Integrating primary and meta-analytic effect size estimates on the effects of PFAS and organochlorine pesticides on human health outcomes

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Highlights

- The database comprises 627 primary studies, yielding 3,627 individual effect size estimates.
- The database also incorporates 91 meta-analyses, contributing 457 meta-analytic effect size estimates.
- The most studied chemicals were PFOA and PFOS, with metabolic disorders being the most frequently assessed health outcomes overall.
- Primary studies were predominantly led by researchers based in the United States, while meta-analyses were most often led by authors from China.
- Based on the database structure and observed reporting patterns, we also offer practical recommendations for improving transparency and data sharing in environmental health research.

Abstract

Persistent organic pollutants such as per- and polyfluoroalkyl substances (PFAS) and organochlorine pesticides are among the most extensively studied environmental contaminants, yet the evidence base remains fragmented across primary studies and meta-analyses, limiting its ability to chart new research directions. To address this fragmentation, we developed a unified database that links primary epidemiological estimates with meta-analytic summaries of associations between PFAS and organochlorine pesticide exposures and human health outcomes. The database was constructed following a systematic five-step process encompassing (1) literature search, (2) literature screening, (3) data extraction, (4) data curation, and (5) visualisation. The final database includes 627 unique primary studies (*n*) providing 3,627 individual primary study estimates *(k)* that were synthesised in 91 meta-analyses comprising 457 pooled effect size estimates. The most frequently investigated chemicals were PFOA (CAS: 335-67-1, *n = 268, k* = 736) and PFOS (CAS: 1763-23-1, *n* = 276, *k* = 682) among PFAS, and DDE (CAS: 72-55-9, *n* = 95 *k* = 150) and p,p'-DDE (CAS: 72-55-9, *n = 90, k* = 136) among organochlorine pesticides. Metabolic disorders (ICD11: 5C8Z, *n = 39, k* = 333) and neoplasms of breast (ICD11: 2C6Z, *n* = 78, *k* = 309) were the most assessed health outcomes. Primary studies were most often led by authors based in the United States, whereas meta-analyses were predominantly conducted by researchers in China. Based on the structure of this database, we outline practical methodological recommendations to improve future conduct and reporting practices, and we discuss potential applications of this database to support future research in environmental health.

Keywords

contamination; pollution; research synthesis; evidence syntheses; heterogeneity

Introduction

Environmental contamination by persistent organic pollutants (POPs) remains a major global threat to human health (Ashraf, 2017) and continues to draw sustained scientific and regulatory attention (Morrison et al., 2025b). Historically, legacy POPs such as organochlorine pesticides have attracted concern due to their widespread agricultural use and vector-control applications (Jayaraj et al., 2016). In recent decades, emerging POPs such as per- and polyfluoroalkyl substances (PFAS) have gained prominence due to their widespread presence in industrial, cosmetic, and household products (Glüge et al., 2020).

To evaluate the associations between exposure to these chemicals and adverse health outcomes, researchers have traditionally relied on primary epidemiological studies such as cross-sectional studies (Mann, 2003). The accumulation of such evidence has naturally led to the rise of secondary research, most notably in the form of systematic reviews and meta-analyses (Morrison et al., 2025a; Ricolfi et al., 2024). Meta-analyses nowadays play a central role in environmental health research by providing quantitative summaries of associations and assessing their generalisability across contexts (Sheehan and Lam, 2015). Consequently, decades of research have produced a large and methodologically diverse body of primary and meta-analytic evidence spanning multiple pollutants, outcomes, and analytical approaches.

Despite this extensive body of work, much of the underlying quantitative evidence remains difficult to access and reuse. A key limitation is that meta-analyses rarely report the quantitative data that support their analyses in open, transparent formats, and the primary studies they draw on are often inconsistently cited or not directly linked to the specific effect sizes or summary statistics reported. There are several databases and systematic evidence maps exist on the adverse health outcomes associated with organochlorine pesticides and PFAS (e.g., Pelch et al., 2022; Ricolfi et al., 2024). These resources largely emphasise qualitative information, such as which pollutants were studied and what impacts were observed, and/or appraise the methodological quality of the evidence base. One relatively recent database, by contrast, provides quantitative evidence for associations between PFAS exposure and adverse health outcomes (Radke et al., 2022). However, no existing resource combines these qualitative insights with quantitative data for organochlorine pesticides, and none links meta-analytic estimates for either contaminant class directly to the primary-study effect sizes that underpin them. Moreover, since the publication of (Radke et al., 2022), research on PFAS has grown substantially. As a result, much of the recent quantitative evidence needed to guide future research remains fragmented and difficult to interpret. This is largely attributable to the limited integration of FAIR principles (Findability, Accessibility, Interoperability, and Reusability) into data-sharing practices in contemporary meta-analyses (Wilkinson et al., 2016).

To overcome these barriers, this paper pursues three related aims. First, we developed a unified database that combines descriptive information (e.g., pollutants studied, health outcomes assessed) with quantitative data (e.g., effect sizes, confidence intervals) for both meta-analytic studies and the primary studies they synthesise. Each record is matched to its original reference, and all chemicals and outcomes are standardised using CAS Registry Numbers (CAS RN) and International Classification of Diseases, 11th Revision (ICD-11) codes, respectively. By systematically extracting, harmonising, and linking data across studies, this resource provides a FAIR-aligned foundation that reduces the manual burden of locating and compiling primary-study effect sizes, enhances the reproducibility of meta-analytic findings, and supports future research (Wilkinson et al., 2016). Second, we intend for the provided data to enable users to identify pollutant–outcome pairs with either substantial or limited quantitative evidence, trace meta-analytic estimates back to their contributing primary studies, assess overlap across meta-analyses, and support re-analysis or the development of future evidence syntheses. Third, based on the database structure and observed reporting patterns, we offer practical recommendations for improving transparency and data sharing in environmental health research.

Methodology

To enhance reporting completeness, we followed the PRISMA-S guidelines (Rethlefsen et al., 2021) and provided a populated PRISMA-S checklist (see Supplementary File 2). The PRISMA-S checklist was populated by KM and cross-checked by LR. We acknowledge that this checklist is not specifically designed for reporting of systematically collated databases of evidence, but it was deemed the most complete existing reporting standard relevant to our use case. We provide the database in full, including the associated metadata and code, in the following archived repository (cite once archived) and GitHub repository

(https://github.com/KyleMorrison99/pop_health_database). We also provide an accessible GitHub data page which can be used to freely download the data https://kylemorrison99.github.io/pop_health_database/. We have acknowledged each author's contributions throughout the methodology using MeRIT (Method Reporting with Initials for Transparency) approach (Nakagawa et al., 2023). All details regarding the literature searching, screening, data extraction, and analysis are provided in Supplementary File 1.

Literature Search Strategy

The literature search included studies in two recent second-order meta-analyses (Morrison et al., 2026; Ricolfi et al., unpublished). These syntheses employed a two-stage search strategy. First, they conducted database searches of the scientific literature in Scopus (searched on 8th April 2024), Web of Science Core Collection, PubMed, ProQuest, and BASE (searched on1st May 2024) (see Supplementary File 1 for full search strings, Boolean operators, search yields, and dates). Second, they included all meta-analyses included in two systematic maps of secondary evidence on organochlorine pesticides and PFAS, respectively (Morrison et al., 2025a; Ricolfi et al., 2024). In general, the search terms used were related to organochlorine pesticides or PFAS substances and to meta-analysis. All records were deduplicated in R using the *RevTools* package (Westgate, 2019) for exact title matches, complemented by Rayyan's built-in deduplication tool (Ouzzani et al., 2016).

Literature Screening Strategy

The literature screening strategy was modified from those in two previous second-order syntheses. The eligibility criteria are provided according to the Population-Exposure-Comparator-Outcome-Study (PECOS) framework in Supplementary File 1, Table S1. We implemented a two-step screening strategy. First, we assessed titles, abstracts, and keywords for relevance. Second, we conducted a full-text screening of potentially eligible studies. To reduce potential screening errors, all meta-analytic literature was screened in duplicate by two independent reviewers (KM 100%, LR 25%, PP 25%, AM 25%, ML 25%). Any disagreements between reviewer decisions were resolved through discussion, with a mediator (SN) involved when necessary. We provide a screening flowchart with eligibility criteria in Supplementary File 1, Figure S1. All studies excluded at the full-text stage were documented with reasons for exclusion (see Supplementary File 1, Table S2). All screening activities were conducted using the Rayyan software platform (Ouzzani et al., 2016). All primary studies that were synthesised in an eligible meta-analysis were deemed eligible for inclusion in the database.

Data Extraction Strategy

We extracted data from each meta-analysis and its synthesised primary studies investigating associations between PFAS and organochlorine pesticide effects on health outcomes. A full list of extracted variables, along with detailed descriptions, is provided in Supplementary File 1 (Tables S3-5) and in both repositories (GITHUB: https://github.com/KyleMorrison99/pop_health_database, cite once archived). For each meta-analysis, we recorded bibliometric information, model structure, and, effect sizes. We also extracted the summary effect size estimates, corresponding confidence intervals, and total heterogeneity (I^2). These data were obtained primarily from the forest plots presented in each paper; where relevant information was not available in the forest plot, we searched the full text. If specific information, such as a measure of heterogeneity, was not reported, this was recorded in the dataset as "not reported." Some of the qualitative variables, such as the pollutant and the outcome, had already been extracted and presented in two previous systematic maps of secondary evidence (Morrison et al., 2025a; Ricolfi et al., 2024). KM and LR manually extracted all predefined variables, with 50% of the total meta-analysis cross-checked by PP, AM.

Data from the primary studies synthesised within each meta-analysis were also extracted. For each primary study, we recorded bibliometric information (e.g., DOI), chemical details (e.g., class, CAS Registry Number), outcome measures mapped to ICD-11 codes, and the primary study's effect size point estimate with corresponding confidence intervals. To extract these primary study estimates, we implemented an AI-assisted approach. KM used OpenAI's GPT 5.2 model to assist with data extraction by uploading each forest plot figure and the data extraction template for primary study estimates (Supplementary File 2) via the "add instructions" tab. For each figure, the model was prompted to extract the study identifier, point estimate, and lower and upper confidence intervals, and to return these in a CSV file using the predefined column headings. We turned off the "*improve model for everyone"* setting to prevent the data provided in the figures from being used to train the model. KM then manually cross-checked each primary and meta-analytic estimate against the corresponding figure before adding the verified data to the master dataset. This process was repeated iteratively across all figures. Following the completion of data extraction by KM, 50% of studies were independently cross-checked (LR: 20%, IG: 10%. MP: 10%, PP: 10%).

To assign DOIs to each primary study, we first matched study names presented in the figures to the reference lists of the corresponding meta-analyses. If a study did not appear in the reference list, we checked whether it had been synthesised in another meta-analysis. When no match was found, we searched Google Scholar to identify a relevant publication. If a DOI could not be determined through any of these methods, it was recorded as "not reported." The matching of DOIs, and the resulting deduplication, to the appropriate study was conducted by KM and cross-checked by LR, PP, MJP and LG.

Data curation and visualisation

We organised the dataset in the *R Statistical Environment* (version 4.2.1; R Core Team, 2021) using *RStudio* (build 576; Posit Team, 2025). We wrangled and structured the data with the *tidyverse* packages (version 2.0.0; Wickham et al., 2019), created visualisations using *ggplot2* (version 3.5.1; Wickham, 2016), and analysed bibliometric data with the *bibliometrix* package (version 0.3.0; Aria and Cuccurullo, 2017).

Results, Discussion, and Recommendations

Structure of the database

We developed a unified database that combines descriptive information with quantitative data for meta-analyses and the included primary studies on the associations between PFAS and organochlorine pesticide exposures and adverse human health outcomes. Detailed metadata describing each extracted variable is provided in Supplementary File 1 and within the repositories.

In total, we retrieved 91 eligible meta-analyses, collectively reporting 457 pooled effect size estimates. Across these, we identified 627 unique primary studies with a retrievable DOI (808 including those without DOI), contributing 3,627 individual primary effect size estimates. On average, each meta-analysis included 5.79 meta-analytic estimates, while each primary study contributed 4.49 estimates (5.56 including those without DOI). Despite this extensive evidence base, there is substantial overlap across synthesised primary studies—many primary studies contribute multiple estimates within and between meta-analyses. This overlap highlights a methodological challenge in the evidence base, which is the dependency structure among effect sizes (Morrison et al., 2025a, 2025b). When correlated estimates derived from the same study are treated as independent, statistical inferences may be biased due to shared sampling errors (Pustejovsky and Tipton, 2022). This, in turn, may lead to inaccurate conclusions based on the evidence due to misrepresenting the confidence in the estimates. Several methodological approaches exist to address such dependencies, including constructing variance–covariance (VCV) matrices to model correlated sampling errors

(Williams et al., 2025) and applying cluster-robust variance estimation (Pustejovsky and Tipton, 2022; Yang et al., 2024). Both techniques can be readily implemented in R, using *metafor* (Viechtbauer, 2010) and *glmmTMB* (Williams et al., 2026) for frequentist approaches, and in *brms* for Bayesian approaches (Bürkner, 2021).

We found that the scientific evidence base on the associations between organochlorine pesticides and PFAS has expanded steadily since the first primary study was published in 1979. Primary research synthesised in the meta-analyses peaked in 2020, with 47 studies published in this year. The first meta-analysis on this topic was published in 2006. The number of meta-analyses increased gradually thereafter, becoming a routine analytical approach for quantifying secondary evidence after 2013 and peaking in 2023 with 23 publications. Based on a visual inspection of Figure 1, the temporal pattern suggests a typical lag between the generation of large volumes of primary evidence and the subsequent emergence of meta-analytical syntheses. The sharp rise in meta-analyses in 2023 may reflect methodological shifts during the COVID-19 pandemic, when restrictions limited laboratory and fieldwork, prompting a shift toward secondary data synthesis (Whitaker et al., 2025).

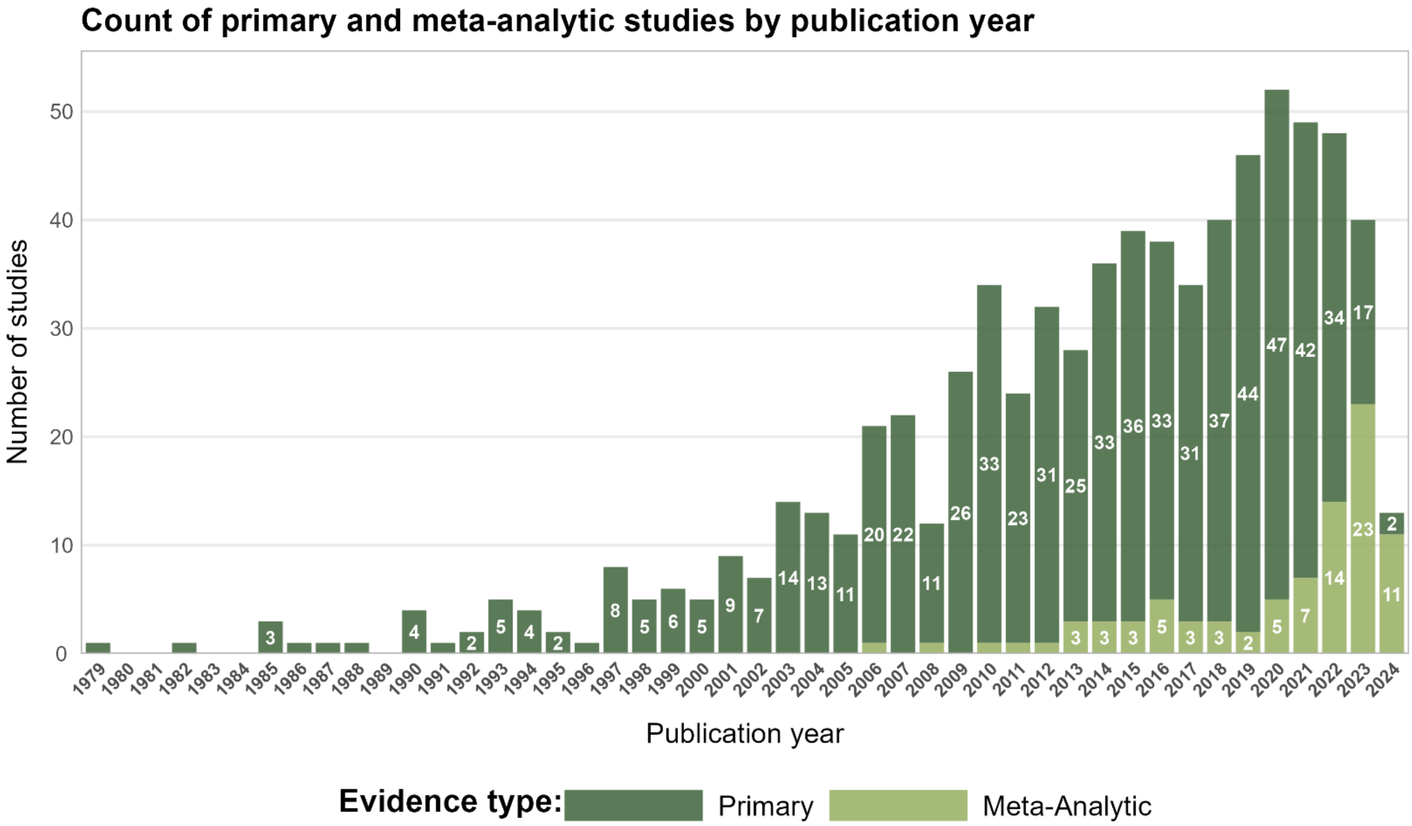

Figure 1) Time trends of the publication of primary and meta-analytic studies.

Stacked bar chart: annual number of unique primary studies synthesised (green) and meta-analyses (yellow) investigating the associations of organochlorine pesticides or PFAS exposure with adverse health outcomes. The search was conducted 2024, and hence, 2024 is an incomplete year of publications.

Chemicals and adverse health outcomes in primary studies

A wide range of chemicals and adverse health outcomes was represented across the synthesised primary studies. Among PFAS, the most frequently examined compounds were PFOA (*n* = 268, *k* = 736; where n is the number of primary studies and k is the number of primary effect size estimates) and PFOS (*n* = 276, *k* = 682), while among the organochlorine pesticides, DDE (*n* = 95, *k* = 150) was the most commonly assessed (Figure 2A). Although organochlorine pesticides accounted for more primary studies and meta-analyses, PFAS contributed more effect size estimates at both the primary and meta-analytic levels. This discrepancy likely reflects differences in methodological approaches across meta-analyses of the two chemical classes, with PFAS-focused meta-analyses more often evaluating multiple outcomes or exposure metrics in a single publication. In terms of health outcomes, the most frequently investigated endpoint was disorders of lipoprotein metabolism or lipidaemias (ICD11: 5C8Z, *n* = 39, *k* = 333) and malignant neoplasms of the breast (ICD11: 2C6Z, *n* = 78, *k* = 309), reflecting substantial research attention on both chemical classes to metabolic and reproductive adverse health outcomes (Figure 2B).

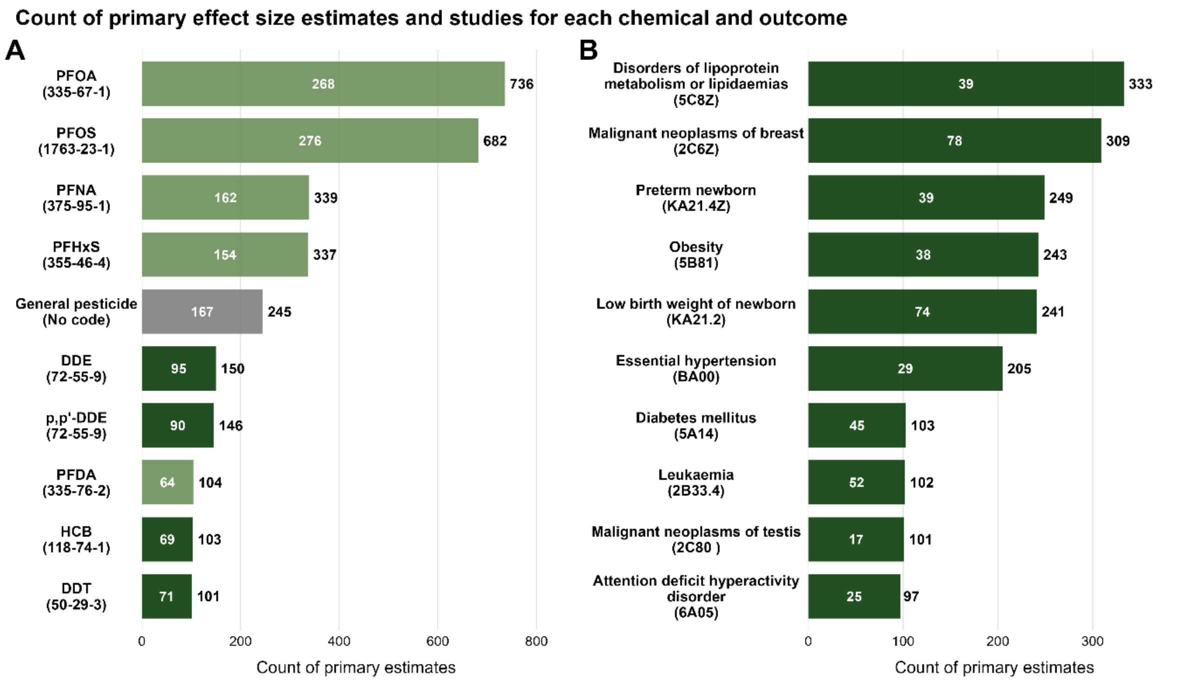

Figure 2) Number of primary-study effect-size estimates and primary studies for each chemical and outcome. *A) Bar plot showing the count of primary study estimates and the number of primary studies for each chemical included in meta-analyses (number of estimates are presented at end of bars and number of total primary studies*

is within each bar) investigating the associations of organochlorine pesticides or PFAS exposure with adverse human health outcomes. We provide the CAS Registry Numbers underneath each of the included chemicals. "General pesticide" refers to primary-study effect-size estimates and primary studies where pesticide exposure was analysed as a broad, non-specific pesticide grouping rather than as an individual named compound. Coloured by chemical class: light green is PFAS, dark green is organochlorine pesticides, and grey is "General pesticide". B) Bar plot showing the count of primary study estimates and the number of primary studies for each adverse health outcome investigated in the synthesised primary studies of meta-analyses on organochlorine pesticides and PFAS exposure. We provide the ICD11 code underneath each of the adverse health outcomes. Both panels are restricted to the 10 most frequently represented categories. The numbers within each bar are the total number of primary studies, and the numbers at the end of each bar are the total number of primary-study effect-size estimates.

Implications of the observed statistical properties of synthesised primary and meta-analytic evidence

The odds ratio was the most frequently reported effect-size measure, encompassing 2,213 primary-study estimates and 246 meta-analytic estimates (Figure 3). This was followed by the β regression coefficient, with 753 primary study estimates and 120 meta-analytic estimates (Figure 3). Explicit reporting of the effect size type was high, with 98.8% (3,582/3,627) of primary-study estimates and 97.8% (447/457) of meta-analytic estimates providing a defined measure, demonstrating strong adherence to quantitative reporting standards (Morrison et al., 2025a; Nakagawa et al., 2017; Page et al., 2021).

Across meta-analyses, I^2 (which quantifies the percentage of total variation across studies that is due to heterogeneity) was the most commonly used statistical estimate of heterogeneity, representing 95.4% of meta-analytic estimates (436/457), while τ^2 or τ (which quantify the absolute variance or standard deviation of true effects) were rarely reported, representing 12.0% of estimates (55/457) (Figure 3). Although I^2 is a useful comparative measure across meta-analyses, it should not be interpreted in isolation or uncritically. This is because the I^2 can be influenced by the sample size of a given study and by sampling error variance (Borenstein, 2024; Higgins and Thompson, 2002). To reduce the potential for misinterpretation and to capture heterogeneity more comprehensively, future meta-analyses should adopt a pluralistic approach (Yang et al., 2025). Alongside the widely reported I^2, authors are encouraged to also present alternative measures of variation amongst effects such as τ^2 or τ and prediction intervals (which describe the expected range of true effects across studies) (Borenstein, 2024; Higgins, 2003; IntHout et al., 2016).

The most used model structure across the included meta-analyses was a random-effects model, representing 82.7% of meta-analytic estimates (378/457). However, as noted previously, each primary study contributed an average of 4.49 primary estimates, introducing non-independence among effect sizes. Random-effects models with a single study level random-effect assume that the number of effect sizes equals the number of studies — an assumption that may hold in many medical meta-analyses where each study contributes a single estimate (Borenstein, 2013) but is routinely violated in environmental meta-analyses such as those included here. To appropriately account for this non-independence, multilevel (hierarchical) models, which partition variance within and between primary studies, are preferable (Nakagawa and Santos, 2012).

The most commonly reported variance estimation method was DerSimonian and Laird, with 20.5% of meta-analytic estimates (94/457). However, some evidence suggests that restricted maximum likelihood (REML) and Hartung–Knapp–Sidik–Jonkman (HKSJ) inference can provide more accurate error rates than the standard DerSimonian–Laird approach in random-effects meta-analysis, particularly when the number of studies is small (IntHout et al., 2014; Jackson et al., 2018). More concerningly, authors did not report the variance estimation method in 68.9% (301/457) of meta-analytic estimates. This is an important area for improvement because the method used to estimate heterogeneity can influence τ^2 estimates and the amount of heterogeneity explained in meta-regression analyses (Tanriver-Ayder et al., 2021).

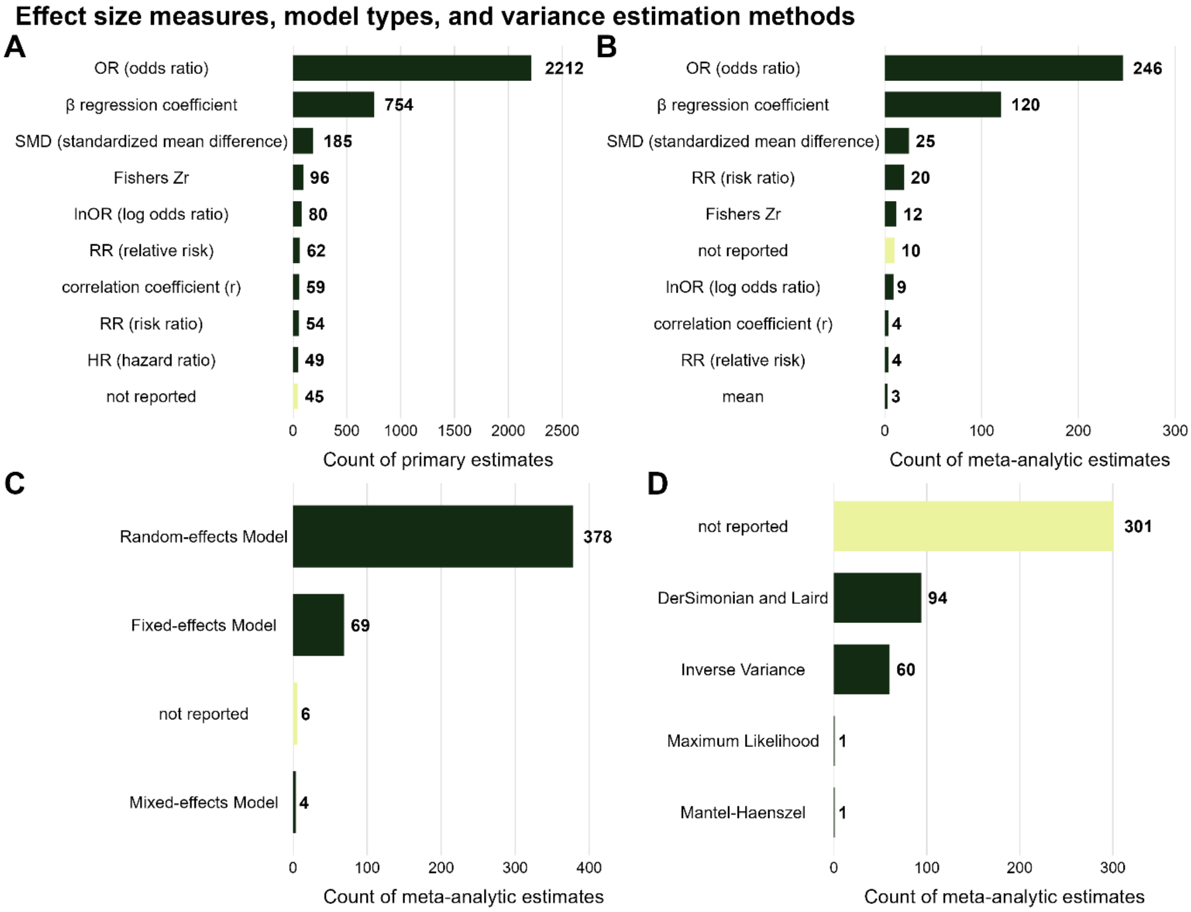

Figure 3) Number of primary and secondary study estimates for each effect size type, model type, and variance estimation method. *A) Bar plot showing the count of primary study estimates for each effect size type included in meta-analyses investigating the associations of PFAS or organochlorine pesticide exposure with adverse human health outcomes. B) Bar plot showing the count of secondary study estimates for each effect size in meta-analyses investigating the associations of PFAS or organochlorine pesticides or exposure with adverse human health outcomes. C) Bar plot showing the count of meta-analytic study estimates using each statistical model type in meta-analyses investigating the associations of PFAS or organochlorine pesticides or exposure with adverse human health outcomes. D) Bar plot showing the count of secondary study estimates using each variance estimation method in meta-*

analyses investigating the associations of PFAS, organochlorine pesticides, or exposure with adverse human health outcomes

Geographical source of primary and meta-analytic evidence

We determined the country of affiliation of each study's first author for primary and meta-analytic studies. Across all included research, 627 unique primary studies had first-author affiliations in 21 countries. First authors were most commonly affiliated with the USA at 34.3% (215/627), China at 12.6% (79/627), Sweden at 5.9% (37/627), and Denmark at 5.9% (37/627) (Figure 4). The 91 unique secondary studies (meta-analyses) had first author affiliations from 36 countries, with the most prolific contributors in terms of meta-analytic publications being China with 44.0% (40/91), the USA with 9.10% (10/91), and Belgium with 5.5% (5/91) (Figure 4). Overall, both primary and secondary evidence were predominantly from Global North countries , consistent with broader global trends in environmental and ecological research (Morrison et al., 2024; Pollo et al., 2024).. Mitigation strategies to improve research inclusivity include encouraging collaborations between researchers in developed and developing countries (Haelewaters et al., 2021; Nakamura et al., 2023), adopting double-blind peer review to reduce systemic bias at the publication stage (Fox et al., 2023).

We also observed marked cross-country differences in the balance between primary evidence generation and synthesis. For example, the United States produced 215 primary studies and 10 meta-analyses (a ratio approximated 22:1), and Denmark produced 37 primary studies and 3 meta-analyses (12:1). In contrast, China conducted 79 primary studies and 40 meta-analyses (2:1), suggesting a comparatively greater focus on evidence synthesis in China. These disparities suggest national differences in research priorities, motivations, and capacities in collecting and synthesising evidence, possibly shaped by research funding and institutional incentives.

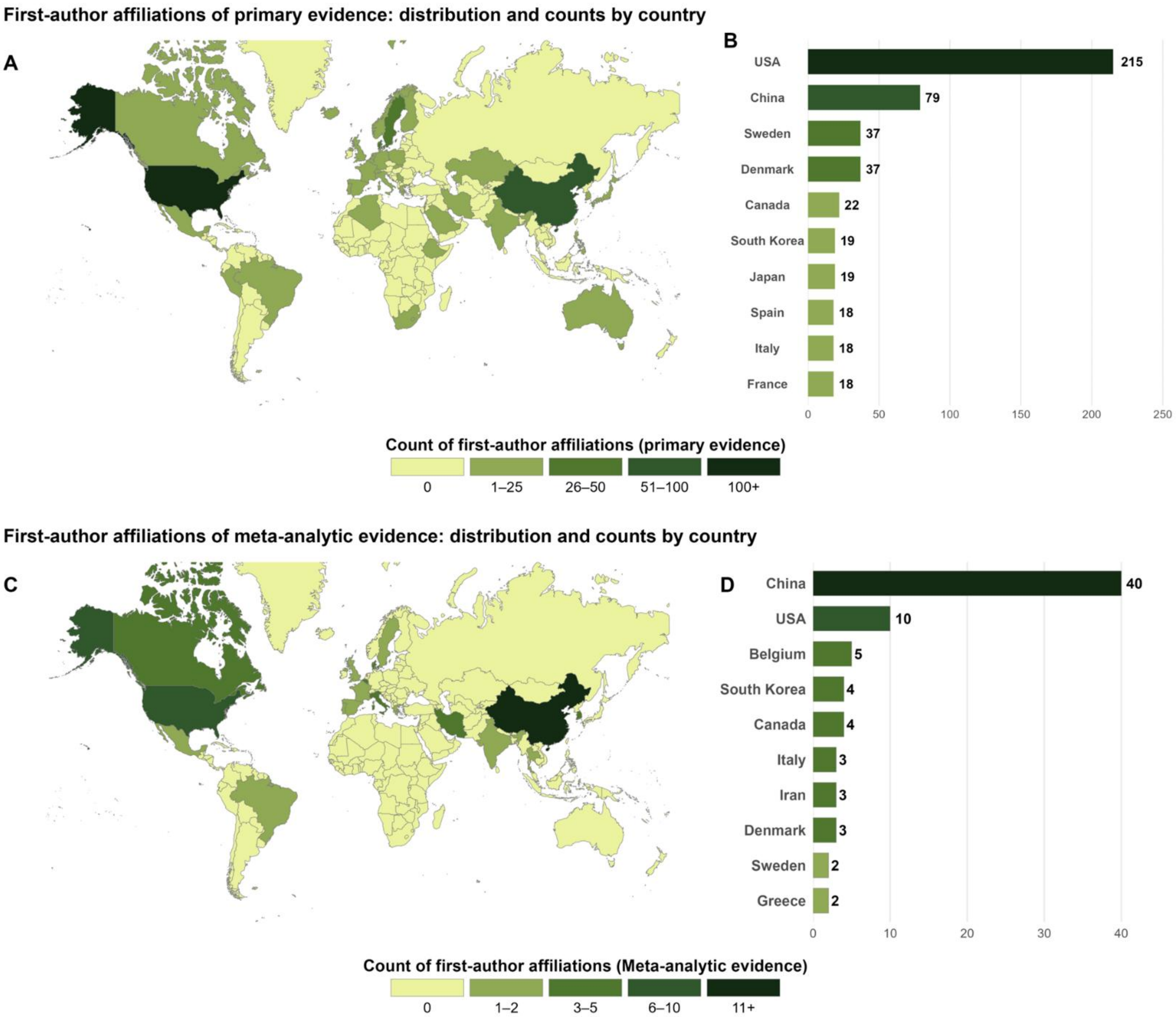

Figure 4) First author affiliations for primary and meta-analytic evidence. *A) World map showing the country of the first authors' affiliation for each of the primary studies*

synthesised in meta-analyes investigating the associations of organochlorine pesticides or PFAS exposure with adverse health outcomes. B) Bar plot showing the total count of each first author's affiliation per country for the primary studies synthesised in meta-analysis investigating the associations of organochlorine pesticides or PFAS exposure with adverse health outcomes. C) World map showing the country of the first authors' affiliation for each meta-analysis investigating the associations of organochlorine pesticides or PFAS exposure with adverse health outcomes. D) Bar plot showing the total count of each first author's affiliation per country for meta-analysis investigating the associations of organochlorine pesticides or PFAS exposure with adverse health outcomes. All bar plots are filtered to show the top 10 counts.

Future use cases

We provide a unified dataset that includes effect-size point estimates and confidence intervals for 457 meta-analytic models and over 3,627 primary-study estimates, along with associated references (DOIs) where available. For every meta-analytic estimate, we additionally report the effect size measure, model type, and variance estimator used. For each primary study, we include the chemical(s) examined, their CAS Registry Numbers, and the corresponding adverse health outcomes, classified according to ICD-11 codes. Collectively, this dataset represents the first comprehensive compilation of both primary and secondary evidence on organochlorine pesticides and PFAS.

For meta-analysts, the dataset reduces the burden of two time-consuming steps of evidence synthesis: screening and extraction. A researcher updating an existing meta-analysis — for example, of PFOA and kidney cancer — can use the harmonised primary-study table to see which studies have already been extracted and coded, cross-check reported effect sizes against the CAS-indexed chemical identifiers and add only the post-2024 literature rather than re-screening the field from scratch (we note that an update covering studies published since early 2024 will be needed). Because the model type and variance estimator are recorded for every meta-analytic estimate, the dataset also allows direct comparison of methodological choices across models estimating the same chemical–outcome pair, supporting replication and sensitivity checks that would otherwise require re-digitising results from dozens of individual papers.

For primary researchers, the dataset functions as a map of the existing evidence base rather than a substitute for it. A researcher designing a new cohort study on organochlorine exposure and thyroid function, for instance, can query the dataset to see that some chemical–outcome pairs are already supported by dozens of primary estimates, while others remain sparsely studied. This lets new data collection be targeted at genuine gaps rather than outcomes that are already well characterised and gives researchers a benchmark against which to interpret the direction and magnitude of their own findings.

For decision-makers and regulatory bodies, the value of the dataset lies in making the existing evidence base auditable rather than in generating new conclusions itself. Consider a risk assessor revisiting the tolerable weekly intake for a specific PFAS congener: the dataset could serve as a starting point for retrieving every eligible meta-analysis reporting an effect size for that compound across ICD-11-coded outcomes identified within the search coverage of this database, allowing the assessor to compare the model types and variance estimators underlying each and to identify whether the evidence is dense and consistent enough to support a revised threshold — or whether it instead exposes gaps (e.g., a single small meta-analysis for a health-relevant outcome) that should be flagged. This audit would need to be supplemented with an updated literature search, risk-of-bias assessment, exposure-response and toxicological evidence, and causal evaluation before informing a regulatory decision. Used this way, the dataset does not replace expert judgement or the broader risk-assessment process, but it shortens the time needed to establish what is and is not currently supported by the literature and creates a traceable link from primary studies through to the meta-analytic estimates that regulatory reviews typically cite.

Challenges and limitations in the construction of the database

During database construction, several limitations were identified in both our approach and the underlying literature. The database includes only primary studies that were synthesised in meta-analyses, allowing evidence to be collated across multiple levels of research and resulting in a large, diverse dataset. However, because inclusion depended on studies being synthesised, the breadth and characteristics of non-synthesised primary studies remain unknown. This means the representativeness of the synthesised evidence relative to the total body of research could not be assessed. Future databases could address this limitation by extending coverage to include non-synthesised primary studies and using an alternative search strategy.

A second limitation relates to the nature of the extracted data. Reported associations in meta-analyses were presented using a range of effect size measures, which are not always directly comparable and require assumptions when transformed to a common metric. This limitation could be overcome if raw data were made available, as this would allow effect sizes to be recalculated consistently across studies. However, improved reporting and data availability at the primary-study level are needed before this becomes possible. Many effect sizes were also reported only in figures, making extraction both challenging and time-consuming. We therefore advocate for the provision of raw and processed data in FAIR-aligned formats (e.g., .csv) to support transparency and accelerate data re-use in future meta-analyses. Extracting DOIs for each study was another challenge, as these were seldom provided alongside effect sizes and often had to be inferred from reference lists or reconstructed manually. Although extensive cross-checking was undertaken to minimise error, some uncertainty may remain. The challenges identified here highlight several areas where future work can improve both database construction and reporting standards. Addressing these issues will enhance data accessibility, reduce human error, and strengthen the transparency and reproducibility of evidence syntheses in environmental health research.

Conclusion

This study presents the first quantitative, FAIR-aligned database that integrates both primary and secondary evidence on the associations between organochlorine pesticide and PFAS exposures and adverse human health outcomes. The database bridges long-standing gaps in how evidence has been collated, standardised, and reported, combining descriptive information on pollutants and health outcomes with quantitative data such as effect sizes, variances, and confidence intervals. Each record is traceably linked to its source publication (DOI) when possible, and synthesis estimates were directly linked to the corresponding primary study estimates. Chemicals and outcomes are further harmonised using CAS Registry Number (CAS RN) and ICD-11 classifications, facilitating interoperability across studies and disciplines. Beyond data compilation, this work provides methodological and reporting recommendations to guide future meta-analyses and improve consistency in reporting across environmental-health research. By systematically extracting, curating, and linking evidence, this resource establishes a comprehensive, reusable foundation to advance quantitative synthesis and guide future research on persistent organic pollutants.

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CRediT authorship contribution statement

Kyle Morrison: Writing – original draft, Visualization, Validation, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Lorenzo Ricolfi:** Writing – review & editing, Validation, Software, Resources, Methodology, Investigation, Data curation, Conceptualization. **Iwo Gross**: Writing – review & editing, Validation, Methodology. **Ayumi Mizuno:** Writing – review & editing, Validation, Methodology. **Pietro Pollo:** Writing – review & editing, Validation, Methodology. **Marija Purger**: Writing – review & editing, Validation, Methodology. **Malgorzata Lagisz:** Writing – review & editing, Validation, Supervision. **Shinichi**

Nakagawa: Writing – review & editing, Supervision, Funding acquisition, Conceptualization.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Declaration of Generative AI and AI-assisted technologies in the writing process

We used OpenAI's GPT 5.2 model to assist with data extraction by uploading each forest plot figure alongside the data extraction template for primary study estimates (Supplementary File 1, Table S3-5) via the "add instructions" feature. For each figure, the model was prompted to extract the study identifier, point estimate, and corresponding lower and upper confidence intervals, and to return the results in CSV format using predefined column headings. The "improve model for everyone" setting was disabled to ensure that no data from the figures were used for model training. GPT 5.2 was also used to support improvements in writing clarity and flow. All AI-generated outputs were carefully reviewed and edited by the authors, who take full responsibility for the final content of this publication.

Supplementary File 1

Supplementary Methodology

Scientific literature sources

We identified potentially relevant meta-analysis using search string in two recent second-order synthesis of systematic reviews and meta-analysis (hereon, meta-analysis) on the associations of organochlorine pesticides and PFAS with adverse human health outcomes (Morrison et al., 2026; Ricolfi et al., unpublished). To identify primary studies, we extracted all synthesised primary evidence reported within each of the included meta-analyses. For transparency, the common search strategy employed in the two second-order syntheses is reiterated below:

The literature search from (Morrison et al., 2026) and (Ricolfi et al., unpublished) included all meta-analyses included in two previous systematic evidence maps, one on organochlorine pesticides (Morrison et al., 2025a) and one on PFAS (Ricolfi et al., 2024). Follow this, they completed searches of 1) Scopus, 2) Web of Science Core Collection, 3) PubMed, and 4) ProQuest, to capture studies published after the evidence-map cutoff of 4 August 2022.

1) Scopus

Date: 08 April 2024

Hits = 781

TITLE-ABS-KEY (((persistent w/3 pollut*) OR organoch* OR aldrin OR chlordane OR chlordecone OR dicofol OR dieldrin OR endrin OR heptachlor OR hexachlorocyclohexane OR hch OR lindane OR endosulfan OR mirex OR

pentachlorobenzene OR chlordecone OR pentachlorophenol OR toxaphene OR ddt OR dichlorodiphenyltrichloroethylene OR dde OR dichlorodiphenyldichloroethylene OR endosulfan OR oxychlordane OR isobenzan OR isodrin OR ddd OR dichlorodiphenyldichloroethane OR methoxychlor OR *fluoroalkyl* OR perfluorin* OR perfluo* OR polyfluo* OR pfas OR pfba OR pfpea OR pfhxa OR pfhpa OR pfoa OR pfna OR pfda OR pfdea OR pfdca OR pfunda OR pfuna OR pfua OR pfuda OR pfdoa OR pfdoda OR pftrda OR pftrida OR pftra OR pfta OR pfteda OR pfo4da OR pfo5doda OR pfbs OR pfbus OR pfpes OR pfhxs OR pfhps OR pfos OR pfns OR pfds OR fts OR ftsa OR pfechs OR fosa OR pfosa OR netfosaa OR "Et-PFOSA- AcOH" OR nmefosaa OR "Me- PFOSA-AcOH" OR adona OR "Cl-PFAES" OR "F-53B" OR genx OR "HFPO-TA" OR "Hydro-Eve" OR "Nafion BP2" OR teflon OR tefal OR (emerging W/3 pollutant) OR "organohalogen*") AND ((systematic* W/3 review*) OR (meta* W/3 review*) OR (meta* W/3 anal*) OR (meta* W/3 regression*))) AND PUBYEAR > 2021

2) Web of Science Core Collection

Date: 01 May 2024

Hits = 407

TS=(((persistent NEAR/3 pollut*) OR organoch* OR aldrin OR chlordane OR chlordecone OR dicofol OR dieldrin OR endrin OR heptachlor OR hexachlorocyclohexane OR hch OR lindane OR endosulfan OR mirex OR pentachlorobenzene OR chlordecone OR pentachlorophenol OR toxaphene OR ddt OR dichlorodiphenyltrichloroethylene OR dde OR dichlorodiphenyldichloroethylene OR endosulfan OR oxychlordane OR isobenzan OR isodrin OR ddd OR dichlorodiphenyldichloroethane OR methoxychlor OR *fluoroalkyl* OR perfluorin* OR perfluo* OR polyfluo* OR pfas OR pfba OR pfpea OR pfhxa OR pfhpa OR pfoa OR pfna OR pfda OR pfdea OR pfdca OR pfunda OR pfuna OR pfua OR pfuda OR pfdoa OR pfdoda OR pftrda OR pftrida OR pftra OR pfta OR pfteda OR pfo4da OR pfo5doda OR pfbs OR pfbus OR pfpes OR pfhxs OR pfhps OR pfos OR pfns OR pfds OR fts OR ftsa

OR pfechs OR fosa OR pfosa OR netfosaa OR "Et-PFOSA- AcOH" OR nmefosaa OR "Me- PFOSA-AcOH" OR adona OR "Cl- PFAES" OR "F-53B" OR genx OR "HFPO-TA" OR "Hydro-Eve" OR "Nafion BP2" OR teflon OR tefal OR (emerging NEAR/3 pollutant) OR "organohalogen*") AND ((systematic* NEAR/3 review*) OR (meta* NEAR/3 review*) OR (meta* NEAR/3 anal*) OR (meta* NEAR/3 regression*)))

3) PubMed

Date: 01 May 2024

Hits = 216

Filters: from 2022 – 2024 (inclusive)

("persistent pollut*"[Title/Abstract] OR organoch*[Title/Abstract] OR aldrin[Title/Abstract] OR chlordane[Title/Abstract] OR chlordecone[Title/Abstract] OR dicofol[Title/Abstract] OR dieldrin[Title/Abstract] OR endrin[Title/Abstract] OR heptachlor[Title/Abstract] OR hexachlorocyclohexane[Title/Abstract] OR hch[Title/Abstract] OR lindane[Title/Abstract] OR endosulfan[Title/Abstract] OR mirex[Title/Abstract] OR pentachlorobenzene[Title/Abstract] OR chlordecone[Title/Abstract] OR pentachlorophenol[Title/Abstract] OR toxaphene[Title/Abstract] OR ddt[Title/Abstract] OR dichlorodiphenyltrichloroethylene[Title/Abstract] OR dde[Title/Abstract] OR dichlorodiphenyldichloroethylene[Title/Abstract] OR endosulfan[Title/Abstract] OR oxychlordane[Title/Abstract] OR isobenzan[Title/Abstract] OR isodrin[Title/Abstract] OR ddd[Title/Abstract] OR dichlorodiphenyldichloroethane[Title/Abstract] OR methoxychlor[Title/Abstract] OR *fluoroalkyl*[Title/Abstract] OR perfluorin*[Title/Abstract] OR perfluo*[Title/Abstract] OR polyfluo*[Title/Abstract] OR pfas[Title/Abstract] OR pfba[Title/Abstract] OR pfpea[Title/Abs (inclusuve)tract] OR pfhxa[Title/Abstract] OR pfhpa[Title/Abstract] OR pfoa[Title/Abstract] OR pfna[Title/Abstract] OR pfda[Title/Abstract] OR pfdea[Title/Abstract] OR pfdca[Title/Abstract] OR pfunda[Title/Abstract] OR pfuna[Title/Abstract] OR pfua[Title/Abstract] OR pfuda[Title/Abstract] OR pfdoa[Title/Abstract] OR pfdoda[Title/Abstract] OR pftrda[Title/Abstract] OR pftrida[Title/Abstract] OR pftra[Title/Abstract] OR pfta[Title/Abstract] OR pfteda[Title/Abstract] OR pfo4da[Title/Abstract] OR pfo5doda[Title/Abstract] OR pfbs[Title/Abstract] OR pfbus[Title/Abstract] OR pfpes[Title/Abstract] OR pfhxs[Title/Abstract] OR pfhps[Title/Abstract] OR pfos[Title/Abstract] OR pfns[Title/Abstract] OR pfds[Title/Abstract] OR fts[Title/Abstract] OR ftsa[Title/Abstract] OR pfechs[Title/Abstract] OR fosa[Title/Abstract] OR pfosa[Title/Abstract] OR netfosaa[Title/Abstract] OR "Et-PFOSA- AcOH"[Title/Abstract] OR nmefosaa[Title/Abstract] OR "Me- PFOSA-AcOH"[Title/Abstract] OR adona[Title/Abstract] OR "Cl- PFAES"[Title/Abstract] OR "F-53B"[Title/Abstract] OR genx[Title/Abstract] OR "HFPO-TA"[Title/Abstract] OR "Hydro-Eve"[Title/Abstract] OR "Nafion BP2"[Title/Abstract] OR teflon[Title/Abstract] OR tefal[Title/Abstract] OR "emerging pollut*"[Title/Abstract] OR "organohalogen*"[Title/Abstract]) AND ("systematic review"[Title/Abstract] OR "meta review"[Title/Abstract] OR "meta anal*"[Title/Abstract] OR meta regression"[Title/Abstract])

4) ProQuest

Dissertation and Theses

Date: 08 April 2024

Hits = 9

(noft(perfluor*) OR noft(pfa) OR noft(organochlor*) OR noft(ocp)) AND (noft(meta-anal*) OR noft(systemat*) OR noft(meta-reg*))

Literature Screening Strategy

We modified the literature screening strategy used in the two second-order synthesis (Morrison et al., 2026; Ricolfi et al., unpublished). This literature screening strategy was conducted in two stages: first, two independent reviewers evaluated all titles, abstracts, and keywords, and then they screened relevant full texts. Any discrepancies between screeners were resolved through discussion and involved a mediator when necessary. The eligibility criteria and screening strategy including our additional restriction is provided below.

Table S1) *The eligibility criteria of meta-analyses structured according to the PECOS framework (Population – Exposure – Comparator – Outcome – Study design)*

Element	**Criteria**
Population	We included meta-analyses synthesising primary studies investigating the associations between exposure to organochlorine pesticides/PFAS and adverse human health outcomes. We have no restrictions on the sex, life stage, or nationality of the human population.
Exposure	Meta-analyses that examined specific organochlorine pesticides/PFAS (e.g., Dichlorodiphenyltrichloroethane [DDT], aldrin, PFOA, PFOS), generic organochlorine pesticides as a chemical group (e.g., total organochlorine pesticides) or generic PFAS as a chemical group were eligible. We included meta-analyses that included summary effect size estimates that were chemicals classes such as "pesticides", "persistent organic pollutants", or "endocrine-disrupting chemicals" without explicitly specifying the specific chemical group were also included in the database.

Comparator	Eligible comparators were populations, subgroups, or conditions characterised by lower or no exposure to organochlorine, as defined by the included primary studies. Meta-analyses of observational studies that did not explicitly state comparators remained eligible if they quantified associations of organochlorine pesticide exposure with health outcomes.
Outcomes	Meta-analyses that assessed any adverse human health outcomes (e.g., breast cancer, type 2 diabetes, neurodevelopmental disorders, reduced semen quality) were included.
Study Design	Meta-analyses statistically synthesising primary studies employing any observational or experimental design, including correlational studies linking organochlorine pesticide exposure levels with health outcomes, were eligible.
Other considerations	There were no restrictions based on publication year. Studies were required to be written published in English, Russian, Polish, Spanish, Portuguese, Japanese, French, Italian, Simplified Chinese, or Traditional Chinese. Publications in other languages were excluded. There were no restrictions on the type of effect size (e.g., odds ratio, risk ratio, β coefficients) or heterogeneity measure (e.g., I^2, τ^2, Q).

Screening flowchart

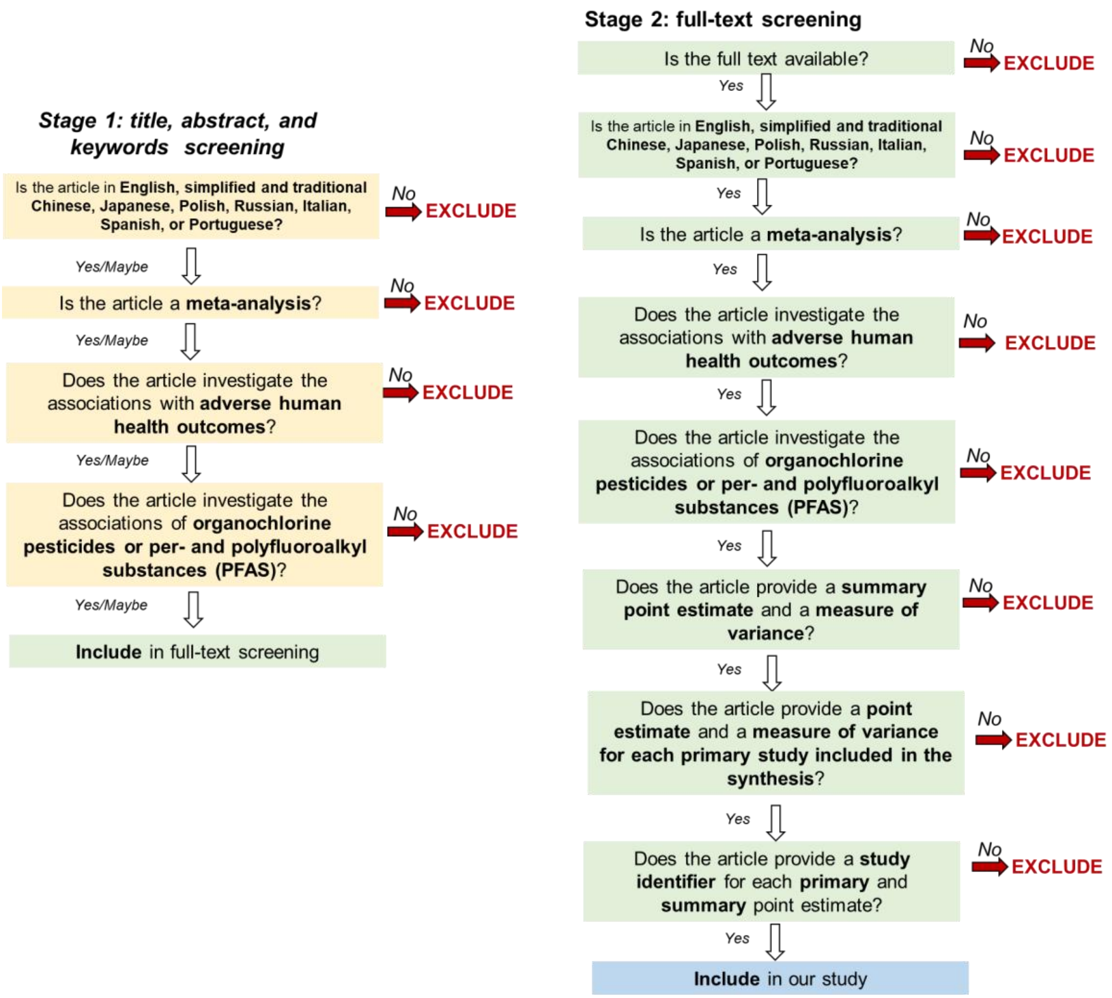

Figure S1) Screening flowchart. *A flowchart presenting the iterative criteria for the two screening stages: (1) title, abstract, and keywords, and (2) full texts.*

Additional screening notes

At both title/abstract and full-text screening stages, we included any meta-analysis that potentially synthesised epidemiological evidence on the association between organochlorine pesticide (OCP) or per- and polyfluoroalkyl substance (PFAS) exposure and a human health outcome. This encompassed meta-analyses that referred to these compounds under broader chemical classes — including pesticides, persistent organic pollutants (POPs), or endocrine-disrupting chemicals (EDCs) — where the synthesis plausibly contained OCP- or PFAS-specific estimates.

A summary point estimate is the pooled effect size reported at the meta-analysis level, derived by statistically combining estimates from two or more primary studies. A single meta-analysis may contribute multiple summary point estimates (e.g., one per chemical, outcome, or subgroup). Meta-analyses were excluded if they reported a pooled estimate without providing individual primary study estimates alongside it, as the latter were required for data extraction.

A study identifier is any element within the meta-analysis that enables the underlying source of a given primary study estimate to be traced (e.g., unique study code, first author name, in-text citation). A meta-analysis was eligible for inclusion even if DOIs could not be located for all contributing primary studies, provided that each extracted effect size was accompanied by at least one usable identifier.

Table S2) *Studies excluded at full-text screening.*

Title	**DOI**	**Reason for exclusion**
Profiling research on PFAS in wildlife: Systematic evidence map and bibliometric analysis	10.1002/2688-8319.12292	meta-analytic and primary estimates not provided
Meta-Analysis Comparing Nominal and Measured Concentrations of Perfluorooctanoic Acid and Perfluorooctane Sulfonate	10.1002/etc.5733	meta-analytic and primary estimates not provided

in Aquatic Toxicity Studies Across Various Experimental Conditions		
ORGANOCHLORINE COMPOUNDS AND ESTROGEN-RELATED CANCERS IN WOMEN	10.1007/BF00054165	meta-analytic and primary estimates not provided
Effects of chemical pollution on the behaviour of cichlid fish	10.1007/s10641-022-01376-9	meta-analytic and primary estimates not provided
A Systematic Review and Meta-analysis of Chemical Exposures and Attention-Deficit/Hyperactivity Disorder in Children	10.1007/s11121-023-01601-6	wrong exposure
Arsenic and Environment: A Systematic Review on Arsenic Sources, Uptake Mechanism in Plants, Health Hazards and Remediation Strategies	10.1007/s11244-023-01901-9	meta-analytic and primary estimates not provided
Effects of perinatal exposure to endocrine disrupting chemicals on the reproductive system of F3 generation male rodents: a meta analysis	10.1007/s11356-021-18338-w	wrong population
Exposure to environmental pollutants and attention-deficit/hyperactivity disorder: an overview of	10.1007/s11356-023-30173-9	meta-analytic and primary estimates not provided

systematic reviews and meta-analyses		
Leveraging Systematic Reviews to Explore Disease Burden and Costs of Per- and Polyfluoroalkyl Substance Exposures in the United States	10.1007/s12403-022-00496-y	meta-analytic and primary estimates not provided
Per- and polyfluoroalkyl substances (PFASs) in consumable species and food products	10.1007/s13197-022-05545-7	meta-analytic and primary estimates not provided
Exposure to Organochlorine Pesticides and Female Breast Cancer Risk According to Molecular Receptors Expression: a Systematic Review and Meta-analysis of Epidemiological Evidence	10.1007/s40572-023-00408-5	meta-analytic and primary estimates not provided
Endocrine-disrupting chemicals (EDCs) and cancer: new perspectives on an old relationship	10.1007/s40618-022-01983-4	meta-analytic and primary estimates not provided
PFAS Exposures and the Human Metabolome: A Systematic Review of Epidemiological Studies	10.1007/s40726-023-00269-4	meta-analytic and primary estimates not provided
Mechanism Exploration of Environmental Pollutants on Premature Ovarian	10.1007/s43032-023-01326-5	meta-analytic and primary estimates not provided

Insufficiency: a Systematic Review and Meta-analysis		
Exploring the Effects of Endocrine-Disrupting Chemicals and miRNA Expression in the Pathogenesis of Endometriosis by Unveiling the Pathways: a Systematic Review	10.1007/s43032-023-01412-8	meta-analytic and primary estimates not provided
Mechanisms and pathways of PFAS degradation by advanced oxidation and reduction processes: A critical review	10.1016/j.cej.2022.138352	meta-analytic and primary estimates not provided
Male reproductive toxicity of perfluorooctanoate (PFOA): Rodent studies	10.1016/j.chemosphere.2020.128608	wrong population
Spherical indentation of polycrystalline cubic boron nitride (PcBN): Contact damage evolution with increasing load and microstructural effects	10.1016/j.chemosphere.2023.137748	meta-analytic and primary estimates not provided
Contact to perfluoroalkyl substances and thyroid health effects: A meta-analysis directing on pregnancy	10.1016/j.chemosphere.2023.137748	meta-analytic and primary estimates not provided

Contact to perfluoroalkyl substances and thyroid health effects: A meta-analysis directing on pregnancy	10.1016/j.chemosphere.2023.137748	meta-analytic and primary estimates not provided
Consumption of fruits and vegetables contaminated with pesticide residues in Brazil: A systematic review with health risk assessment	10.1016/j.chemosphere.2023.138244	meta-analytic and primary estimates not provided
Polychlorinated biphenyl (PCB) half-lives in humans: A systematic review	10.1016/j.chemosphere.2023.140359	meta-analytic and primary estimates not provided
Corrigendum to â€œAssessing the health risk of hyperuricemia in participants with persistent organic pollutants exposure - a systematic review and meta-analysisâ€� [Ecotoxicol. Environ. Saf. 251 (Feb 2023) 114525] (Ecotoxicology and Environmental Safety (2023) 251, (S0147651323000295), (10.1016/j.eco...	10.1016/j.ecoenv.2023.114661	meta-analytic and primary estimates not provided
Per- and polyfluoroalkyl substances in Chinese surface waters: A review	10.1016/j.ecoenv.2023.115178	meta-analytic and primary estimates not provided

Association between prenatal perfluorinated compounds exposure and risk of pregnancy complications: A meta-analysis	10.1016/j.ecoenv.2024.116017	meta-analytic and primary estimates not provided
Association between prenatal perfluorinated compounds exposure and risk of pregnancy complications: A meta-analysis	10.1016/j.ecoenv.2024.116017	meta-analytic and primary estimates not provided
Pesticide residues levels in raw cow's milk and health risk assessment across the globe: A systematic review	10.1016/j.envadv.2022.100266	meta-analytic and primary estimates not provided
PFAS exposure of humans, animals and the environment: Protocol of an evidence review map and bibliometric analysis	10.1016/j.envint.2021.106973	meta-analytic and primary estimates not provided
Human exposure pathways to poly- and perfluoroalkyl substances (PFAS) from indoor media: A systematic review	10.1016/j.envint.2022.107149	meta-analytic and primary estimates not provided
The PFAS-Tox Database: A systematic evidence map of health studies on 29 per- and polyfluoroalkyl substances	10.1016/j.envint.2022.107408	meta-analytic and primary estimates not provided

Risk assessment for PFOA and kidney cancer based on a pooled analysis of two studies	10.1016/j.envint.2022.107425	meta-analytic and primary estimates not provided
Systematic review and meta-analysis of epidemiologic data on vaccine response in relation to exposure to five principal perfluoroalkyl substances	10.1016/j.envint.2023.107734	meta-analytic and primary estimates not provided
A metabolomic investigation of serum perfluorooctane sulfonate and perfluorooctanoate	10.1016/j.envint.2023.108198	meta-analytic and primary estimates not provided
Thermal processing reduces PFAS concentrations in blue food â€“ A systematic review and meta-analysis	10.1016/j.envpol.2022.119081	wrong population
Insights into the mechanisms of organic pollutant toxicity to earthworms: Advances and perspectives	10.1016/j.envpol.2022.119120	meta-analytic and primary estimates not provided
Occurrence of persistent organic pollutants (POPs) in the atmosphere of South Korea: A review	10.1016/j.envpol.2022.119586	meta-analytic and primary estimates not provided
The effects of exposure to environmentally relevant	10.1016/j.envpol.2022.120422	wrong population

PFAS concentrations for aquatic organisms at different consumer trophic levels: Systematic review and meta-analyses		
Cross-sectional associations between exposure to per- and polyfluoroalkyl substances and body mass index among European teenagers in the HBM4EU aligned studies	10.1016/j.envpol.2022.120566	meta-analytic and primary estimates not provided
To what extent are filter feeder elasmobranchs exposed to marine pollution? A systematic review	10.1016/j.envpol.2022.120881	meta-analytic and primary estimates not provided
Chlorinated organic pollutants in global flooded soil and sediments: Pollution status and potential risk	10.1016/j.envpol.2023.121270	meta-analytic and primary estimates not provided
Pacific salmon as vectors of environmental contaminants: An experimental test confirms synoptic surveys in natural streams	10.1016/j.envpol.2023.122355	meta-analytic and primary estimates not provided

Persistent organic pollutants exposure and risk of autism spectrum disorders: A systematic review and meta-analysis	10.1016/j.envpol.2023.122439	meta-analytic and primary estimates not provided
A systematic review and meta-analysis of occupational exposures and risk of follicular lymphoma	10.1016/j.envres.2021.110887	meta-analytic and primary estimates not provided
How to investigate human health effects related to exposure to mixtures of per- and polyfluoroalkyl substances: A systematic review of statistical methods	10.1016/j.envres.2021.112565	meta-analytic and primary estimates not provided
A review on per- and polyfluorinated alkyl substances (PFASs) in microplastic and food-contact materials	10.1016/j.envres.2021.112595	meta-analytic and primary estimates not provided
Pesticide exposure and child growth in low- and middle-income countries: A systematic review	10.1016/j.envres.2022.114230	meta-analytic and primary estimates not provided
Endocrine-disrupting chemicals and endocrine neoplasia: A forty-year systematic review	10.1016/j.envres.2022.114869	wrong exposure

Lack of association between endocrine disrupting chemicals and male fertility: A systematic review and meta-analysis	10.1016/j.envres.2022.114942	wrong exposure
Perfluoroalkyl and polyfluoroalkyl substances and hypertensive disorders of pregnancy: A systematic review and meta-analysis	10.1016/j.envres.2023.116064	meta-analytic and primary estimates not provided
A systematic review on distribution, sources and sorption of perfluoroalkyl acids (PFAAs) in soil and their plant uptake	10.1016/j.envres.2023.116156	meta-analytic and primary estimates not provided
Human biomonitoring of environmental contaminants in Gulf Countries-current status and future directions	10.1016/j.envres.2023.116650	meta-analytic and primary estimates not provided
Association between prenatal exposure to per- and polyfluoroalkyl substances and neurodevelopment in children: Evidence based on birth cohort	10.1016/j.envres.2023.116812	meta-analytic and primary estimates not provided
Correlation between in vitro toxicity of pesticides and in vivo risk guidelines in support of complex	10.1016/j.fct.2022.113502	meta-analytic and primary estimates not provided

operating site risk management: A meta-analysis		
A plausibility database summarizing the level of evidence regarding the hazards induced by the exposome on children health	10.1016/j.ijheh.2023.114311	meta-analytic and primary estimates not provided
Quantitative relationship between earthwormsâ€™ sensitivity to organic pollutants and the contaminantsâ€™ degradation in soil: A meta-analysis	10.1016/j.jhazmat.2022.128286	meta-analytic and primary estimates not provided
Impact of chemical pollution on threatened marine mammals: A systematic review	10.1016/j.jhazmat.2023.132203	meta-analytic and primary estimates not provided
Occurrence, spatiotemporal trends, fate, and treatment technologies for microplastics and organic contaminants in biosolids: A review	10.1016/j.jhazmat.2024.133471	meta-analytic and primary estimates not provided
Perfluorohexyloctane in dry eye disease: A systematic review of its efficacy and safety as a novel therapeutic agent	10.1016/j.jtos.2023.10.001	meta-analytic and primary estimates not provided

Pediatric poisoning deaths in Saudi Arabia: A systematic review	10.1016/j.legalmed.2022.102173	meta-analytic and primary estimates not provided
Occurrence, mass loading, and post-control temporal trend of legacy perfluoroalkyl substances (PFASs) in the middle and lower Yangtze River	10.1016/j.marpolbul.2023.115966	meta-analytic and primary estimates not provided
The SH-SY5Y human neuroblastoma cell line, a relevant in vitro cell model for investigating neurotoxicology in human: Focus on organic pollutants	10.1016/j.neuro.2022.07.008	meta-analytic and primary estimates not provided
Perfluoroalkyl substances and lipid concentrations in the blood: A systematic review of epidemiological studies	10.1016/j.scitotenv.2022.158036	meta-analytic and primary estimates not provided
Polychlorinated biphenyls and risk of metabolic syndrome and comparison with the risk of diabetes: A systematic review and meta-analysis	10.1016/j.scitotenv.2023.165773	wrong exposure
Pesticides in aquifers from Latin America and the Caribbean	10.1016/j.scitotenv.2023.165992	meta-analytic and primary estimates not provided

Integration of life cycle assessment and system dynamics modeling for environmental scenario analysis: A systematic review	10.1016/j.scitotenv.2023.166545	meta-analytic and primary estimates not provided
A systematic review on the current situation of emerging pollutants in Mexico: A perspective on policies, regulation, detection, and elimination in water and wastewater	10.1016/j.scitotenv.2023.167426	meta-analytic and primary estimates not provided
Exposure to pesticides during pregnancy and the risk of neural tube defects: A systematic review	10.1016/j.scitotenv.2023.169317	meta-analytic and primary estimates not provided
A meta-analysis highlighting the increasing relevance of the hair matrix in exposure assessment to organic pollutants	10.1016/j.scitotenv.2024.170535	meta-analytic and primary estimates not provided
Is exposure to chemical pollutants associated with sleep outcomes? A systematic review	10.1016/j.smrv.2023.101805	meta-analytic and primary estimates not provided
A systematic review of mechanistic studies on the relationship between pesticide exposure and cancer induction	10.1016/j.taap.2022.116280	meta-analytic and primary estimates not provided

Human 2,3,7,8-tetrachlorodibenzo-p-dioxin exposure and thyroid cancer risk	10.1016/j.tox.2023.153474	meta-analytic and primary estimates not provided
Effect of persistent organic pollutants in patients with ischemic stroke and all stroke: A systematic review and meta-analysis	10.1016/j.tox.2023.153567	wrong exposure
Exploring a mechanism-based approach for the identification of endocrine disruptors using Adverse Outcome Pathways (AOPs) and New Approach Methodologies (NAMs) : A perfluorooctane sulfonic acid case study.	10.1016/j.tox.2024.153794	meta-analytic and primary estimates not provided
Sonolysis of per- and poly fluoroalkyl substances (PFAS): A meta-analysis	10.1016/j.ultsonch.2022.105944	meta-analytic and primary estimates not provided
Global patterns and temporal trends of perfluoroalkyl substances in municipal wastewater: A meta-analysis	10.1016/j.watres.2022.118784	meta-analytic and primary estimates not provided
Treatment Options for Pseudoaneurysm After Carotid Endarterectomy: A Systematic Review and Illustrative Case	10.1016/j.wneu.2022.08.124	meta-analytic and primary estimates not provided

Global Exposure to Per- and Polyfluoroalkyl Substances and Associated Burden of Low Birthweight	10.1021/acs.est.1c08669	meta-analytic and primary estimates not provided
Systematic Evidence Mapping of Potential Exposure Pathways for Per- and Polyfluoroalkyl Substances Based on Measured Occurrence in Multiple Media	10.1021/acs.est.2c07185	meta-analytic and primary estimates not provided
Poly- and Perfluoroalkyl Substances in Municipal Wastewater Treatment Plants in the United States: Seasonal Patterns and Meta-Analysis of Long-Term Trends and Average Concentrations	10.1021/acsestwater.1c00377	meta-analytic and primary estimates not provided
Age at menarche and chemical exposure: per- and polyfluoroalkyl substances (PFAS), dichloro-diphenyl-trichloroethane (DDT), dichloro-diphenyl-dichloroethylene (DDE), and polychlorinated biphenyls (PCBs)	10.1080/03014460.2023.2221039	meta-analytic and primary estimates not provided

Maternal pesticide exposure and its relation to childhood cancer: an umbrella review of meta-analyses	10.1080/09603123.2021.1900550	meta-analytic and primary estimates not provided
Endocrine disrupting chemicals and breast cancer: a systematic review of epidemiological studies	10.1080/10408398.2021.1903382	meta-analytic and primary estimates not provided
A critical review on the bioaccumulation, transportation, and elimination of per- and polyfluoroalkyl substances in human beings	10.1080/10643389.2023.2223118	full text not available
The transplacental transfer efficiency of per- and polyfluoroalkyl substances (PFAS): a first meta-analysis	10.1080/10937404.2021.2009946	meta-analytic and primary estimates not provided
Pesticide exposure and risk of cardiovascular disease: A systematic review	10.1080/17441692.2020.1808693	meta-analytic and primary estimates not provided
Association between polychlorinated biphenyl exposure and thyroid hormones: a systematic review and meta-analysis	10.1080/26896583.2022.2149213	wrong exposure
Relationship between Alcohol Co-Ingestion and Clinical Outcome in	10.1093/alcalc/agac045	wrong exposure

Pesticide Self-Poisoning: A Systematic Review and Meta-Analysis		
Public health evaluation of PFAS exposures and breastfeeding: a systematic literature review	10.1093/toxsci/kfad053	full text not available
The environmental and occupational influence of pesticides on male fertility: A systematic review of human studies	10.1111/andr.13228	meta-analytic and primary estimates not provided
Avian colouration in a polluted world: a meta-analysis	10.1111/brv.13067	wrong exposure
Plant-based feed additives in <i>Cyprinus carpio</i> aquaculture	10.1111/raq.12840	meta-analytic and primary estimates not provided
Environmental risk scores of persistent organic pollutants associate with higher ALS risk and shorter survival in a new Michigan case/control cohort	10.1136/jnnp-2023-332121	meta-analytic and primary estimates not provided
Association of Pentachlorophenol with Fetal Risk of Prolonged Bradycardia: A Systematic Review and Meta-Analysis	10.1155/2022/7552294	meta-analytic and primary estimates not provided
Retraction: Association of Pentachlorophenol with	10.1155/2023/9807423	full text not available

Fetal Risk of Prolonged Bradycardia: A Systematic Review and Meta-Analysis (Journal of Healthcare Engineering (2022) 2022 (7552294) DOI: 10.1155/2022/7552294)		
Meta-Analysis of Body Concentration of Polychlorinated Biphenyls and Prostate Cancer	10.1177/07482337221129162	wrong exposure
Systematic review of prenatal exposure to endocrine disrupting chemicals and autism spectrum disorder in offspring	10.1177/13623613211039950	meta-analytic and primary estimates not provided
Environmental health influences in pregnancy and risk of gestational diabetes mellitus: a systematic review	10.1186/s12889-022-13965-5	wrong exposure
Determinants of maternal and neonatal PFAS concentrations: a review	10.1186/s12940-023-00992-x	meta-analytic and primary estimates not provided
Sex difference of pre- and post-natal exposure to six developmental neurotoxicants on intellectual abilities: a systematic review and	10.1186/s12940-023-01029-z	wrong exposure

meta-analysis of human studies		
Human exposure to pesticides and thyroid cancer: a worldwide systematic review of the literatures	10.1186/s13044-023-00153-9	meta-analytic and primary estimates not provided
Environmental and occupational factors and higher risk of couple infertility: a systematic review study	10.1186/s43043-022-00124-4	meta-analytic and primary estimates not provided
Systematic Evidence Map for Over One Hundred and Fifty Per-and Polyfluoroalkyl Substances (PFAS)	10.1289/EHP10343	meta-analytic and primary estimates not provided
Epidemiology Evidence for Health Effects of 150 per- and Polyfluoroalkyl Substances: A Systematic Evidence Map	10.1289/EHP11185	meta-analytic and primary estimates not provided
Metabolic Signatures of Youth Exposure to Mixtures of Per- and Polyfluoroalkyl Substances: A Multi-Cohort Study	10.1289/EHP11372	meta-analytic and primary estimates not provided
Linking Prenatal Environmental Exposures to Lifetime Health with Epigenome-Wide Association Studies: State-	10.1289/EHP12956	meta-analytic and primary estimates not provided

of-the-Science Review and Future Recommendations		
Ecological Toxic Effect of Perfluorinated Compounds on Fish Based on Meta-analysis	10.13227/j.hjkx.202209239	meta-analytic and primary estimates not provided
Indoor residual spraying for the control of visceral leishmaniasis: A systematic review	10.1371/journal.pntd.0010391	meta-analytic and primary estimates not provided
Honey contamination from plant protection products approved for cocoa (Theobroma cacao) cultivation: A systematic review of existing research and methods	10.1371/journal.pone.0280175	meta-analytic and primary estimates not provided
The association between polycystic ovary syndrome and environmental pollutants based on animal and human study; a systematic review	10.1515/reveh-2022-0187	full text not available
Residues of carcinogenic pesticides in food: a systematic review	10.1515/reveh-2022-0253	meta-analytic and primary estimates not provided
Exposure to perfluoroalkyl and polyfluoroalkyl substances and risk of stroke in adults: a meta-analysis	10.1515/reveh-2023-0021	full text not available

Association between exposure to per- and polyfluoroalkyl substances and levels of lipid profile based on human studies	10.1515/reveh-2023-0146	meta-analytic and primary estimates not provided
Concentration of Tetrabromobisphenol-A in fish: systematic review and meta-analysis and probabilistic health risk assessment	10.1515/reveh-2023-0157	full text not available
Early exposure to agricultural pesticides and the occurrence of autism spectrum disorder: a systematic review	10.1590/1984-0462/2023/41/2021360	meta-analytic and primary estimates not provided
Systematic Review: Association of Pesticide Exposure and Child Wheeze and Asthma	10.2174/1573396318666220510124457	meta-analytic and primary estimates not provided
Assessment of endocrine disruptive properties of PFOS: EFSA/ECHA guidance case study utilising AOP networks and alternative methods	10.2903/j.efsa.2022.e200418	meta-analytic and primary estimates not provided
Early-life exposure to endocrine-disrupting chemicals and autistic traits in childhood and adolescence: a systematic	10.3389/fendo.2023.1184546	meta-analytic and primary estimates not provided

review of epidemiological studies		
A tool for screening potentially inappropriate prescribing in Chinese children	10.3389/fphar.2022.1019795	meta-analytic and primary estimates not provided
A Critical Review and Meta-Analysis of Impacts of Per- and Polyfluorinated Substances on the Brain and Behavior	10.3389/ftox.2022.881584	meta-analytic and primary estimates not provided
A systematic review of the evaluation of endocrine-disrupting chemicals in the Japanese medaka (<i>Oryzias latipes</i>) fish	10.3389/ftox.2023.1272368	meta-analytic and primary estimates not provided
The Emergence of Antibiotics Resistance Genes, Bacteria, and Micropollutants in Grey Wastewater	10.3390/app13042322	meta-analytic and primary estimates not provided
Occupational Exposures and Risks of Non-Hodgkin Lymphoma: A Meta-Analysis	10.3390/cancers15092600	meta-analytic and primary estimates not provided
Pesticide research on environmental and human exposure and risks in sub-saharan africa: A systematic literature review	10.3390/ijerph19010259	meta-analytic and primary estimates not provided

Air Pollution and Cognitive Impairment across the Life Course in Humans: A Systematic Review with Specific Focus on Income Level of Study Area	10.3390/ijerph19031405	meta-analytic and primary estimates not provided
Organic Pollutants Associated with Plastic Debris in Marine Environment: A Systematic Review of Analytical Methods, Occurrence, and Characteristics	10.3390/ijerph20064892	meta-analytic and primary estimates not provided
Early-Life Exposure to Perfluoroalkyl Substances (PFAS) and Child Language and Communication Development: A Systematic Review	10.3390/ijerph20247170	meta-analytic and primary estimates not provided
Studying the Impact of Persistent Organic Pollutants Exposure on Human Health by Proteomic Analysis: A Systematic Review	10.3390/ijms232214271	meta-analytic and primary estimates not provided
Impact of Pesticides on Cancer and Congenital Malformation: A Systematic Review	10.3390/toxics10110676	meta-analytic and primary estimates not provided

Per- and Polyfluoroalkyl Substances and Breastfeeding as a Vulnerable Function: A Systematic Review of Epidemiological Studies	10.3390/toxics11040325	meta-analytic and primary estimates not provided
Effects of Dichlorodiphenyltrichloroethane on the Female Reproductive Tract Leading to Infertility and Cancer: Systematic Search and Review	10.3390/toxics11090725	meta-analytic and primary estimates not provided
Emerging Contaminants: An Emerging Risk Factor for Diabetes Mellitus	10.3390/toxics12010047	meta-analytic and primary estimates not provided
A Review of Analytical Methods and Technologies for Monitoring Per- and Polyfluoroalkyl Substances (PFAS) in Water	10.3390/w15203577	meta-analytic and primary estimates not provided
Insights into Organochlorine Pesticides Exposure in the Development of Cardiovascular Diseases: A Systematic Review	10.34172/aim.2023.86	meta-analytic and primary estimates not provided
Prenatal Maternal Risk Factors Contributing to Atopic Dermatitis: A Systematic Review and	10.5021/ad.21.268	meta-analytic and primary estimates not provided

Meta-Analysis of Cohort Studies		
Systematic review of residual toxicity studies of pesticides to bees and veracity of guidance on pesticide labels	10.7717/peerj.16672	meta-analytic and primary estimates not provided
Associations between exposure to organochlorine pesticides and diabetes risk: a systematic review	not reported	full text not available
Investigations on the State of Pops in Ghana, and Human Biomonitoring of Dioxin-like Polychlorinated Biphenyls (Dlpcbs), Polychlorinated, Polybrominated and Mixed Halogenated Dibenzo-p-Dioxins and Furans (PCDD/Fs, PBDD/Fs, and PXDD/Fs) in Vulnerable Ghanaian Populations	not reported	meta-analytic and primary estimates not provided
Investigating the Relationship between Modifiable Environmental Risk Factors and Incidence of Colorectal Cancer: A Community Based Study	not reported	meta-analytic and primary estimates not provided

Comprehensive analysis, Henry's law constant determination, and photocatalytic degradation of polychlorinated biphenyls (PCBs) and/or other persistent organic pollutants (POPs).	not reported	meta-analytic and primary estimates not provided
Chemical pollution, exposome and health in the population of the Canary Islands: a systematic review of the studies carried out and analysis of the situation	not reported	meta-analytic and primary estimates not provided

Data extraction variables

The data was extracted and stored in three .csv files for the extraction variables listed in Tables S3 - S5.

Table S3) List of extracted variables describing bibliometric details of meta-analyses. N/A stands for "Not Applicable".

Items	Description /Instructions	Predefined_options
extractor_initials	Write the initials of the data extractor in capital letters (e.g. KM).	N/A
meta_analysis_id	Use the format "author_year" to create a unique identifier for the meta-analysis (e.g., morrison_2023). If the same author has multiple publications in the same year, add a letter to differentiate them (e.g., morrison_2023a).	N/A

ma_title	Provide the full title of the eligible study being extracted.	N/A
ma_doi	Provide the short form DOI of the eligible study (e.g., 10.32942/X2231N).	N/A
url	Provide the full URL linking to the article (e.g., https://ecoevorxiv.org/repository/view/6169/).	N/A
journal	Provide the full name of the journal or the platform where the data is reported.	N/A
year	Provide the year when the meta-analysis was published.	N/A
programming_langauge	Provide the programming language or software used to conduct the analysis. If not reported state "not reported".	N/A
code_link	Provide the link or the file name to code used to conduct the analysis. If not reported state "not reported".	N/A
references_file	Provide the name of the reference file downloaded from Web of Science provide in the format author_year_refs (e.g., morrison_2025_refs).	N/A

Table S4) List of extracted variables for the meta-analytic summary point estimates and statistical details.

Items	Description/Instructions	Predefined_options
extractor_initials	Write the initials of the data extractor in capital letters (e.g. KM).	N/A
meta_analysis_id	Use the format "*author_year*" to create a unique identifier for the meta-analysis (e.g., morrison_2025). If the same author has multiple publications in the same year, add a letter to differentiate them (e.g., morrison_2025a).	N/A
measurement_id	Use the format "*author_year_m_n*" to create a unique identifier for each measurement in the meta-	N/A

	analysis (e.g., *morrison_2025_m_001*).	
source	Provide the source of the summary point estimate and confidence interval. This may be a figure, table or in external repository.	N/A
model	Provide the model type used to conduct the analysis (e.g., fixed, random or multi-level). If the model type is not reporting state “not reported”.	N/A
variance_estimation_method	Provide the variance estimation method used in the meta-analysis (e.g., restricted maximum likelihood, or DerSimonian and Laird). If the variance estimation method is not provided state “not reported”.	N/A
ma_effect_size_measure	Provide the effect size measure used for meta-analytic summary effect size estimate.	N/A
ma_point_estimate	Provide the point estimate for the meta-analytic summary effect size estimate.	N/A
ma_l_ci	Provide the lower bound of the 95% confidence interval for the meta-analytic summary effect size estimate.	N/A
ma_u_ci	Provide the upper bound of the 95% confidence interval for the meta-analytic summary effect size estimate.	N/A
I_squared	Provide the I^2 value representing heterogeneity for the meta-analytic summary effect size estimate. If I^2 is not reported, state “not reported.”	N/A
tau_square	Provide the τ^2 value representing between-study variance for the meta-analytic summary effect size estimate. If τ^2 is not reported, state “not reported.”	N/A

cochrane_q	Provide the Cochrane Q statistic assessing heterogeneity for the meta-analytic summary effect size estimate. If the Q statistic is not reported, state “not reported.”	N/A

Table S5) List of extracted variables for the primary point estimates, and respective chemicals exposed and associated adverse health outcomes. N/A stands for “Not Applicable”.

Items	Description /Instructions	Predefined_options
measurement_id	Use the format "*author_year_m_n*" to create a unique identifier for each measurement in the meta-analysis (e.g., *morrison_2025_m_001*).	N/A
primary_study_id	Use the format “*author_year_m_n_p_n*” to create a unique identifier for each primary study estimate synthesised in the meta-analysis (e.g., *morrison_2025_m_001_p_001)*.	N/A
identifier	Provide the identifier used in the meta-analysis for the primary study estimate. This may be in multiple formats such as author, author et al., year or a reference.	N/A
primary_author_year	Provide the primary author and year for each included primary study (e.g., *morrison_2025*). This information can typically be derived from the study identifier. Each author–year combination should be unique across the database. If multiple primary studies share the same author–year combination, append a lowercase letter to distinguish them (e.g., *morrison_2025a*).	N/A

primay_doi	Provide the short-form DOI for each primary study. This can be obtained by matching the *author_year* identifier with the corresponding reference. If the primary study is not directly cited, cross-check other instances of the same *author_year* across the meta-analysis. If a match is found, record the corresponding DOI; if no match is identified, state "not reported."	N/A
chemical_class	Provide the chemical class for the exposure chemical in the primary study. These will be organochlorine pesticides, PFAS or, other.	OCP
		PFAS
		other
chemical	Provide the chemical for the exposure chemical in the primary study (e.g., DDT, PFOS, PFOA).	N/A
CAS_number	Provide the Chemical Abstracts Service (CAS) Registry Number for each exposure chemical. The primary source should be the CAS Common Chemistry database (https://commonchemistry.cas.org). If the CAS number is not available in this database, use an alternative reliable source.	N/A
CAS_source	Provide the full URL of the source used to obtain the CAS number.	N/A
impact	Provide the adverse health outcome as stated by the meta-analysis for the synthesised primary study estimate.	N/A
ICD11	Provide the adverse health outcome based on the International Classification of Diseases, 11th Revision (ICD-11), available at https://icd.who.int/browse/2024-01/mms/en. If no relevant outcome	N/A

	can be identified, state "not provided."	
ICD11_code	Provide the corresponding ICD-11 diagnostic code according to the International Classification of Diseases, 11th Revision (ICD-11), available at https://icd.who.int/browse/2024-01/mms/en. If no relevant code can be identified, state "not provided."	N/A
effect_size_estimate	Provide the effect size measure used for the primary study estimate (e.g., odds ratio, standardized mean difference, β regression coefficient).	N/A
point_estimate	Provide the point estimate for the primary study estimate.	N/A
lower_ci	Provide the lower bound of the 95% confidence interval for the primary study estimate.	N/A
upper_ci	Provide the upper bound of the 95% confidence interval for the primary study estimate.	N/A

Supplementary results

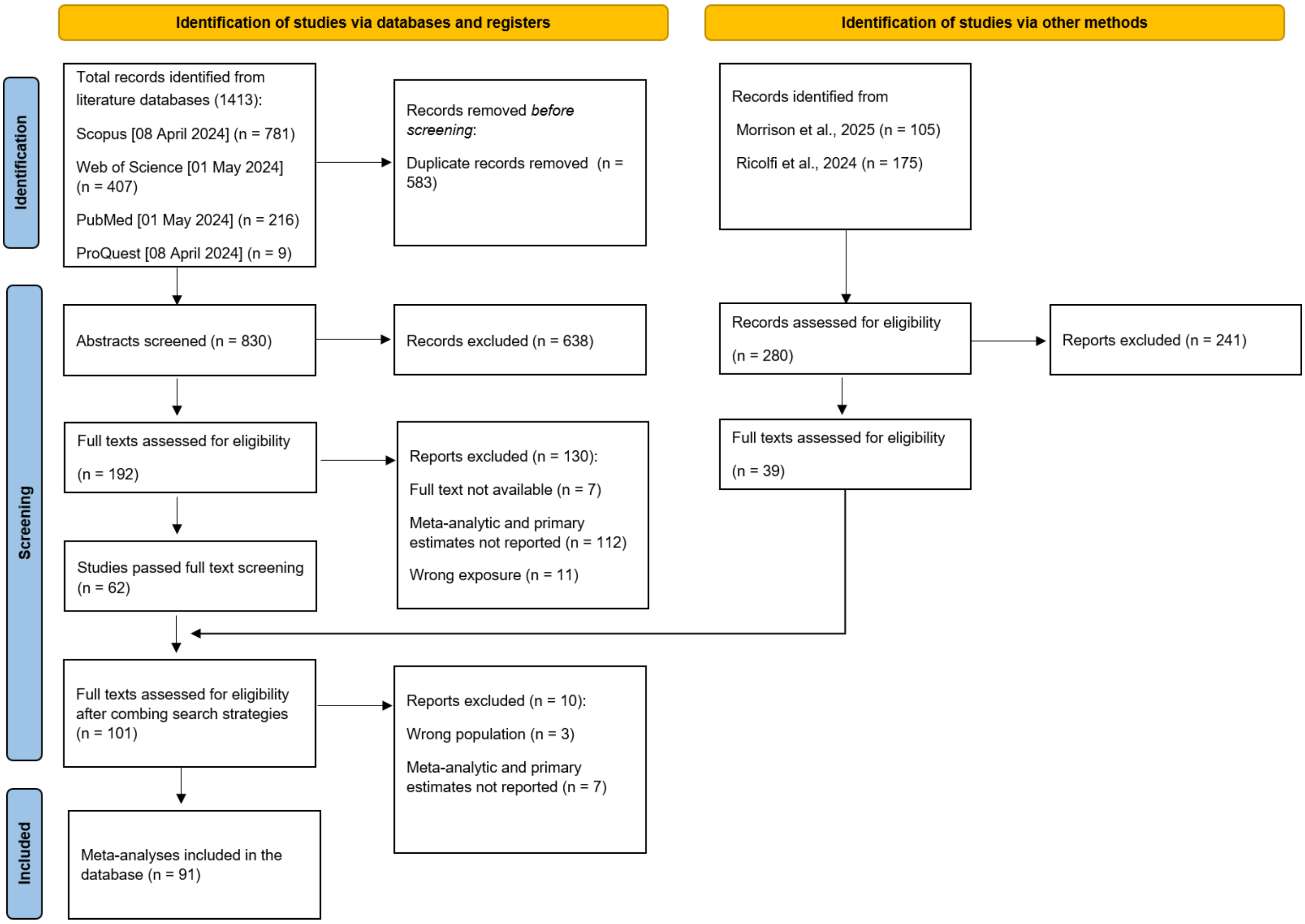

Figure S2) *PRISMA flowchart (Page et al., 2021). Diagram illustrating the study selection process for our second order meta-analysis investigating the associations of PFAS and organochlorine pesticides with adverse human health outcomes from published meta-analyses.*

Section/topic	#	Checklist item	Location(s) Reported
INFORMATION SOURCES AND METHODS			
Database name	1	Name each individual database searched, stating the platform for each.	Literature Search Strategy
Multi-database searching	2	If databases were searched simultaneously on a single platform, state the name of the platform, listing all of the databases searched.	NA
Study registries	3	List any study registries searched.	Literature Search Strategy
Online resources and browsing	4	Describe any online or print source purposefully searched or browsed (e.g., tables of contents, print conference proceedings, web sites), and how this was done.	NA
Citation searching	5	Indicate whether cited references or citing references were examined, and describe any methods used for locating cited/citing references (e.g., browsing reference lists, using a citation index, setting up email alerts for references citing included studies).	Literature Search Strategy
Contacts	6	Indicate whether additional studies or data were sought by contacting authors, experts, manufacturers, or others.	NA
Other methods	7	Describe any additional information sources or search methods used.	NA
SEARCH STRATEGIES			
Full search strategies	8	Include the search strategies for each database and information source, copied and pasted exactly as run.	Supplementary File 1, Scientific Literature Sources
Limits and restrictions	9	Specify that no limits were used, or describe any limits or restrictions applied to a search (e.g., date or time period, language, study design) and provide justification for their use.	Supplementary File 1, Scientific Literature Sources
Search filters	10	Indicate whether published search filters were used (as originally designed or modified), and if so, cite the filter(s) used.	Supplementary File 1, Scientific Literature Sources
Prior work	11	Indicate when search strategies from other literature reviews were adapted or reused for a substantive part or all of the search, citing the previous review(s).	Supplementary File 1, Scientific Literature Sources
Updates	12	Report the methods used to update the search(es) (e.g., rerunning searches, email alerts).	NA
Dates of searches	13	For each search strategy, provide the date when the last search occurred.	Literature Search Strategy
PEER REVIEW			

Peer review	14	Describe any search peer review process.	NA
MANAGING RECORDS			
Total Records	15	Document the total number of records identified from each database and other information sources.	Supplementary File 1, Scientific Literature Sources
Deduplication	16	Describe the processes and any software used to deduplicate records from multiple database searches and other information sources.	Literature Search Strategy

PRISMA-S: An Extension to the PRISMA Statement for Reporting Literature Searches in Systematic Reviews
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