Methodological appendix PlasticHealthAware V1.0

Overview

This is the methodological appendix for PlasticHealthAware V1.0. It describes the methodology used to search for, evaluate, and extract data from references on plastic and human health. Here, the search strategy, PRISMA diagram and list of excluded studies are presented. It also provides the glossary and abbreviations.

Suggested citation for PlasticHealthAware V1.0:

Mulders Y., Cann, S., Carpenter, C., Chiles, T., Kabeya H., Lyons A., Mack, M., Sonn C., Symeonides, C., Thapa K., Dunlop S., Landrigan P. (2025). The Global Observatory on Planetary Health: PlasticHealthAware (Version 1.0). Boston College, Boston. https://plastichealthaware.bc.edu/

Contents

Glossary

Effect size	A quantitative measure of the magnitude of the effect. In this instance, the larger the effect size, the stronger the relationship between the exposure to a plastic-associated chemical/s and a health outcome.
β-coefficient	The degree of change in the outcome variable for every 1-unit of change in the predictor variable, in this case, the plastic-associated chemical.
Fixed effects model	Fixed effects model assumes that the true effect observed is the same in every study and any differences are solely due to random sampling error (chance) within each study. The results can be considered a typical effect.
Random effects model	Random effects model assumes that observed effects follow a distribution (usually normal) and differences are due to both random sampling error (chance) within studies and also variation between studies. The result can be considered an average effect.
General population	A study sample or population that is representative of general population exposure to the chemical of interest (c.f. a special exposure group or a special risk group for exposure). Including both adults and children unless otherwise specified.
Meta-analysis	A statistical technique used to combine the numerical results of 2 or more separate studies of the same research question, in order to derive a single overall estimate.
Odds ratio	A quantitative measure of association between an exposure and an outcome, in this instance a health outcome. The odds ratio represents the odds that an outcome will occur given a particular exposure, compared to the odds of the outcome occurring in the absence of that exposure. Odds ratios are most commonly used in case-control studies; however, they can also be used in cross-sectional and cohort study designs. Odds ratios > 1 indicate that an exposure is harmful; < 1 indicates a protective effect.
Risk ratio	A quantitative measure of association comparing the risk of a health outcome among one group with the risk among another group in this instance the groups being differentiated by exposure to plastic-associated chemicals. Calculated by

dividing the risk in one group by the risk in the comparison group. A risk ratio of 1 indicated identical risk in both groups. A risk ratio > 1 indicates and increased risk, usually in the more highly exposed group; a risk ratio <1 indicates a decreased risk.

Abbreviations

Chemicals

Bisphenols

BPA	Bisphenol A
BPS	Bisphenol S
BPF	Bisphenol F

Phthalates and metabolites

ΣDEHP	Sum of all measured DEHP metabolites
BBP	Butyl benzyl phthalate
DEP	Diethyl phthalate
DEHP	Di (2-ethylhexyl) phthalate
DEHP met.	Di (2-ethylhexyl) phthalate metabolites
DiBP	Diisobutyl phthalate
DnBP	Di-n-butyl phthalate
MBzP	Monobenzyl phthalate
MECPP	Mono (2-ethyl-5-carboxypentyl) phthalate
MEHP	Mono (2-ethylhexyl) phthalate
MEHHP	Mono (2-ethyl-5-hydroxyhexyl) phthalate
MEOHP	Mono (2-ethyl-5-oxohexyl) phthalate
MEP	Monoethyl phthalate
MiBP	Monoisobutyl phthalate
MMP	Monomethyl phthalate
MnBP	Mono-n-butyl phthalate

Flame retardants

PBB	Polybrominated biphenyl
PBDEs	Polybrominated diphenyl ethers
PCBs	Polychlorinated biphenyls (and individual PCB congeners, e.g. PCB 99, PCB 105, PCB 183, PCB 187)
PCB classes I, II, III	Functional classes of PCBs based on structural and biological considerations [1]

Per- and Polyfluoroalkyl Substances

PFAS	Per- and Polyfluoroalkyl Substances
PFHxS	Perfluorohexane sulfonate
PFNA	Perfluorononanoic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
PFBS	Perfluorobutanesulfonic acid
PFDA	Perfluorodecanoic acid
PFDoDA	Perfluorododecanoic acid
PFHpA	Perfluoroheptanoic acid
PFHpS	Perfluoroheptanesulfonic acid
PFHxA	Perfluorohexanoic acid

Health outcomes

AGD	Anogenital distance
CE	Comet extent
ADHD	Attention deficit hyperactive disorder
ApoB	Apolipoprotein B
ASD	Autism spectrum disorder
Bayley-III	Bayley Scales of Infant and Toddler Development, 3rd ed
BMI	Body mass index
BSID-II	Bayley Scales of Infant Development, 2nd ed
CBCL	Child Behaviour Checklist
CVD	Cardiovascular disease
DBP	Diastolic blood pressure
DLBCL	Diffuse large B-cell lymphoma
DSM-IV	Diagnostic and Statistical Manual of Mental Disorder, 4th ed
FL	Follicular lymphoma
FSIQ	Full Scale IQ
fT4	Free thyroxine
GCS	General Cognitive Scale
HDL	High-density lipoprotein
HOMA-IR	Homeostatic Model Assessment for Insulin Resistance
IQ	Intelligence quotient
LDL	Low-density lipoprotein
LIN	Linearity
MDI	Mental Development Index

MSCA	McCarthy Scales of Children's Abilities
NHL	Non-Hodgkin’s lymphoma
PCOS	Polycystic ovary syndrome
PDI	Psychomotor Development Index
SBP	Systolic blood pressure
SDQ	Strengths and Difficulties Questionnaire
SPL	Spontaneous pregnancy loss
T2D	Type 2 diabetes mellitus
T3	Triiodothyronine
Tail%	Percent of DNA in tail
TC	Total cholesterol
TDM	Tail distributed moment
TG	Triglycerides
TSH	Thyroid stimulating hormone
TT4	Total thyroxine
VCL	Curvilinear velocity
VSL	Straight line velocity
WISC	Wechsler Intelligence Scale for Children
WPPSI	Wechsler Preschool & Primary Scale of Intelligence

Other

AMSTAR	Assessment MeaSurement Tool for the Analysis of Systematic Reviews
EE	Effect estimates
ICD-11	International Classification of Diseases, 11th revision
IRIS	Integrated Risk Information System
MD	Mean difference
MMT	Million metric tonnes
MOOSE	Meta-analysis of Observational Studies in Epidemiology
NIAS	Non-intentionally added substances
OHAT	Office of Health Assessment and Translation
OR	Odds ratio
PECO	Population Exposure Comparator Outcome
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
RR	Relative risk
SMD	Standardised mean difference
SMR	Standardised mortality ratios

Methodology

We followed established umbrella review methods[2] expanding on the work published by Symeonides et al. (2024).[3] We used vote counting and harvest plots to assimilate the large and diverse data on plastic and plastic-associated chemical exposure and human health outcomes across the lifespan. A glossary of chemical abbreviations used is available in the Glossary section above.

Search strategy

PubMed was searched on 23 August 2023 (see Search Strategy section below). Search filters employed a combination of terms (and indexing terms in PubMed). We included broad terms such as "plastic" alongside terms relating to functional terminology such as "plasticiser/plasticizer" and "flame retardant". We also included common-use terminology and abbreviations such as ”phthalates” and "PVC", and technical chemical terminology such as 4,4'-isopropylidenediphenol (bisphenol A) and di (2-ethylhexyl) phthalate (DEHP). Search terms encompassed microplastic particles; nanoplastics were not separately searched because reliable analytical techniques to quantify individual human exposure to these smaller particles, and therefore the opportunities for direct observational research, are not yet available. For plastic polymers, all major commodity polymers were considered: polyethylene, polypropylene, polyethylene terephthalate, polyvinyl chloride, polycarbonates, polystyrene, nylon(s), and fluoropolymers including polytetrafluoroethylene. For plasticisers and flame retardants, our search terms were selected to capture all major chemical classes,[4] including: (ortho- and tere-) phthalates, cyclohexanoates, adipates, sebacates, trimellitates, dibenzoates, citrate esters, organophosphate esters (OPEs), PCBs, PBDEs, polybrominated biphenyls (PBBs). We also included a range of specific and general terms to capture other plasticisers or flame retardants not included in these major classes (decabromodiphenyl ethane, hexabromocyclododecane, any other polybrominated or polychlorinated chemicals, and melamine polyphosphate). Bisphenols and PFAS were separately searched using a range of terms capturing common-use and technical terminology for these classes, and major chemicals within these classes. We also used specific search terms for flame retardant bisphenols such as the halogenated bisphenol tetrabromobisphenol A and the

organophosphate bisphenol A diphenyl phosphate. Anything published before 26th of August 2020 was assumed to have been included in the original Umbrella Review,[3] and not included in this search window. Filters were applied to both databases to limit to systematic reviews. Grey literature was not included.

Eligibility criteria

Eligibility criteria were aligned to the population, exposure, comparator, outcome (PECO) framework.[5] We thus captured meta-analyses (i.e. systematic reviews with meta-analyses, meta-analyses and pooled analyses) of studies that evaluated the association between exposure to plastic particles and plastic-associated chemicals and human health outcomes. This included environmental as well as occupational exposure and poisoning. We also captured any human health outcome irrespective of age. Participants could be healthy or have pre-existing illness.

Meta-analyses examining exposure to other additives, e.g. antimicrobials, antioxidants, antistatic agents, fillers, processing agents, and UV, light and heat stabilisers, or combined exposures were excluded. Meta-analyses that included studies investigating endocrine disrupting chemicals that included plastic polymers or additives were eligible for inclusion, but only if evaluated separately from chemicals that were not plastic related.

We included any analysis with comparisons of plastic-associated chemical exposure, including high versus low, any versus none, and any linear or non-linear dose responses. Meta-analyses of studies were ineligible if they included studies where measures of exposure were indirect (e.g. questionnaire-based surveys, dust), where exposure was attributable to an occupation in plastic manufacturing or fossil fuel extraction, or in the presence of a medical, surgical or dental device such as a prosthesis or implant. If an article presented separate meta-analyses for more than one health outcome (and any combination of exposures), we included each of these separately, recording whether extracted estimates related to the primary analysis (or analyses) of the paper, or related to a secondary analysis. Articles that did not present a meta-analysis or statistical combination of multiple studies for a health outcome, with a measure such as relative risks (RR), odds ratios (OR), or regression coefficients, were ineligible. Analyses of

composite exposure to a group of plastic-associated chemicals were included, as well as subgroup analyses investigating individual chemicals (such as total phthalates and individual phthalate diesters or total PCBs and specific PCB congeners). Other subgroups that further investigated population differences (age, gender) and differences in measurement of exposure (e.g. serum, urine) aligned to the main analyses of the included reviews were also included. Only reviews and analyses published in English were included.

Selection and assessment of methodological quality

Citations from database searching were uploaded into DistillerSR and duplicates removed. Titles and abstracts of remaining records were subsequently screened independently by two reviewers (YM, CS) considering the eligibility criteria. Full text of potentially relevant reviews and syntheses were retrieved and reviewed (YM, CS); where necessary, inclusion was determined by discussion between reviewers.

Methodological quality of eligible reviews, meta-analyses and pooled analyses was independently assessed by two reviewers (YM, AL, HK). Umbrella review methodology appraises the quality of reporting of the systematic review, and not directly the quality of the primary research included therein. We used the AMSTAR tool,[6] an 11-item checklist designed to assess methodological quality of systematic reviews of interventions. AMSTAR has been shown to be a reliable and valid tool for quality assessment of systematic reviews and meta-analyses of observational research.[7] AMSTAR was selected for continuity with the original Umbrella review, and due to more rapid completion and greater inter-rater reliability to mitigate multiple appraisers involved rather than other tools.[8] We established an arbitrary categorisation system to convey the appraisal findings: AMSTAR scores of 9-11 were rated as high quality (low risk of bias), 6-8 as moderate quality, and less than 6 as low quality (high risk of bias). For expedience, the AMSTAR tool was also used to assess the quality of included pooled analyses. Because pooled analyses lack many design features inherent in a systematic review,[9] we therefore scored them universally as 'low' in the quality appraisal.

Data extraction

Data were extracted from the included reviews using a structured form DistillerSR, tailored to prompt retrieval of relevant information. Data extraction was performed in duplicate by 2 independent members of the review team (YM, AL, HK) and all data conflicts were resolved by discussion or input from a senior reviewer (YM, CS). All data were extracted exactly as reported in the source publications, making no adjustments for number of decimal points, or suspected extraction errors from the primary literature.

Data summary and presentation

Health outcomes assessed with meta-analyses were aligned to corresponding chapters in the International Classification of Diseases, ICD-11 (https://icd.who.int/en). Considering the wide range of exposures, outcomes and outcome measures identified, it was not possible to estimate overall EE and therefore no further statistical meta-analysis of findings was considered.[2,10]

To synthesise data and establish evidence of effect across a large heterogeneous data set, we used vote counting with harvest plots.[10] The bars in the harvest plots represent individual EE (main or subgroup), placed on a matrix to indicate whether exposure to the plastic-associated chemical had a negative (decreased, left-hand column) or positive (increased, right-hand column) influence on the outcome based on the EE (point) reported. Where there was no influence, the direction of any non-significant effect is indicated as an increase (>), no change (-), or a decrease (<) in the measure or risk estimate (centre column)[10]. Effect size is not portrayed within the hover box for each bar, and in the table below.

Search Strategy

PubMed search (23 August 2023)

Plastics and plastic polymers	"plastics"[mh:noexp] OR plastic*[tiab] OR "microplastics"[mh] OR microplastic*[tiab] OR "polyethylenes"[mh] OR polyethylene*[tiab] OR "polypropylenes"[mh] OR polypropylene*[tiab] OR "polystyrenes"[mh] OR polystyrene*[tiab] OR "polyvinyl chloride"[mh] OR polyvinyl chloride*[tiab] OR polycarbonate*[tiab] OR teflon[tiab] OR nylon[tiab] OR "plasticizers"[mh] OR "flame retardants"[mh] OR "endocrine disruptors"[mh] OR endocrine disrupt*[tiab]
Plastic-associated chemicals	
Bisphenols	bisphen*[tiab] OR diphen*[tiab] OR BPA[tiab] OR 4,4'-isopropylidenediphenol[tiab] OR “2,2-Bis(4-hydroxyphenyl)propane”[tiab] OR Diphenylolpropane[tiab] OR “4,4'-(propane-2,2-diyl)diphenol”[tiab]
Plasticisers	plasticiser*[tiab] OR plasticizer*[tiab] OR phthalate*[tiab] OR phthalic acid[tiab] OR orthophthal*[tiab] OR ortho-phthal*[tiab] OR “benzene-1,2-dicarboxy”[tiab] OR benzenedicarboxy*[tiab] OR DEHP[tiab] OR terephthalate*[tiab] OR adipate*[tiab] OR sebacate*[tiab] OR trimellitate*[tiab] OR tricresyl*[tiab] OR cresyldiphenyl*[tiab] OR cyclohexanoate*[tiab] OR dibenzoate*[tiab] OR Acetyl tributyl citrate[tiab]
Flame retardants & PFAS	flame retardant*[tiab] OR fire retardant*[tiab] OR fireproof[tiab] OR polychlorinated biphenyl*[tiab] OR PCBs[tiab] OR polychlorinated biphenyl*[tiab] OR tetradecachloro*[tiab] OR "polybrominated biphenyl"[tiab] OR polybrominated biphenyl*[tiab] OR Polybrominated Diphenyl Ether*[tiab] OR PBDEs[tiab] OR polybrom*[tiab] OR decabromo*[tiab] OR hexabromocyclododecan*[tiab] OR "HBCD"[tiab] OR tetrabromobisphenol*[tiab] OR TBBPA[tiab] OR TBBP[tiab] OR tetrabrom*[tiab] OR organophosphate ester*[tiab] OR triphenyl phosphate*[tiab] OR Triphenylphosphate*[tiab] OR triphenyl ester*[tiab] OR "tricresyl"[tiab] OR trixylyl*[tiab] OR trixylenyl*[tiab] OR tris(2-chloroethyl)phosphate[tiab] OR TCEP[tiab] OR tris(chloropropyl)phosphate[tiab] OR TCPP[tiab] OR tris(1,3-dichloro-2-propyl)phosphate*[tiab] OR TDCPP[tiab] OR resorcinol bis*[tiab] OR RDP[tiab] OR bisphenol A diphenyl phosphate[tiab] OR BADP[tiab] OR melamine polyphosphate*[tiab] OR diphenylcresylphosphate*[tiab] OR Tetrachlorophthal*[tiab] OR fluoropolymer*[tiab] OR Polyfluor*[tiab] OR Perfluor*[tiab] OR PFOA[tiab] OR PFOS[tiab] OR PFS[tiab] OR hexafluoropropylene*[tiab] OR GENX[tiab] OR polytetrafluoroethylene*[tiab] OR PTFE[tiab]
Systematic review/ meta-analysis	AND (Systematic review [sb] OR meta-analysis)
Limits	NOT surgery

PRISMA

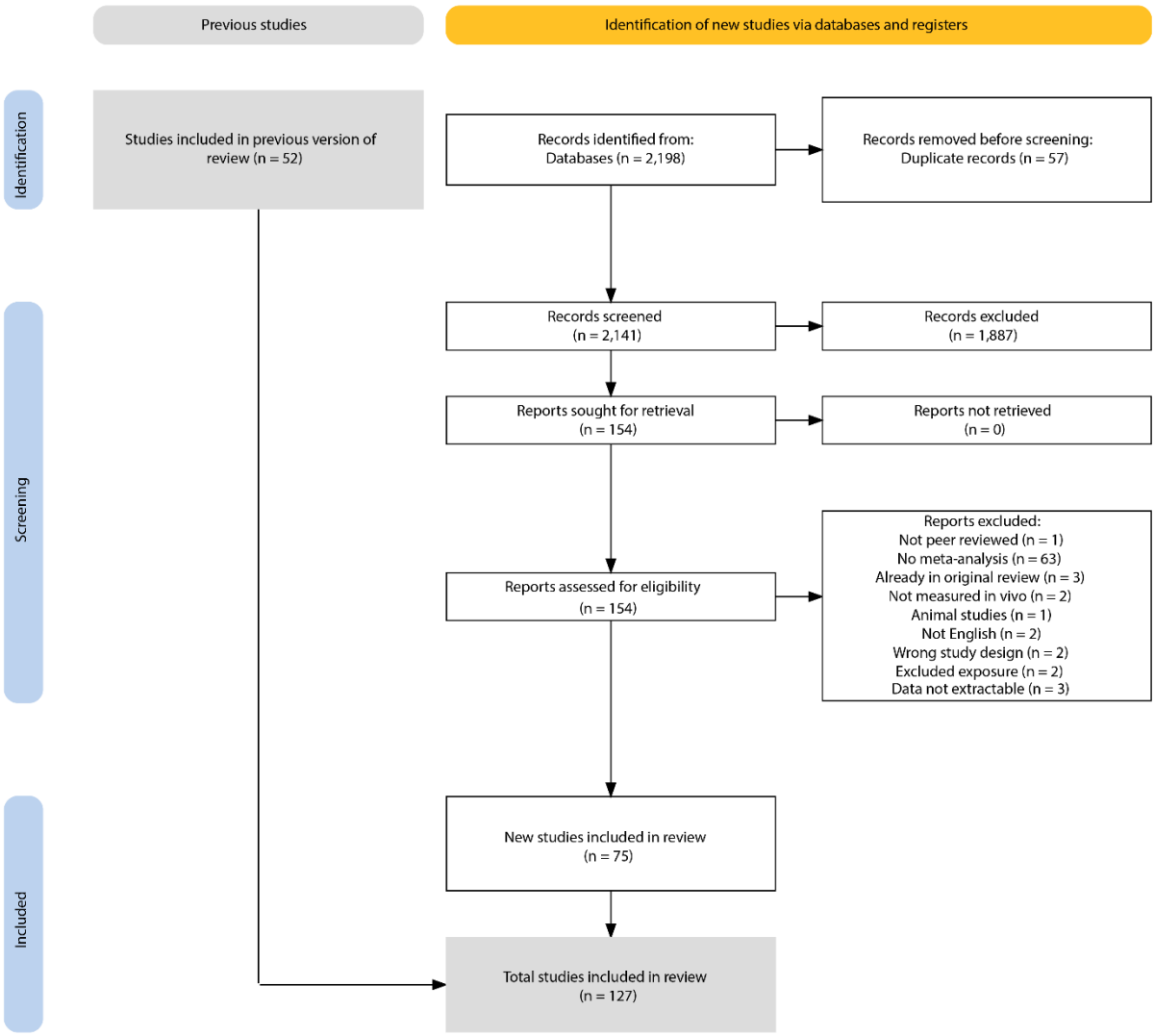

Figure 1: PRISMA diagram presenting process of study identification, selection and final inclusion in the PlasticHealthAware dashboard.

Excluded studies list

Table 1. References excluded after full text assessment against eligibility criteria

Reference	Reason for Exclusion
(RefID: 1992) Abulehia, H. F. S.; Mohd Nor, N. S.; Sheikh Abdul Kadir, S. H. (2022). *The Current Findings on the Impact of Prenatal BPA Exposure on Metabolic Parameters: In Vivo and Epidemiological Evidence*	No meta-analysis
(RefID: 1993) Ataei, Y.; Sun, Y.; Liu, W.; S. Ellie A; Dong, H.; Ahmad, U. M. (2022). *Health Effects of Exposure to Indoor Semi-Volatile Organic Compounds in Chinese Building Environment: A Systematic Review*	No meta-analysis
(RefID: 2056) Azizi, M.; Mami, S.; Noorimotlagh, Z.; Mirzaee, S. A.; Silva Martinez, S.; Bazgir, N. (2023). *The role of polybrominated diphenyl ethers in the induction of cancer: a systematic review of insight into their mechanisms*	No meta-analysis
(RefID: 1994) Bertoletti, A. C. C.; Peres, K. K.; Faccioli, L. S.; Vacci, M. C.; Mata, I. R. D.; Kuyven, C. J.; Bosco, S. M. D. (2022). *Early exposure to agricultural pesticides and the occurrence of autism spectrum disorder: a systematic review*	No meta-analysis
(RefID: 2057) Bigambo, F. M.; Sun, H.; Yan, W.; Wu, D.; Xia, Y.; Wang, X.; Wang, X. (2020). *Association between phenols exposure and earlier puberty in children: A systematic review and meta-analysis*	Already in original review
(RefID: 1995) Bousoumah, R.; Leso, V.; Iavicoli, I.; Huuskonen, P.; Viegas, S.; Porras, S. P.; Santonen, T.; Frery, N.; Robert, A.; Ndaw, S. (2021). *Biomonitoring of occupational exposure to bisphenol A, bisphenol S and bisphenol F: A systematic review*	No meta-analysis
(RefID: 1996) Caporossi, L.; Capanna, S.; Viganò, P.; Alteri, A.; Papaleo, B. (2021). *From Environmental to Possible Occupational Exposure to Risk Factors: What Role Do They Play in the Etiology of Endometriosis?*	No meta-analysis
(RefID: 1997) Caserta, D.; De Marco, M. P.; Besharat, A. R.; Costanzi, F. (2022). *Endocrine Disruptors and Endometrial Cancer: Molecular Mechanisms of Action and Clinical Implications, a Systematic Review*	No meta-analysis
(RefID: 1998) Cho, Y. M.; Cho, Y. M.; Choi, K. H. (2021). *The current status of studies of human exposure assessment of microplastics and their health effects: A rapid systematic review*	No meta-analysis
(RefID: 2074) Costello, E.; Rock, S.; Stratakis, N.; Eckel, S. P.; Walker, D. I.; Valvi, D.; Cserbik, D.; Jenkins, T.; Xanthakos, S. A.; Kohli, R.; Sisley, S.; Vasiliou, V.; La Merrill, M. A.; Rosen, H.; Conti, D. V.; McConnell, R.; Chatzi,	Data not in extractable format

L. (2022). *Exposure to per- and Polyfluoroalkyl Substances and Markers of Liver Injury: A Systematic Review and Meta-Analysis*	
(RefID: 1999) Cunha, Y. G. O.; do Amaral, G. C. B.; Felix, A. A.; Blumberg, B.; Amato, A. A. (2023). *Early-life exposure to endocrine-disrupting chemicals and autistic traits in childhood and adolescence: a systematic review of epidemiological studies*	No meta-analysis
(RefID: 2000) Dehghani, F.; Yousefinejad, S.; Walker, D. I.; Omidi, F. (2022). *Metabolomics for exposure assessment and toxicity effects of occupational pollutants: current status and future perspectives*	No meta-analysis
(RefID: 2077) Dev, P.; Chakravarty, K.; Pandey, M.; Ranjan, R.; Cyriac, M.; Mishra, V. N.; Pathak, A. (2023). *Effect Of Persistent Organic Pollutants In Patients With Ischemic Stroke And All Stroke: A Systematic Review And Meta-Analysis*	Not included exposure
(RefID: 2001) Dreshaj, D.; Pasha, F. (2021). *Overview of the content of bisphenol a in the amniotic fluid of pregnant women and its adverse health outcomes*	No meta-analysis
(RefID: 2002) Eberle, C.; Stichling, S. (2022). *Environmental health influences in pregnancy and risk of gestational diabetes mellitus: a systematic review*	No meta-analysis
(RefID: 2003) Ehrlich, V.; Bil, W.; Vandebriel, R.; Granum, B.; Luijten, M.; Lindeman, B.; Grandjean, P.; Kaiser, A. M.; Hauzenberger, I.; Hartmann, C.; Gundacker, C.; Uhl, M. (2023). *Consideration of pathways for immunotoxicity of per- and polyfluoroalkyl substances (PFAS)*	No meta-analysis
(RefID: 2004) Ermler, S.; Kortenkamp, A. (2022). *Systematic review of associations of polychlorinated biphenyl (PCB) exposure with declining semen quality in support of the derivation of reference doses for mixture risk assessments*	No meta-analysis
(RefID: 2058) Farahani, M.; Rezaei-Tavirani, M.; Arjmand, B. (2021). *A systematic review of microRNA expression studies with exposure to bisphenol A*	No meta-analysis
(RefID: 2005) Fauconnier, M. B.; Albert, C.; Tondreau, A.; Maumy, L.; Rouzier, R.; Bonneau, C. (2023). *[Bisphenol A and breast cancer: State of knowledge and meta-analysis]*	Not English
(RefID: 2006) Ferrante, M.; Cristaldi, A.; Oliveri Conti, G. (2021). *Oncogenic Role of miRNA in Environmental Exposure to Plasticizers: A Systematic Review*	No meta-analysis
(RefID: 2007) Fowler, C. H.; Bagdasarov, A.; Camacho, N. L.; Reuben, A.; Gaffrey, M. S. (2022). *Toxicant exposure and the developing brain: A systematic review of the structural and functional MRI literature*	No meta-analysis

(RefID: 2008) Gan, H.; Zhang, Y.; Wang, Y. F.; Tao, F. B.; Gao, H. (2023). *Relationships of prenatal organophosphate ester exposure with pregnancy and birth outcomes: A systematic scoping review of epidemiological studies*	No meta-analysis
(RefID: 2009) Gao, H.; Wang, Y. F.; Wang, Z. W.; Wang, Y.; Tao, F. B. (2022). *Prenatal phthalate exposure associated with age-specific alterations in markers of adiposity in offspring: A systematic review*	No meta-analysis
(RefID: 2010) Gao, H.; Zhang, C.; Tao, F. B. (2021). *Association between prenatal phthalate exposure and gestational metabolic syndrome parameters: a systematic review of epidemiological studies*	No meta-analysis
(RefID: 2011) Gao, X. X.; Zuo, Q. L.; Fu, X. H.; Song, L. L.; Cen, M. Q.; Wu, J. (2023). *Association between prenatal exposure to per- and polyfluoroalkyl substances and neurodevelopment in children: Evidence based on birth cohort*	No meta-analysis
(RefID: 2012) Ghanati, K.; Jahanbakhsh, M.; Shakoori, A.; Aghebat-Bekheir, S.; Khalili-Rikabadi, A.; Sadighara, P. (2023). *The association between polycystic ovary syndrome and environmental pollutants based on animal and human study; a systematic review*	No meta-analysis
(RefID: 2059) Guillotin, S.; Delcourt, N. (2022). *Studying the Impact of Persistent Organic Pollutants Exposure on Human Health by Proteomic Analysis: A Systematic Review*	No meta-analysis
(RefID: 2013) Guo, J.; Liu, K.; Yang, J.; Su, Y. (2023). *Prenatal exposure to bisphenol A and neonatal health outcomes: A systematic review*	No meta-analysis
(RefID: 2014) Guo, P.; Furnary, T.; Vasiliou, V.; Yan, Q.; Nyhan, K.; Jones, D. P.; Johnson, C. H.; Liew, Z. (2022). *Non-targeted metabolomics and associations with per- and polyfluoroalkyl substances (PFAS) exposure in humans: A scoping review*	No meta-analysis
(RefID: 2015) Heilmann, N. Z.; Reeves, K. W.; Hankinson, S. E. (2022). *Phthalates and bone mineral density: a systematic review*	No meta-analysis
(RefID: 2016) Ho, S. H.; Soh, S. X. H.; Wang, M. X.; Ong, J.; Seah, A.; Wong, Y.; Fang, Z.; Sim, S.; Lim, J. T. (2022). *Perfluoroalkyl substances and lipid concentrations in the blood: A systematic review of epidemiological studies*	No meta-analysis
(RefID: 2060) Kahn, L. G.; Harley, K. G.; Siegel, E. L.; Zhu, Y.; Factor-Litvak, P.; Porucznik, C. A.; Klein-Fedyshin, M.; Hipwell, A. E. (2021). *Persistent organic pollutants and couple fecundability: a systematic review*	No meta-analysis
(RefID: 2017) Kolan, A. S.; Hall, J. M. (2023). *Association of Preterm Birth and Exposure to Endocrine Disrupting Chemicals*	Wrong study design

(RefID: 2018) Kortenkamp, A.; Martin, O.; Ermler, S.; Baig, A.; Scholze, M. (2022). *Bisphenol A and declining semen quality: A systematic review to support the derivation of a reference dose for mixture risk assessments*	No meta-analysis
(RefID: 2019) Koutaki, D.; Paltoglou, G.; Vourdoumpa, A.; Charmandari, E. (2021). *The Impact of Bisphenol A on Thyroid Function in Neonates and Children: A Systematic Review of the Literature*	No meta-analysis
(RefID: 2135) Lee, J.; Kim, J.; Zinia, S. S.; Park, J.; Won, S.; Kim, W. J. (2023). *Prenatal phthalate exposure and cord blood DNA methylation*	Data not in extractable format
(RefID: 2020) Lee, Y. J.; Jung, H. W.; Kim, H. Y.; Choi, Y. J.; Lee, Y. A. (2021). *Early-Life Exposure to Per- and Poly-Fluorinated Alkyl Substances and Growth, Adiposity, and Puberty in Children: A Systematic Review*	No meta-analysis
(RefID: 2094) Liao, Y. C.; Xu, Y. J.; Chen, J. K.; Boonhat, H.; Su, B. Y.; Lin, Y. C.; Lin, R. T. (2023). *Sex differences in children's cognitive functions and phthalates exposure: a meta-analysis*	Data not in extractable format
(RefID: 2061) Liu, W.; Sun, Y.; Liu, N.; Hou, J.; Huo, X.; Zhao, Y.; Zhang, Y.; Deng, F.; Kan, H.; Zhao, Z.; Huang, C.; Zhao, B.; Zeng, X.; Qian, H.; Zheng, X.; Liu, W.; Mo, J.; Sun, C.; Su, C.; Zou, Z.; Li, H.; Guo, J.; Bu, Z. (2022). *Indoor exposure to phthalates and its burden of disease in China*	Not measured in vivo
(RefID: 2100) Luo, Y.; Deji, Z.; Huang, Z. (2020). *Exposure to Perfluoroalkyl Substances and Allergic Outcomes in Children: A Systematic Review and Meta-Analysis*	Already in original review
(RefID: 2062) Macedo, S.; Teixeira, E.; Gaspar, T. B.; Boaventura, P.; Soares, M. A.; Miranda-Alves, L.; Soares, P. (2023). *Endocrine-disrupting chemicals and endocrine neoplasia: A forty-year systematic review*	No meta-analysis
(RefID: 2022) Martin, O.; Scholze, M.; Ermler, S.; McPhie, J.; Bopp, S. K.; Kienzler, A.; Parissis, N.; Kortenkamp, A. (2021). *Ten years of research on synergisms and antagonisms in chemical mixtures: A systematic review and quantitative reappraisal of mixture studies*	No meta-analysis
(RefID: 2023) Martínez-Martínez, M. I.; Alegre-Martínez, A.; Cauli, O. (2021). *Prenatal exposure to phthalates and its effects upon cognitive and motor functions: A systematic review*	No meta-analysis
(RefID: 2021) Marí-Bauset, S.; Peraita-Costa, I.; Donat-Vargas, C.; Llopis-González, A.; Marí-Sanchis, A.; Llopis-Morales, J.; Morales Suárez-Varela, M. (2021). *Systematic review of prenatal exposure to endocrine disrupting chemicals and autism spectrum disorder in offspring*	No meta-analysis

(RefID: 2024) Mohammadparast-Tabas, P.; Arab-Zozani, M.; Naseri, K.; Darroudi, M.; Aramjoo, H.; Ahmadian, H.; Ashrafipour, M.; Farkhondeh, T.; Samarghandian, S. (2023). *Polychlorinated biphenyls and thyroid function: a scoping review*	Animal studies
(RefID: 2025) Mohanto, N. C.; Ito, Y.; Kato, S.; Kamijima, M. (2021). *Life-Time Environmental Chemical Exposure and Obesity: Review of Epidemiological Studies Using Human Biomonitoring Methods*	No meta-analysis
(RefID: 2063) Mousavi, S. E.; Delgado-Saborit, J. M.; Adivi, A.; Pauwels, S.; Godderis, L. (2022). *Air pollution and endocrine disruptors induce human microbiome imbalances: A systematic review of recent evidence and possible biological mechanisms*	No meta-analysis
(RefID: 2026) Mustieles, V.; Balogh, R. K.; Axelstad, M.; Montazeri, P.; Márquez, S.; Vrijheid, M.; Draskau, M. K.; Taxvig, C.; Peinado, F. M.; Berman, T.; Frederiksen, H.; Fernández, M. F.; Marie Vinggaard, A.; Andersson, A. M. (2023). *Benzophenone-3: Comprehensive review of the toxicological and human evidence with meta-analysis of human biomonitoring studies*	Not included exposure
(RefID: 2027) National Toxicology, Program (2018). *Report on Carcinogens Monograph on Antimony Trioxide: RoC Monograph 13*	Not published in peer reviewed journal
(RefID: 2028) Peinado, F. M.; Iribarne-Durán, L. M.; Artacho-Cordón, F. (2023). *Human Exposure to Bisphenols, Parabens, and Benzophenones, and Its Relationship with the Inflammatory Response: A Systematic Review*	No meta-analysis
(RefID: 2029) Praveena, S. M.; Munisvaradass, R.; Masiran, R.; Rajendran, R. K.; Lin, C. C.; Kumar, S. (2020). *Phthalates exposure and attention-deficit/hyperactivity disorder in children: a systematic review of epidemiological literature*	No meta-analysis
(RefID: 2030) Prueitt, R. L.; Hixon, M. L.; Fan, T.; Olgun, N. S.; Piatos, P.; Zhou, J.; Goodman, J. E. (2023). *Systematic review of the potential carcinogenicity of bisphenol A in humans*	No meta-analysis
(RefID: 2031) Pulvirenti, E.; Ferrante, M.; Barbera, N.; Favara, C.; Aquilia, E.; Palella, M.; Cristaldi, A.; Conti, G. O.; Fiore, M. (2022). *Effects of Nano and Microplastics on the Inflammatory Process: In Vitro and In Vivo Studies Systematic Review*	No meta-analysis
(RefID: 2032) Rivera-Núñez, Z.; Kinkade, C. W.; Zhang, Y.; Rockson, A.; Bandera, E. V.; Llanos, A. A. M.; Barrett, E. S. (2022). *Phenols, Parabens, Phthalates and Puberty: a Systematic Review of Synthetic Chemicals Commonly Found in Personal Care Products and Girls' Pubertal Development*	No meta-analysis

(RefID: 2033) Romo-Huerta, M. J.; Cervantes-Urenda AÉ, D. R.; Velasco-Neri, J.; Torres-Bugarín, O.; Valdivia AÉ, D. C. M. (2021). *Genotoxicity Associated with Residual Monomers in Restorative Dentistry: A Systematic Review*	No meta-analysis
(RefID: 2035) Schell, L. M.; West, C. N. (2023). *Age at menarche and chemical exposure: per- and polyfluoroalkyl substances (PFAS), dichloro-diphenyl-trichloroethane (DDT), dichloro-diphenyl-dichloroethylene (DDE), and polychlorinated biphenyls (PCBs)*	No meta-analysis
(RefID: 2036) Seymore, T. N.; Rivera-Núñez, Z.; Stapleton, P. A.; Adibi, J. J.; Barrett, E. S. (2022). *Phthalate exposures and placental health in animal models and humans: a systematic review*	No meta-analysis
(RefID: 2037) Sharma, P.; Bilkhiwal, N.; Chaturvedi, P.; Kumar, S.; Khetarpal, P. (2021). *Potential environmental toxicant exposure, metabolizing gene variants and risk of PCOS-A systematic review*	No meta-analysis
(RefID: 2038) Singh, V.; Cortes-Ramirez, J.; Toms, L. M.; Sooriyagoda, T.; Karatela, S. (2022). *Effects of Polybrominated Diphenyl Ethers on Hormonal and Reproductive Health in E-Waste-Exposed Population: A Systematic Review*	No meta-analysis
(RefID: 2039) Sirohi, D.; Al Ramadhani, R.; Knibbs, L. D. (2020). *Environmental exposures to endocrine disrupting chemicals (EDCs) and their role in endometriosis: a systematic literature review*	No meta-analysis
(RefID: 2040) Srnovršnik, T.; Virant-Klun, I.; Pinter, B. (2023). *Polycystic Ovary Syndrome and Endocrine Disruptors (Bisphenols, Parabens, and Triclosan)-A Systematic Review*	No meta-analysis
(RefID: 2041) Stavridis, K.; Triantafyllidou, O.; Pisimisi, M.; Vlahos, N. (2022). *Bisphenol-A and Female Fertility: An Update of Existing Epidemiological Studies*	No meta-analysis
(RefID: 2042) Suresh, S.; Singh, S. A.; Vellapandian, C. (2022). *Bisphenol A exposure links to exacerbation of memory and cognitive impairment: A systematic review of the literature*	No meta-analysis
(RefID: 2064) Sussman, T. J.; Baker, B. H.; Wakhloo, A. J.; Gillet, V.; Abdelouahab, N.; Whittingstall, K.; Lepage, J. F.; St-Cyr, L.; Boivin, A.; Gagnon, A.; Baccarelli, A. A.; Takser, L.; Posner, J. (2022). *The relationship between persistent organic pollutants and Attention Deficit Hyperactivity Disorder phenotypes: Evidence from task-based neural activity in an observational study of a community sample of Canadian mother-child dyads*	Wrong study design
(RefID: 2043) Szcz?sna, D.; Wieczorek, K.; Jurewicz, J. (2022). *An exposure to endocrine active persistent pollutants and endometriosis - a review of current epidemiological studies*	No meta-analysis

(RefID: 2044) Timmermann, A.; Avenbuan, O. N.; Romano, M. E.; Braun, J. M.; Tolstrup, J. S.; Vandenberg, L. N.; Fenton, S. E. (2023). *Per- and Polyfluoroalkyl Substances and Breastfeeding as a Vulnerable Function: A Systematic Review of Epidemiological Studies*	No meta-analysis
(RefID: 2045) Vidal, M. S.; Menon, R.; Yu, G. F. B.; Amosco, M. D. (2022). *Actions of Bisphenol A on Different Feto-Maternal Compartments Contributing to Preterm Birth*	No meta-analysis
(RefID: 2046) Virant-Klun, I.; Imamovic-Kumalic, S.; Pinter, B. (2022). *From Oxidative Stress to Male Infertility: Review of the Associations of Endocrine-Disrupting Chemicals (Bisphenols, Phthalates, and Parabens) with Human Semen Quality*	No meta-analysis
(RefID: 2047) Vrachnis, N.; Loukas, N.; Vrachnis, D.; Antonakopoulos, N.; Zygouris, D.; K?lialexi, A.; Pergaliotis, V.; Iavazzo, C.; Mastorakos, G.; Iliodromiti, Z. (2021). *A Systematic Review of Bisphenol A from Dietary and Non-Dietary Sources during Pregnancy and Its Possible Connection with Fetal Growth Restriction: Investigating Its Potential Effects and the Window of Fetal Vulnerability*	No meta-analysis
(RefID: 2048) Wallace, D. A.; Gallagher, J. P.; Peterson, S. R.; Ndiaye-Gueye, S.; Fox, K.; Redline, S.; Johnson, D. A. (2023). *Is exposure to chemical pollutants associated with sleep outcomes? A systematic review*	No meta-analysis
(RefID: 2065) Wan, M. L. Y.; Co, V. A.; El-Nezami, H. (2022). *Endocrine disrupting chemicals and breast cancer: a systematic review of epidemiological studies*	No meta-analysis
(RefID: 2049) West, C. N.; Schell, L. M.; Gallo, M. V. (2021). *Sex differences in the association of measures of sexual maturation to common toxicants: Lead, dichloro-diphenyl-trichloroethane (DDT), dichloro-diphenyl-dichloroethylene (DDE), and polychlorinated biphenyls (PCBs)*	No meta-analysis
(RefID: 2050) Wieczorek, K.; Szcz?sna, D.; Jurewicz, J. (2022). *Environmental Exposure to Non-Persistent Endocrine Disrupting Chemicals and Endometriosis: A Systematic Review*	No meta-analysis
(RefID: 2051) Wigle, D. T.; Arbuckle, T. E.; Turner, M. C.; Bérubé, A.; Yang, Q.; Liu, S.; Krewski, D. (2008). *Epidemiologic evidence of relationships between reproductive and child health outcomes and environmental chemical contaminants*	No meta-analysis
(RefID: 2052) Wu, F.; Hu, M.; Qu, W. D.; Zhou, Y. (2022). *[The association between bisphenol A exposure and obesity/overweight in children and adolescents: dose-response Meta analysis]*	Not English

(RefID: 2053) Yu, C.; Lu, J.; Zhao, J.; Zhao, T.; Long, C.; Lin, T.; Wu, S.; Wen, S.; Wei, G. (2022). *Maternal phthalate exposure during pregnancy and male reproductive disorders: a systematic review and metaanalysis*	Not measured in vivo
(RefID: 2054) Zeng, Z.; Wang, Q.; Liang, W.; Huo, X.; Ngai, S. (2021). *Early-life exposure to widespread environmental toxicants and children's health risks: A focus on the post-vaccination antibody potency or immunoglobulin levels*	No meta-analysis
(RefID: 2126) Zhang, H.; Gao, F.; Ben, Y.; Su, Y. (2020). *Association between phthalate exposure and risk of spontaneous pregnancy loss: A systematic review and meta-analysis*	Already in original review
(RefID: 2055) Zhang, Y.; Ma, N. Y. (2021). *Environmental Risk Factors for Endometriosis: An Umbrella Review of a Meta-Analysis of 354 Observational Studies With Over 5 Million Populations*	No meta-analysis

References

1 Wolff MS, Camann D, Gammon M, Stellman SD. Proposed PCB congener groupings for epidemiological studies. *Environ Health Perspect* 1997; **105**: 13–4.

2 Aromataris E, Fernandez R, Godfrey CM, Holly C, Khalil H, Tungpunkom P. Summarizing systematic reviews: methodological development, conduct and reporting of an umbrella review approach. *JBI Evid Implement* 2015; **13**: 132.

3 Symeonides C, Aromataris E, Mulders Y, *et al.* An umbrella review of meta-analyses evaluating associations between human health and exposure to major classes of plastic-associated chemicals. *Ann Glob Health* 2024; **90**: 00, 1–52.

4 Seewoo BJ, Goodes LM, Mofflin L, *et al.* The plastic health map: A systematic evidence map of human health studies on plastic-associated chemicals. *Environ Int* 2023; **181**: 108225.

5 Morgan RL, Whaley P, Thayer KA, Schünemann HJ. Identifying the PECO: A framework for formulating good questions to explore the association of environmental and other exposures with health outcomes. *Environ Int* 2018; **121**: 1027–31.

6 Shea BJ, Grimshaw JM, Wells GA, *et al.* Development of AMSTAR: a measurement tool to assess the methodological quality of systematic reviews. *BMC Med Res Methodol* 2007; **7**: 10.

7 Pieper D, Mathes T, Eikermann M. Can AMSTAR also be applied to systematic reviews of non-randomized studies? *BMC Res Notes* 2014; **7**: 609.

8 Gates M, Gates A, Duarte G, *et al.* Quality and risk of bias appraisals of systematic reviews are inconsistent across reviewers and centers. *J Clin Epidemiol* 2020; **125**: 9–15.

9 Taioli E, Bonassi S. Pooled analysis of epidemiological studies involving biological markers. *Int J Hyg Environ Health* 2003; **206**: 109–15.

10 McKenzie JE, Brennan SE. Synthesizing and presenting findings using other methods. In: Cochrane Handbook for Systematic Reviews of Interventions version 6.2 (updated February 2021). John Wiley & Sons, Ltd, 2021: 321–47.