocular-nasal	2.37 (1.3-4.34)	<0.001	697
Mwanga et al., 2023	Bleach	Work-related Asthma*	Respiratory	0.65 (0.32-1.33)	>0.05	697
Mwanga et al., 2023	Bleach	Work-related Asthma**	Respiratory	0.24 (0.06-1.03)	>0.05	697
Mwanga et al., 2023	Bleach	Work-related Asthma***	Respiratory	1.16 (0.49-2.75)	>0.05	697
Ndlela & Naidoo, 2023	Chlorine	Breathless with Wheeze	Respiratory	1.26 (0.45-3.46)	>0.05	174
Ndlela & Naidoo, 2023	Chlorine	Wheeze without cold	Respiratory	1.48 (0.59-3.68)	>0.05	174
Ndlela & Naidoo, 2023	Chlorine	Shortness of Breath	Respiratory	1.27 (0.48-3.21)	>0.05	174

Ndlela & Naidoo, 2023	Chlorine	Chronic Cough	Respiratory	1.13 (0.45-2.08)	>0.05	174
Ndlela & Naidoo, 2023	Chlorine	Chronic Phlegm	Respiratory	0.64 (0.19-2.14)	>0.05	174
Ndlela & Naidoo, 2023	Chlorine	Breathlessness	Respiratory	1.04 (0.41-2.64)	>0.05	174
Ndlela & Naidoo, 2023	Bleach	Breathless with Wheeze	Respiratory	1.39 (0.47-4.08)	>0.05	174
Ndlela & Naidoo, 2023	Bleach	Wheeze without cold	Respiratory	0.8 (0.31-2.05)	>0.05	174
Ndlela & Naidoo, 2023	Bleach	Shortness of Breath	Respiratory	1.68 (0.55-5.14)	>0.05	174
Ndlela & Naidoo, 2023	Bleach	Chronic Cough	Respiratory	1.5 (0.61-3.65)	>0.05	174
Ndlela & Naidoo, 2023	Bleach	Chronic Phlegm	Respiratory	0.34 (0.97-1.2)	>0.05	174
Ndlela & Naidoo, 2023	Bleach	Breathlessness	Respiratory	1.33 (0.48-3.68)	>0.05	174
Su et al., 2019	Chlorine	U-Asthma	Respiratory	3.11 (1.46-6.63)	0.003	885
Su et al., 2019	Chlorine	Asthma exacerbations	Respiratory	2.71 (1.25-5.86)	0.011	885
Patel et al, 2023	Bleach	New asthma onset	Respiratory	1.91 (1.10-3.33)	<0.05	2,421
Glutaraldehyde						
Study	**Specific product**	**Health outcome**	**Health outcome cluster**	**OR (95% CI)**	**p-value**	**Sample size**
Gonzalez et al., 2014	GU	New-onset asthma	Respiratory	3.01 (0.92-9.86)	0.06	248
Dumas et al., 2017	GU	Poorer asthma control	Respiratory	1.54 (1.15-2.06)	0.02	2193
Norbäck, 1988	GU	Nasal catarrh	Ocular-nasal	3.0 (NA-NA)	0.04	107
Dumas et al., 2020	GU	Asthma incidence	Respiratory	(HR) 1.11 (0.88-1.41)	>0.05	35,665
Dumas et al., 2021	GU	Asthma incidence	Respiratory	(HR) 1.61 (1.00-2.59)	>0.05	1,869
Norbäck, 1988	GU	Nasal obstruction	Respiratory	2.9 (NA-NA)	0.03	107

Norbäck, 1988	GU	Smarting of the throat	Respiratory	3.6 (NA-NA)	0.02	107
Norbäck, 1988	GU	Headache	Neurological	2.6 (NA-NA)	0.04	107
Norbäck, 1988	GU	Nausea	Gastrointestinal	4.9 (NA-NA)	0.05	107
Norbäck, 1988	GU	Rashes on the hands	Skin	4.4 (NA-NA)	0.0009	107
Norbäck, 1988	GU	Eczema	Skin	6.2 (NA-NA)	0.002	107
Mwanga et al., 2023	GU	WRONS*	Ocular-nasal	1.2 (0.56-2.57)	>0.05	697
Mwanga et al., 2023	GU	WRONS**	Ocular-nasal	0.57 (0.17-1.95)	>0.05	697
Mwanga et al., 2023	GU	WRONS***	Ocular-nasal	3.69 (1.3-10.45)	<0.05	697
Mwanga et al., 2023	GU	Work-related Asthma*	Respiratory	0.88 (0.29-2.66)	>0.05	697
Mwanga et al., 2023	GU	Work-related Asthma**	Respiratory	0.79 (0.18-3.57)	>0.05	697
Mwanga et al., 2023	GU	Work-related Asthma***	Respiratory	1.45 (0.3-6.95)	>0.05	697
Patel et al., 2023	GU	New onset asthma	Respiratory	1.24 (0.78-1.95)	>0.05	2,421
Quaternary Ammonium Compounds						
Study	**Specific product**	**Health outcome**	**Health outcome cluster**	**OR (95% CI)**	**p-value**	**Sample size**
Gonzalez et al., 2014	QACs	New asthma	Respiratory	7.56 (1.84-31.05)	0.005	543
Gonzalez et al., 2014	QACs	Nasal symptoms	Ocular-nasal	3.21 (1.42-7.22)	0.005	543
Dumas et al., 2017	QACs	Poorer asthma control	Respiratory	1.31 (0.97-1.75)	0.14	4102
Kobos et al., 2022	QACs	Skin Disorders	Skin	2.49 (1.25-4.94)	0.05	559
Su et al., 2019	QACs	Mild asthma	Respiratory	0.64 (0.35-1.19)	NA	2030
Su et al., 2019	QACs	U-Asthma	Respiratory	1.29 (0.47-3.49)	NA	2030
Su et al., 2019	QACs	Asthma exacerbations	Respiratory	1.37	NA	2030

				(0.48-3.9)		
Ndlela & Naidoo, 2023	QACs	Breathless with Wheeze	Respiratory	0.95 (0.33-2.73)	>0.05	174
Ndlela & Naidoo, 2023	QACs	Wheeze without cold	Respiratory	1.28 (0.49-3.33)	>0.05	174
Ndlela & Naidoo, 2023	QACs	Shortness of Breath	Respiratory	3.44 (1.13-10.51)	<0.05	174
Ndlela & Naidoo, 2023	QACs	Chronic Cough	Respiratory	0.69 (0.26-1.82)	>0.05	174
Ndlela & Naidoo, 2023	QACs	Chronic Phlegm	Respiratory	0.59 (0.18-1.91)	>0.05	174
Ndlela & Naidoo, 2023	QACs	Breathlessness	Respiratory	1.72 (0.66-4.47)	>0.05	174
Mwanga et al., 2023	QACs	WRONS	Ocular-nasal	1.04 (0.33-3.26)	>0.05	697
Mwanga et al., 2023	QACs	Work-related Asthma	Respiratory	2.7 (0.71-10.23)	>0.05	697
Patel et al, 2023	QACs	New asthma onset	Respiratory	1.91 (1.10-3.33)	<0.05	2,421
Peracetic acid, acetic acid and hydrogen peroxide						
Study	**Specific product**	**Health outcome**	**Health outcome cluster**	**OR (95% CI)**	**p-value**	**Sample size**
Otterspoor and Farrell, 2019	PAA	increased safe-work related incident reporting		NA	NA	64
Casey et al., 2017	PAA, AA, and HP	watery eyes	Ocular-nasal	2.88 (NA-NA)	>0.05	163
Kobos et al., 2022	HP	Allergic Reactions	Immunological	6.12 (1.18-44.47)	0.05	559
Hawley et al., 2018	PAA, AA, and HP	eye (44%), upper airway (58%), and lower airway (34%) symptoms				50
Blackley et al., 2023	PAA, AA, and HP	Nasal irritation	Ocular-nasal	1.91 (1.12-3.23)	NA	67
Blackley et al., 2023	PAA, AA, and HP	Eye irritation	Ocular-nasal	1.72 (1.14-2.6)	NA	67
Use of spraying						
Study	**Exposure**	**Health outcome**	**Health outcome cluster**	**OR (95% CI)**	**p-value**	**Sample size**
Lee et al., 2014	high exposure	SRCE	CRS	1.79 (0.81-3.96)	>0.05	183
Lee et al., 2014	high exposure	Respiratory symptoms	Respiratory	1.98	>0.05	183

				(0.87-4.51)		
Lee et al., 2014	medium exposure	SRCE	CRS	2.82 (1.16-6.82)	<0.05	183
Lee et al., 2014	NA	Respiratory symptoms	Respiratory	3.16 (1.24-8.04)	<0.05	18
Mwanga et al., 2023	medium exposure	HASS	Respiratory	5.01 (1.8-13.91)	<0.01	697
Dumas et al., 2012	NA	Current asthma	Respiratory	2.87 (1.02-8.11)	<0.05	724
Mehtar et al., 2016	NA	Respiratory conditions	Respiratory	32.95 (22-49)	<0.001	1550
Mehtar et al., 2016	NA	Eye conditions	Ocular-nasal	30.95 (21-43)	<0.001	1550
Mehtar et al., 2016	NA	Skin conditions	Skin conditions	22.95 (15-32)	<0.001	1550
Gonzalez et al., 2014	NA	New-onset asthma	Respiratory	1.3 (0.56-3.04)	0.53	543
Patel et al, 2023		New asthma onset	Respiratory	1.92 (1.12-3.47)	<0.05	2,421

General disinfection tasks

Study	tasks	Exposure	Health outcome	Health outcome cluster	OR (95% CI)	p-value	Sample size
Caridi et al., 2019	Clean Fixed Surfaces	NA	moderate exacerbation	Respiratory	3.10 (1.25-7.67)	<0.05	2,030
Caridi et al., 2019	Clean Fixed Surfaces	NA	Current asthma	Respiratory	1.84 (1.26, 2.68)	<0.05	2,030
Caridi et al., 2019	Clean Fixed Surfaces	NA	bronchial hyper-responsiveness-related symptoms	Respiratory	1.38 (1.08-1.77)	<0.05	2,030
Gonzalez et al., 2014	general disinfection	NA	New-onset asthma	Respiratory	4.68 (1.08-20.22)	0.03	543
Gonzalez et al., 2014	dilution of disinfectants	NA	New-onset asthma	Respiratory	4.56 (1-20.29)	0.049	543

Dumas et al., 2012	cleaning/disinfecting tasks	moderate/high intensity	Current asthma	Respiratory	2.32 (1.11-4.86)	<0.05	724
Lee et al., 2014	Mopping, wet cleaning, and damp wiping	medium exposure	SRCE	CRS	1.36 (0.52-3.61)	>0.05	183
Lee et al., 2014	Mopping, wet cleaning, and damp wiping	high exposure	SRCE	CRS	1.62 (0.58-4.55)	>0.05	183
Lee et al., 2014	Mopping, wet cleaning, and damp wiping	medium exposure	Respiratory symptoms	Respiratory	2.3 (0.74-7.17)	>0.05	183
Lee et al., 2014	Mopping, wet cleaning, and damp wiping	high exposure	Respiratory symptoms	Respiratory	3.11 (0.94-10.3)	>0.05	183
Mwanga et al., 2023	Manually sterilise/disinfection medical instruments	≥100 min/week	WRONS	Ocular-nasal	2.92 (1.33-6.41)	<0.01	37

OR = Odds ratio, 95% CI = 95% confidence interval, WRONS = Work-related ocular-nasal symptoms, * = Exposed versus not exposed, **= exposed 1–99 min/week, ***= exposed ≥100 min/week, U-Asthma = Undiagnosed/untreated asthma, GU = glutaraldehyde, CH = Cohort study, CR = Cross-sectional study, CA = Case control study, CS = Case study, SRCE = Symptoms related to chemical exposure, CRS= Chemical-related symptoms, HASS = Higher Asthma Symptom Score, NA = Not applicable, HR = hazard rate

Table S6. Excluded studies and reasons for exclusion

Reference (o = outcome, i = intervention, p = population, d = design, b = background article, t -= publication type, l = language, u = Update available, r = only research protocol, n = reports not retrieved	Reasons for exclusion									
	o	i	p	d	b	t	l	u	r	n
(L. AD et al., 1993)			X							
(T. AD et al., 1991)			X							
(Afework et al., 2023)		X								
(Agathos & HA, 1982)				X						
(Agthe et al., 2009)		X								
(Ahmed-Lecheheb et al., 2012)		X								
(Alexandre et al., 2021)		X								
(Alexis DESCATHA Jean-Baptiste BARBE-RICHAUD, Jeremy BLOTTIAUX, 2022)		X								
(Alimohammadi & Naderi, 2021)				X						
(Alnimr et al., 2021)	X									
(Ambrosino et al., 2022)	X									
(Amini Tapouk et al., 2020)	X									
(Amlôt et al., 2017)			X							
(Amr & Bollinger, 2004)		X								
(Angelova-Fischer et al., 2016)	X									
(Anggraini & Lestari, 2022)	X									
(Antolín et al., 2021)			X							
(Archangelidi et al., 2021)				X						
(Assadian et al., 2021)			X							
(Astrid et al., 2021)	X									
(Azmi et al., 2021)		X								
(Babić et al., 2020)			X							
(Baccolini et al., 2019)		X								
(Barbaud, 2002)			X							
(Bardaweel et al., 2023)		X								
(Batalla et al., 2012)							X			
(Bauer et al., 2023)			X							
(Bédard et al., 2014)			X							
(Berger et al., 2022)	X									

Reference (o = outcome, i = intervention, p = population, d = design, b = background article, t -= publication type, l = language, u = Update available, r = only research protocol, n = reports not retrieved	Reasons for exclusion									
	o	i	p	d	b	t	l	u	r	n
(Bernardini et al., 1983)										X
(Bessonneau et al., 2013)		X								
(Bhat et al., 2022)				X						
(Bijlsma & Cohen, 2016)						X				
(Brune et al., 2021)	X									
(Burgaz et al., 1992)	X									
(Byrns et al., 2017)	X									
(Caetano et al., 2021)	X									
(Carling, 2021)				X						
(Carling et al., 2023)	X									
(Carol Sharma et al., 2023)			X							
(Carvalho & Conte-Junior, 2021)		X								
(CC et al., 2011)			X							
(Cebeci et al., 2021)		X								
(Centers for Diseases Prevention and Control, 1984)										X
(Chaari et al., 2010)					X					
(Charlier et al., 2021)				X						
(Choi et al., 2021)				X						
(CL et al., 2016)		X								
(Clausen et al., 2020)				X						
(Cochrane et al., 2015)				X						
(Coggon et al., 2004)			X							
(CP et al., 2005)					X					
(Cucurachi & MG, 2010)			X							
(Curran et al., 2019)				X						
(Cutts et al., 2021)	X									
(Cutuli et al., 2021)		X								
(CY et al., 2003)							X			
(Daba et al., 2022)		X								
(Davidovits et al., 2003)			X							

(Dalton et al., 2023)			X							
Reference (o = outcome, i = intervention, p = population, d = design, b = background article, t -= publication type, l = language, u = Update available, r = only research protocol, n = reports not retrieved	Reasons for exclusion									
	o	i	p	d	b	t	l	u	r	n
(De Groot et al., 2021)		X								
(de Oliveira et al., 2023)	X									
(De Troeyer et al., 2022)			X							
(Delclos et al., 2007)		X								
(Descatha et al., 2023)		X								
(Dhama et al., 2021)			X							
(DJ et al., 1993)		X								
(Ding et al., 2021)		X								
(Doll et al., 2018)										
(Donnay et al., 2011)				X						
(Doolan & Crilly, 2019)		X								
(Dore et al., 2022)			X							
(Dorgham & Dorgham, 2021)				X						
(Dotson et al., 2020)	X									
(Dumas, 2021)								X		
(Dumas, Bédard, et al., 2021)	X									
(Dumas & Le Moual, 2020)				X						
(Dumas et al., 2014)	X									
(Dumas et al., 2015)	X									
(Dumas, Wiley, Henneberger, et al., 2017)		X								
(EL et al., 2020)		X								
(Epelle et al., 2023)				X						
(Erdem et al., 2020)		X								
(Erfani et al., 2023)				X						
(Estienney et al., 2022)	X									
(F et al., 1998)										X
(Faller et al., 2018)		X								
(Felemban et al., 2021)		X								
(Fickenscher et al., 2023)	X									

(Flyvholm, 1993)			X							
(Folletti et al., 2017)			X							
Reference (o = outcome, i = intervention, p = population, d = design, b = background article, t -= publication type, l = language, u = Update available, r = only research protocol, n = reports not retrieved	Reasons for exclusion									
	o	i	p	d	b	t	l	u	r	n
(França et al., 2019)		X								
(Frickmann et al., 2018)		X								
(García-Ávila et al., 2020)			X							
(Garvey et al., 2018)	X									
(Gasparini et al., 2020)		X								
(Ge et al., 2021)	X									
(Gerding et al., 2023)			X							
(Gerster et al., 2014)			X							
(Ghafoor et al., 2021)			X							
(Gharaibeh et al., 2021)	X									
(Ghelli et al., 2022)		X								
(Goodyear et al., 2018)	X									
(Gould, 1994)		X								
(Graham et al., 2023)			X							
(Groenewold et al., 2019)			X							
(Gruszecka et al., 2021)	X									
(GS, 1988)				X						
(Gupta et al., 2021)	X									
(Gutterman et al., 2013)		X								
(HA, 1992)		X								
(Hamnerius et al., 2021)			X							
(Hamnerius, Svedman, Bergendorff, Björk, Bruze, Engfeldt, et al., 2018)			X							
(Hamnerius, Svedman, Bergendorff, Björk, Bruze, & Pontén, 2018)		X								
(A. A. Han et al., 2022)		X								
(J. H. Han et al., 2015)				X						
(Hatt et al., 2020)	X									
(Haufroid et al., 2007)	X									
(Hautemanière et al., 2013)	X									

(Hawley et al., 2016)				X						
(Heibati et al., 2022)			X							
Reference (o = outcome, i = intervention, p = population, d = design, b = background article, t -= publication type, l = language, u = Update available, r = only research protocol, n = reports not retrieved	Reasons for exclusion									
	o	i	p	d	b	t	l	u	r	n
(Held et al., 2002)			X							
(Hell & Pauser, 2007)				X						
(Henn et al., 2015)	X									
(Hetzmann et al., 2021)		X								
(HG et al., 2023)			X							
(HH, 1971)										X
(HH et al., 2021)			X							
(Hildre et al., 2023)			X							
(HK et al., 2023)		X								
(Holtjer et al., 2023)			X							
(Homyer & Mehendale, 2023)	X									
(Houben et al., 2006)		X								
(Huang et al., 2023)	X									
(IA et al., 1995)			X							
(Ilyas et al., 2020)				X						
(Ishihara et al., 2020)	X									
(Ituen et al., 2021)				X						
(JA et al., 2021)			X							
(Jacobsen et al., 2022)			X							
(Jann et al., 2021)	X									
(JD et al., 2008)			X							
(JE et al., 1990)			X							
(L. JM et al., 2022)	X									
(M. JM & DN, 2016)		X								
(Jonsdottir et al., 2023)			X							
(JP et al., 1984)	X									
(JS et al., 2020)	X									
(JW et al., 1983)										X

(KA et al., 2021)	X									
(Kampf, 2008)				X						
Reference (o = outcome, i = intervention, p = population, d = design, b = background article, t -= publication type, l = language, u = Update available, r = only research protocol, n = reports not retrieved	Reasons for exclusion									
	o	i	p	d	b	t	l	u	r	n
(Kampf & Muscatiello, 2003)		X								
(Kampf et al., 2002)		X								
(Kampf et al., 2008)		X								
(Kampf et al., 2020)	X									
(Kathare et al., 2022)			X							
(Keegel & RL, 2018)			X							
(Kieć-Swierczyńska, 1996)			X							
(Kieć-Swierczyńska & Krecisz, 2000)										X
(Kiely et al., 2021)		X								
(Kirman et al., 2021)				X						
(C. KM, 2015)		X								
(O. KM & Farooque, 2014)				X						
(Konno et al., 2023)		X								
(Kovach et al., 2017)	X									
(Krause & Dolák, 2021)	X									
(Kruszewska et al., 2022)			X							
(KS, GB, & Agner, 2012)			X							
(KS et al., 2016)		X								
(KS, GB, TL, et al., 2012)		X								
(Kundrapu et al., 2012)		X								
(Laditka et al., 2020)			X							
(Larese Filon et al., 2021)				X						
(Larner et al., 2020)	X									
(S. Lee et al., 2021)		X								
(Lei et al., 2017)	X									
(Leinster et al., 1993)	X									
(Lemire et al., 2022)			X							
(Li et al., 2018)			X							

(Lin et al., 2021)			X							
(Liss et al., 2003)		X								
(Lodola et al., 2000)		X								
Reference (o = outcome, i = intervention, p = population, d = design, b = background article, t -= publication type, l = language, u = Update available, r = only research protocol, n = reports not retrieved	Reasons for exclusion									
	o	i	p	d	b	t	l	u	r	n
(Lu et al., 2022)	X									
(Lu et al., 2023)	X									
(Luchini et al., 2021)			X							
(da S. MA et al., 1997)	X									
(G. J. MA et al., 2013)									X	
(Maier et al., 2015)	X									
(Małaszuk et al., 2000)										X
(Mallakpour et al., 2021)		X								
(Manyele et al., 2008)		X								
(Marena et al., 2002)	X									
(Matulonga et al., 2016)			X							
(McKinley et al., 2023)	X									
(Melgar et al., 2022)	X									
(Mirabelli et al., 2007)	X									
(Moccia et al., 2020)	X									
(Mohite et al., 2022)		X								
(Mohtar et al., 2021)	X									
(Molin et al., 2015)		X								
(MS et al., 2006)	X									
(Mungan et al., 2019)			X							
(Munyendo & Kiprop, 2016)		X								
(MV et al., 2008)			X							
(Mwanga et al., 2022)	X									
(Nakamura et al., 2020)	X									
(Navarathna et al., 2023)		X								
(Nemli et al., 2021)				X						
(Neves et al., 2021)		X								

(Nguyen et al., 2021)				X						
(Nielsen & Bach, 1999)			X							
(Obed et al., 2021)		X								
Reference (o = outcome, i = intervention, p = population, d = design, b = background article, t -= publication type, l = language, u = Update available, r = only research protocol, n = reports not retrieved	Reasons for exclusion									
	o	i	p	d	b	t	l	u	r	n
(Ofstead et al., 2022)	X									
(Oie et al., 2011)	X									
(Okazaki et al., 2022)			X							
(Okeke et al., 2023)				X						
(Omrane et al., 2022)			X							
(Ortí-Lucas & Muñoz-Miguel, 2017)	X									
(Oza et al., 2022)		X								
(PA et al., 1992)	X									
(Pałczyński et al., 2001)			X							
(Parry et al., 2022)	X									
(PE et al., 1990)					X					
(Pechter et al., 2005)			X							
(Pemberton & Kimber, 2021)						X				
(Peters et al., 2022)		X								
(Petti et al., 2013)	X									
(Peyneau et al., 2022)				X						
(Pironti et al., 2021)	X									
(Polecka et al., 2023)			X							
(Polivka et al., 2022)				X						
(Pontes et al., 2008)			X							
(Popin et al., 2008)			X							
(Popp et al., 1994)	X									
(Prodi, Rui, AB, et al., 2016)		X								
(Prodi, Rui, Fortina, et al., 2016)		X								
(Purwar et al., 2022)				X						
(Quinn et al., 2015)				X						
(Quinot et al., 2018)		X								

(Quinot et al., 2017)		X								
(Rai et al., 2020a)	X									
(Rai et al., 2020b)		X								
Reference (o = outcome, i = intervention, p = population, d = design, b = background article, t -= publication type, l = language, u = Update available, r = only research protocol, n = reports not retrieved	Reasons for exclusion									
	o	i	p	d	b	t	l	u	r	n
(Rangel et al., 2022)	X									
(Rava et al., 2017)			X							
(Razali et al., 2022)				X						
(Restrepo et al., 2014)	X									
(Ricke et al., 2022)			X							
(Rideout et al., 2005)										X
(Rivers et al., 2021)			X							
(Roberts et al., 2022)			X							
(Robinson et al., 2019)	X									
(Rock et al., 2022)	X									
(Rogers et al., 2023)		X								
(Rollins et al., 2020)						X				
(Rose et al., 2019)	X									
(Rustemeyer et al., 1994)			X							
(Rutala & Weber, 2019)				X						
(Rutala & Weber, 2016)				X						
(Rybka et al., 2021)	X									
(Saito et al., 2015)	X									
(Salomone et al., 2018)	X									
(Sanguinet & Edmiston, 2021)	X									
(Santovito et al., 2014)		X								
(Sattar et al., 2015)	X									
(Sauvé & Friesen, 2019)	X									
(Schäferhenrich et al., 2023)			X							
(Scheepers et al., 2017)		X								
(Schnell et al., 2021)		X								
(Schnuch et al., 1998)				X						

(Schöbel et al., 2023)	X									
(Schulte et al., 2012)		X								
(Sedeh et al., 2023)		X								
Reference (o = outcome, i = intervention, p = population, d = design, b = background article, t -= publication type, l = language, u = Update available, r = only research protocol, n = reports not retrieved	Reasons for exclusion									
	o	i	p	d	b	t	l	u	r	n
(Seifi & Reza Kamali, 2021)	X									
(Sellaoui et al., 2021)	X									
(Shepherd et al., 2020)		X								
(Sher & Mulder, 2020)	X									
(Shi et al., 2022)		X								
(Si et al., 2018)	X									
(Siani & Maillard, 2015)				X						
(Siani et al., 2018)	X									
(S. E. Simmons et al., 2021)	X									
(S. Simmons et al., 2021)	X									
(Singgih et al., 1986)		X								
(Sit et al., 2021)			X							
(Sit et al., 2022)		X								
(SJ et al., 2015)		X								
(SJ et al., 2013)			X							
(Society of Gastroenterology Nurses and Associates, 1996)					X					
(Sonday et al., 2023)			X							
(Song et al., 2019)				X						
(Spencer et al., 2017)		X								
(Starke et al., 2021)				X						
(Steege et al., 2014)			X							
(Stjärne Aspelund et al., 2016)	X									
(Stoeva et al., 2020)		X								
(F.-C. Su et al., 2018)	X									
(Takigawa & Endo, 2006)				X						
(Tang et al., 2023)	X									
(Tasar et al., 2021)			X							

(Teska et al., 2022)	X									
(TL, 1987)					X					
(Tofanelli et al., 2020)	X									
(Tomb et al., 2018)	X									
Reference (o = outcome, i = intervention, p = population, d = design, b = background article, t -= publication type, l = language, u = Update available, r = only research protocol, n = reports not retrieved	Reasons for exclusion									
	o	i	p	d	b	t	l	u	r	n
(Tyski et al., 2022)				X						
(Tyski et al., 2021)	X									
(Vaidya et al., 2020)		X								
(van den Berg et al., 2021)		X								
(VC et al., 2003)		X								
(Versoza et al., 2020)	X									
(Vincent et al., 2017)	X									
(Vizcaya et al., 2013)		X								
(Walton & Rogers, 2017)				X						
(Watanabe et al., 2014)	X									
(WB et al., 1985)										
(Weber et al., 2016)	X									
(Weber et al., 2019)				X						
(Whitworth et al., 2020)			X							
(Wilson et al., 2022)		X								
(Wilson et al., 2023a)				X						
(Wilson et al., 2023b)			X							
(Wiszniewska & Walusiak-Skorupa, 2014)										X
(WJ et al., 1990)					X					
(Wright et al., 2023)	X									
(Xie et al., 2021)	X									
(Yang et al., 2017)	X									
(Yanke et al., 2021)		X								
(Ye et al., 2020)			X							
(Youssef et al., 2023)			X							
(Yüksel, Nørreslet, et al., 2022)		X								

(Yüksel, Sonne, et al., 2022)			X							
(Zahrallayali et al., 2021)			X							
(Zhang et al., 2023)		X								

Table S7. Risk of bias assessment for included studies

	Major domains						Minor domains			
Study	Recruitment procedure and follow-up	Exposure definition and measurement	Outcome source and validation	Confounding	Analysis method	Chronology	Assessor blinding	Funding	Conflict of interest	OVERALL
(Blackley et al., 2023)										
(Caridi et al., 2019)										
(Casey et al., 2017)										
(Chang et al., 2018)										
(Dumas et al., 2012)										
(Dumas et al., 2019)										
(Dumas et al., 2020)										
(Dumas, et al., 2021)										
(Dumas, et al., 2017)										
(Estrin et al., 1987)										
(Gannon et al., 1995)										
(Garrido et al., 2022)										
(Gaskins et al., 2017)										
(Gonzalez et al., 2014)										
(Hawley et al., 2018)										
(Kobos et al., 2022)										
(Kurth et al., 2017)										

(Laborde-Castérot et al., 2012)										
(Lee et al., 2014)										
(Mac Hovcová et al., 2013)										
(Mehtar et al., 2016)										
(Mwanga et al., 2023)										
(Nayebzadeh, 2007)										
(Ndlela & Naidoo, 2023)										
(Nettis et al., 2002)										
(Norbäck, 1988)										
(Otterspoor & Farrell, 2019)										
(Patel et al., 2023)										
(F. C. Su et al., 2019)										

 Low risk; Unclear; High risk;

Table S8. Combined Odds Ratios (ORs) and Confidence Intervals (CIs) for respiratory conditions across studies

Study	Exposure	Outcomes	OR (95%CI), p value	Combined OR (95%CI), p value
Ndlela & Naidoo, 2023	Chlorine-based products	Wheeze without cold	1.48 (0.59-3.68), p>0.05	1.19 (0.73-1.96), p>0.05
Ndlela & Naidoo, 2023		Chronic Cough	1.13 (0.45-2.08), p>0.05	
Ndlela & Naidoo, 2023		Breathlessness	1.04 (0.41-2.64), p>0.05	
Su et al., 2019		Undiagnosed/untreated asthma	3.11 (1.46-6.63), p= 0.003	2.90 (1.69-4.99), p=0.003
Su et al., 2019		Asthma attacks/exacerbations	2.71 (1.25-5.86), p=0.01	
Mwanga et al., 2023	Glutaraldehyde (exposed vs not exposed)	Work related asthma	0.88 (0.29-2.66), p=0.05	1.54 (1.15-2.06), p=0.05
Mwanga et al., 2023	Glutaraldehyde (exposed 1–99 min/week vs not exposed)		0.79 (0.18-3.57), p=0.05	
Mwanga et al., 2023	Glutaraldehyde (exposed ≥100 min/week vs not exposed)		1.45 (0.30-6.95), p=0.05	
Ndlela & Naidoo, 2023	QACs	Wheeze without cold	1.28 (0.49-3.33), p=0.05	1.16 (0.66-2.02), p=0.05
Ndlela & Naidoo, 2023		Chronic Cough	0.69 (0.26-1.82), p=0.05	
Ndlela & Naidoo, 2023		Breathlessness	1.72 (0.66-4.47), p=0.05	
Su et al., 2019	QACs	Mild asthma	0.64 (0.35-1.19) NA	0.87 (0.54-1.38) NA
Su et al., 2019		U-Asthma	1.29 (0.47-3.49) NA	
Su et al., 2019		Asthma exacerbations	1.37 (0.48-3.9) NA	
Lee et al., 2014	Use of spray (medium exposure)	Respiratory symptoms	3.16 (1.24-8.04), p=0.05	2.43 (1.31-4.50), p>0.05
Lee et al., 2014	Use of spray (high exposure)	Respiratory symptoms	1.98 (0.87-4.51), p>0.05	
Gonzalez et al., 2014	GDTs	New-onset asthma	4.68 (1.08-20.22), p=0.03	4.62 (1.62-13.2), p-0.03

Gonzalez et al., 2014	GDTs (dilution of disinfectant)	New-onset asthma	4.56 (1.0-20.29), p=0.03	
Caridi et al., 2019	GDTs	Current asthma	1.84 (1.26-2.68), p=0.05	1.95 (1.39-2.74), p=0.05
Caridi et al., 2019	GDTs	exacerbation	3.1 (1.25-7.67), p=0.05	
Caridi et al., 2019	GDTs	BHR symptom	1.38 (1.08-1.77), p=0.05	
Lee et al., 2014	GDTs (medium exposure)	Respiratory symptoms	2.3 (0.74-7.17), NA	2.65 (1.16-6.05), NA
Lee et al., 2014	GDTs (high exposure)	Respiratory symptoms	3.11 (0.94-10.3) NA	

Table S9. Studies excluded from the meta-analysis and reasons for exclusion

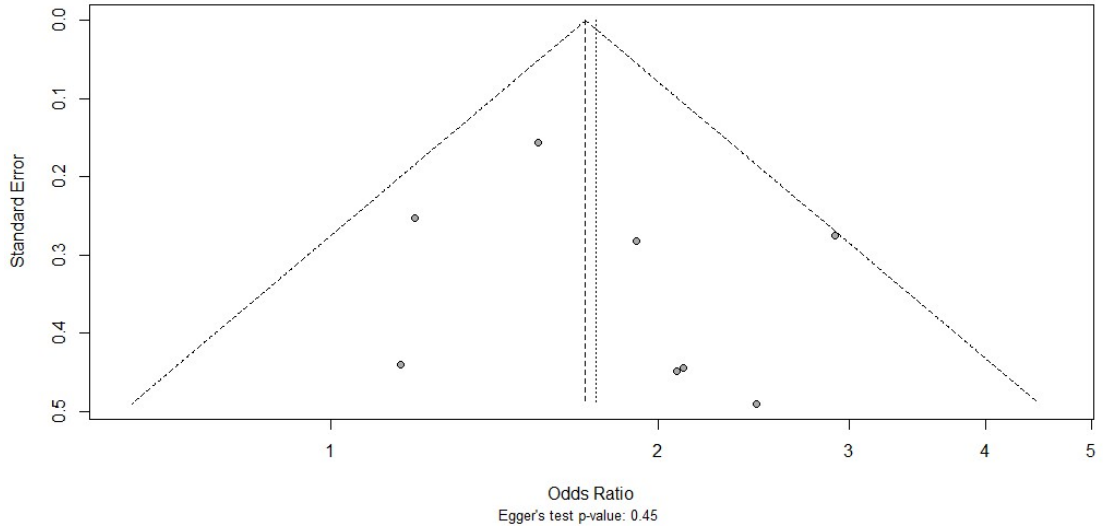
Intervention/Exposure assessed	Study excluded from meta-analysis	Reason for exclusion
Chlorine-based products	(Mehtar et al., 2016)	Not comparable exposure. It assessed direct spraying of chlorine on healthcare workers rather than environmental exposure alone.
	(Dumas et al., 2019) (Dumas et al., 2020)	Not comparable outcome (the study estimated adjusted hazard ratio instead of odds ratio)
	(Kobos et al., 2022)	Not comparable outcome (skin disorder was quantified instead of respiratory conditions)
Glutaraldehyde	(Dumas et al., 2019) (Dumas et al., 2020)	Not comparable outcome (the study estimated adjusted hazard ratio instead of odds ratio)
	(Dumas, Gaskins, et al., 2021)	Not comparable outcome (the study estimated adjusted hazard ratio instead of odds ratio)
	(Gannon et al., 1995)	Not comparable outcome (the study estimated prevalence instead of odds ratio)
	(Nayebzadeh, 2007)	Not comparable exposure. It assessed the effect of indoor ventilation on glutaraldehyde concentration in air
	(Norbäck, 1988)	Not comparable outcome (the study estimated prevalence instead of odds ratio)
QACs	(Dumas et al., 2019) (Dumas et al., 2020)	Not comparable outcome (the study estimated adjusted hazard ratio instead of odds ratio)
	(Kobos et al., 2022)	Not comparable outcome (FeNO levels were quantified as proxy for respiratory conditions)

	(Mwanga et al., 2023)	Not comparable outcome (skin disorder was quantified instead of respiratory conditions)
Use of spray	(Mehtar et al., 2016)	Not comparable exposure. It assessed direct spraying of chlorine on healthcare workers rather than environmental exposure alone.
General disinfection tasks	(Kurth et al., 2017)	Not comparable outcome (the study estimated prevalence ratio instead of odds ratio)

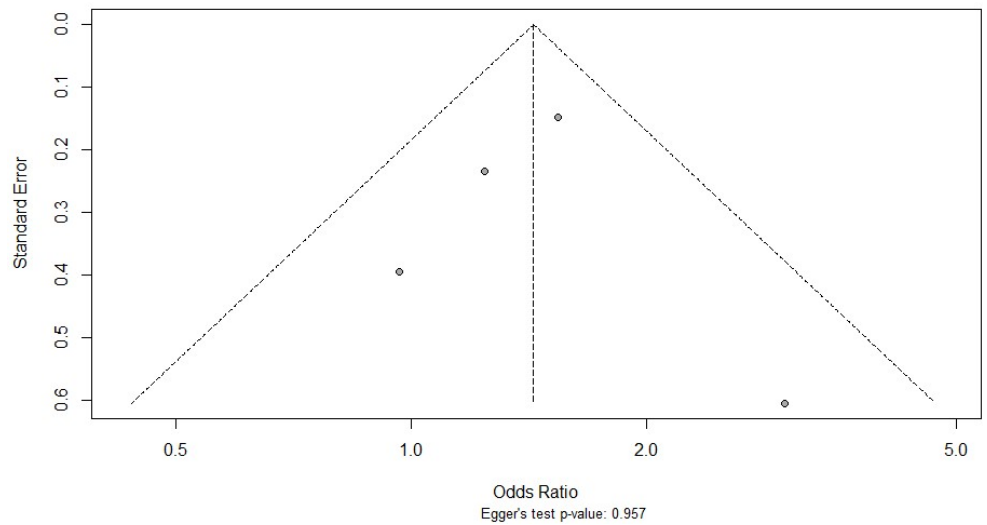
Table S10. Funnel plots

Funnel plots depicting the relationship between the odds ratios and their standard errors for studies examining the effect of different disinfectant application methods on respiratory conditions. The vertical line represents the overall effect estimate, while the diagonal lines indicate the expected 95% confidence intervals.

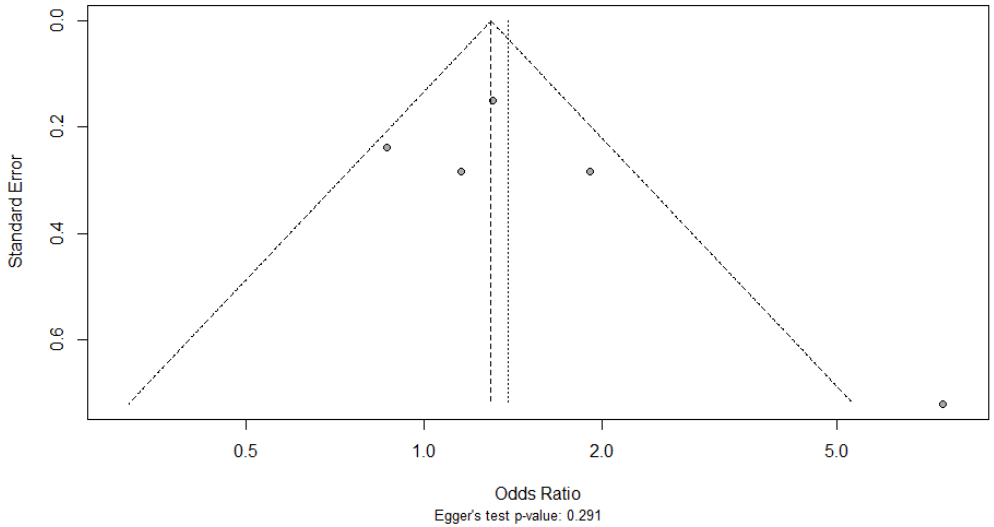
Chlorine-based product



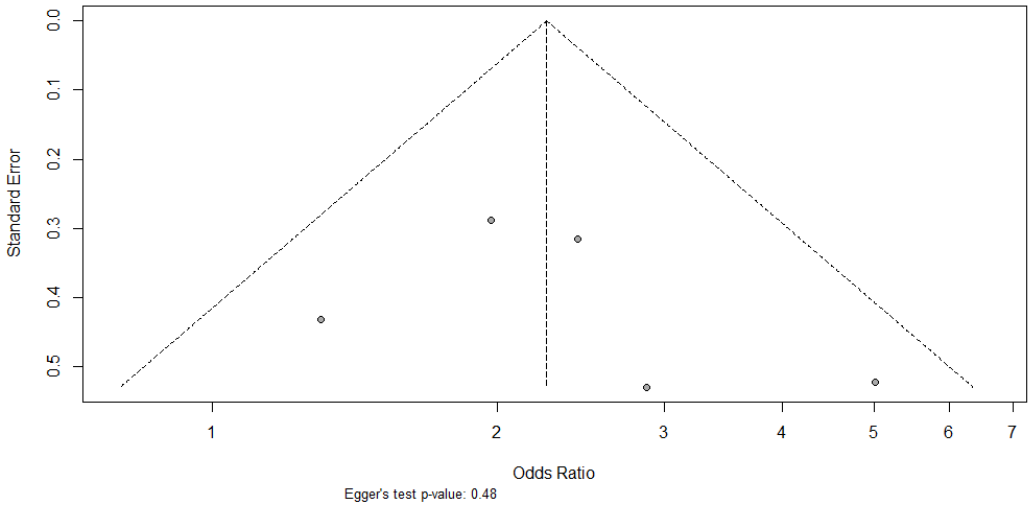
Glutaraldehyde



Quaternary Ammonium Compounds



Use of spray



General disinfection tasks

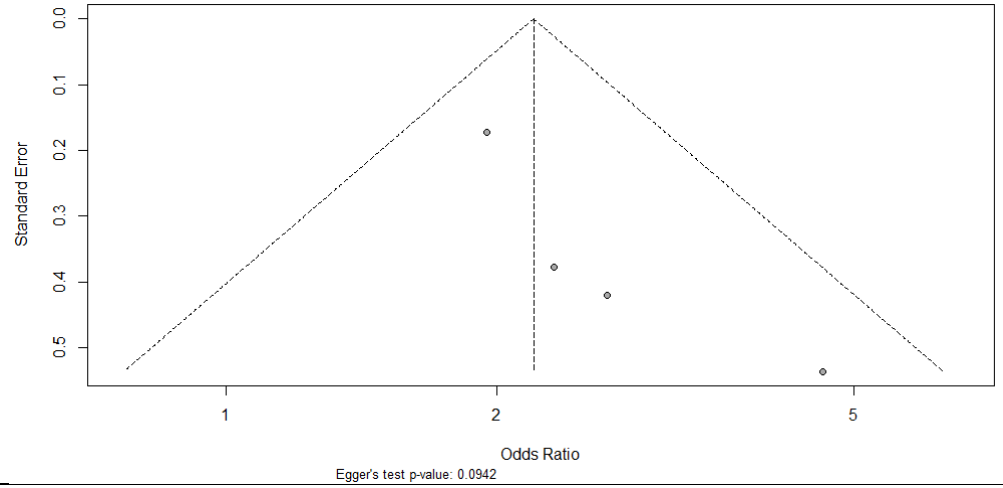


Table S11. Meta-regression results

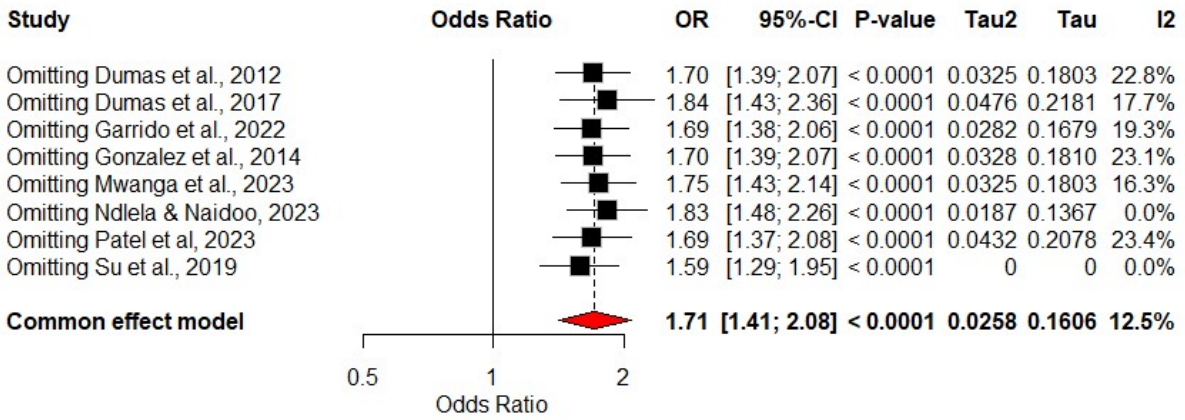
Chlorine-Based Product						
Term	Estimate	Standard error	Z-value	P-value	Cl-low	Cl-high
Interceptor	0.900639566	0.569570809	1.58126005	0.11381859	-0.215698706	2.016977838
Cohort study	-0.207845075	0.663747774	-0.313138639	0.754175334	-1.508766806	1.093076657
Cross-sectional	-0.435980599	0.61387138	-0.710214897	0.477570884	-1.639146396	0.767185198
Sample size	-1.55771E-06	0.000203365	-0.007659639	0.993888552	-0.000400147	0.000397031
Glutaraldehyde						
Interceptor	0.837914077	1.076665414	0.778249274	0.436422074	-1.272311358	2.948139512
Cross-sectional	-0.253837148	0.786363031	-0.322798934	0.74684752	-1.795080369	1.287406072
Sample size	-0.000185195	0.000414202	-0.447111889	0.654794275	-0.000997015	0.000626626
QACs						
Cross-sectional	NA	NA	NA	NA	NA	NA
Interceptor*	0.615326785	0.530150554	1.16066423	0.245778474	-0.423749208	1.654402777
Sample size	-9.68933E-05	0.000210533	-0.4602292	0.645351714	-0.00050953	0.000315743
Use of spray						
Interceptor	1.107540023	0.716192161	1.546428574	0.122001098	-0.296170819	2.511250865
Cross-sectional	-0.21613373	0.745346564	-0.289977495	0.771833455	-1.67698615	1.244718691
Sample size	-7.35193E-05	0.000306358	-0.23997877	0.810346715	-0.000673969	0.000526931
General Disinfection Tasks (GDT)						
Interceptor	1.044237568	0.408096839	2.558798469	0.010503461	0.244382461	1.844092675
Cross-sectional	0.20012901	0.454762932	0.440073269	0.659884042	-0.691189958	1.091447978

Sample size	-0.000279931	0.0002168	-1.291198843	0.196634736	-0.000704851	0.000144988
*Only sample size was included as moderator as all included studies were cross-sectional studies						

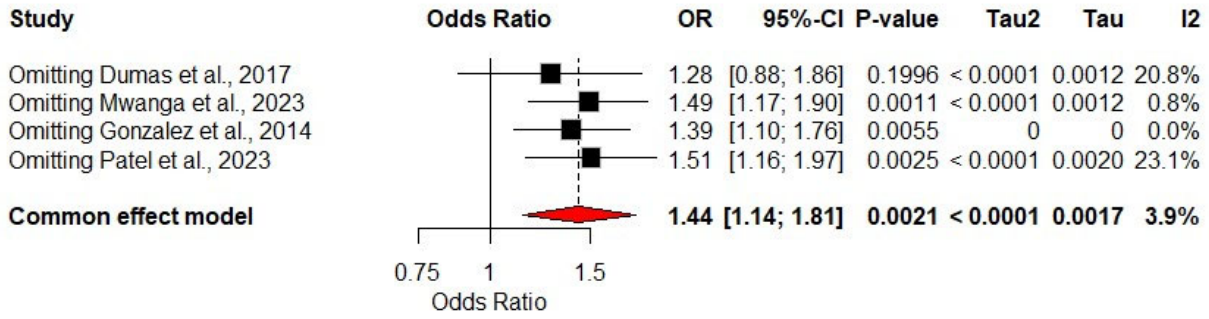
Table S12. Leave-one-out analysis results

Forest plots showing the odds ratios (OR) with 95% confidence intervals (CI) for respiratory conditions associated with different disinfectants and application methods exposure after omitting individual studies. The square shapes represent the individual results. The diamond shape represents the overall effect estimate from the common effect model.

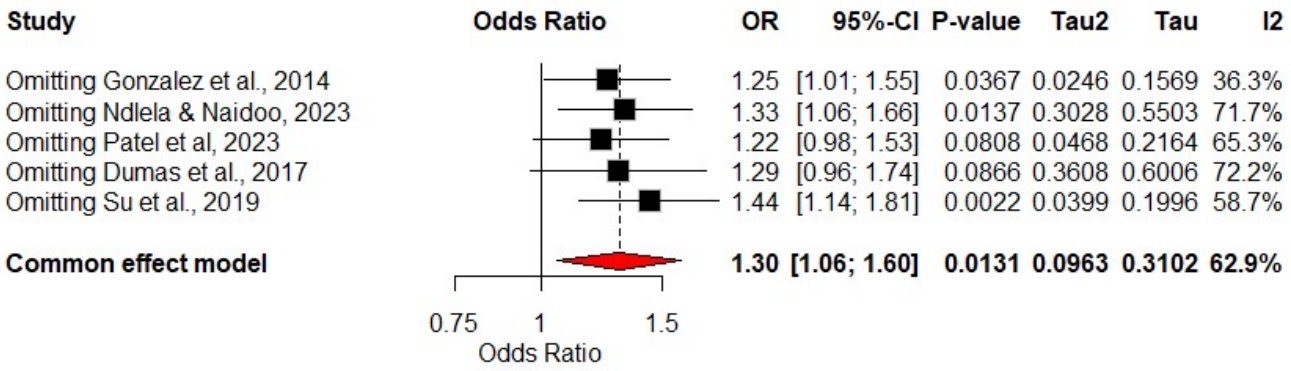
Leave-one-out chlorine-based products



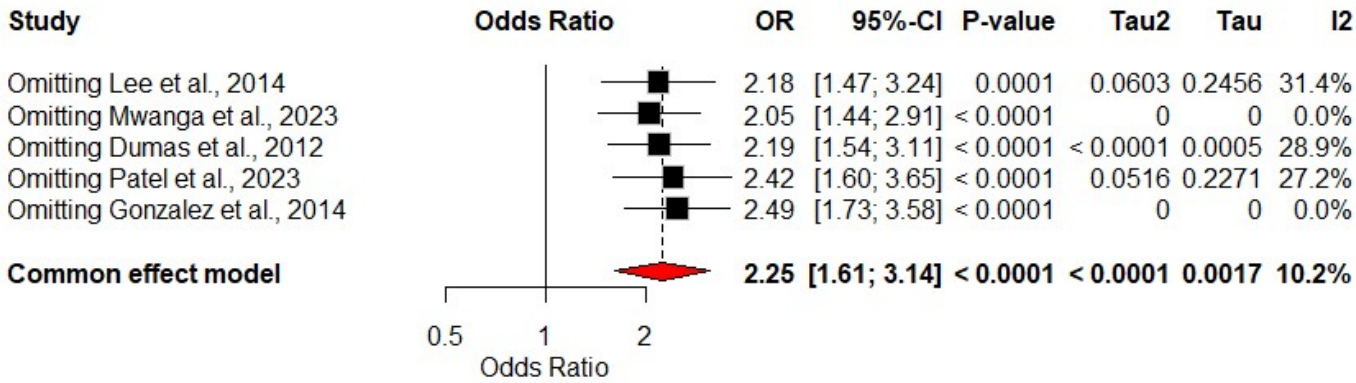
Leave-one-out glutaraldehyde



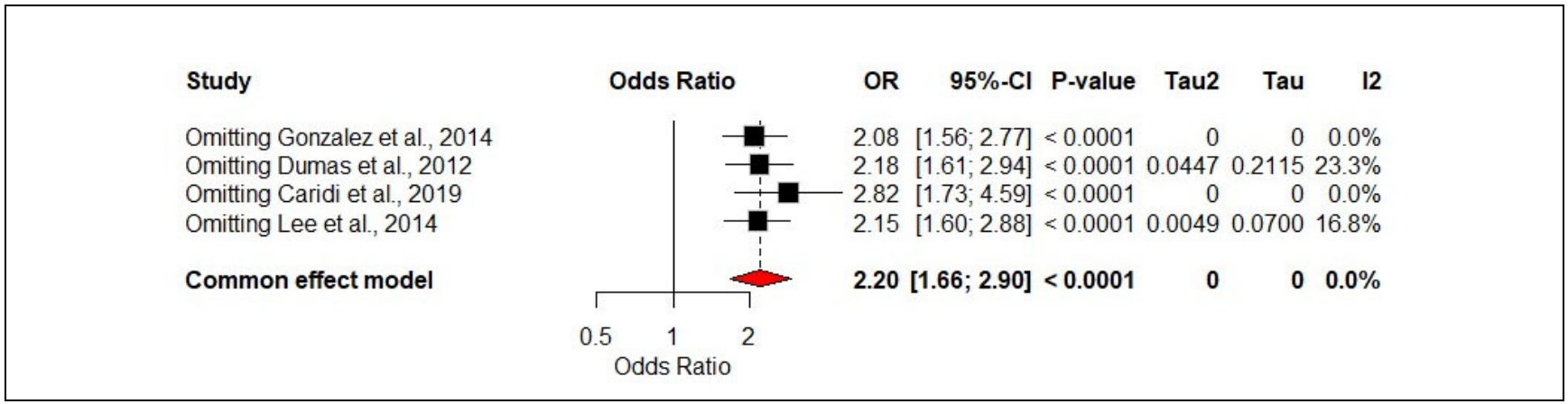
Leave-one-out QACs



Leave-one-out use of spray



Leave-one-out general disinfection tasks


Study
Odds Ratio
OR
95%-CI
P-value
Tau2
Tau
I2
Omitting Gonzalez et al., 2014
2.08 [1.56; 2.77] < 0.0001 0 0 0.0%
Omitting Dumas et al., 2012
2.18 [1.61; 2.94] < 0.0001 0.0447 0.2115 23.3%
Omitting Caridi et al., 2019
2.82 [1.73; 4.59] < 0.0001 0 0 0.0%
Omitting Lee et al., 2014
2.15 [1.60; 2.88] < 0.0001 0.0049 0.0700 16.8%
Common effect model
2.20 [1.66; 2.90] < 0.0001 0 0 0.0%
0.5
1
2
Odds Ratio

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