Methodological appendix PlasticHealthAware V2.0

Overview

This is the methodological appendix for PlasticHealthAware V2.0. 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 V2.0:

Mulders Y., Cann, S., Carpenter, C., Chiles, T., Kabeya H., Lyons A., Shetty, S., Sonn C., Symeonides, C., Tahroudi, Z., Thapa K., Dunlop S., Landrigan P. (2026). The Global Observatory on Planetary Health: PlasticHealthAware (Version 2.0). 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.
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

BBP	Benzyl butyl phthalate
DBP met.	composite measure of DBP metabolite exposures
DEHP	Di(2-ethylhexyl) phthalate
DEHP met.	Unspecified combination of DEHP metabolite exposures
DnBP	Di-n-butyl phthalate
MBzP	Mono(2-ethyl-5-hydroxyhexyl) phthalate
MCHP	Mono(2-ethylhexyl) phthalate
MCMHP	Mono(2-carboxymethyl-5-hexyl) phthalate
MCNP	Mono(2-ethyl-5-oxohexyl) phthalate
MCOP	Mono(6-carboxy-2-methylheptyl) phthalate
MCPP	Mono(2-ethyl-5-carboxypentyl) phthalate
MECPP	Mono(2-ethyl-5-hydroxyhexyl) phthalate
MEHHP	Mono(2-ethylhexyl) phthalate
MEHP	Mono(2-ethylhexyl) phthalate
MEOHP	Mono(2-ethyl-5-oxohexyl) phthalate
MEP	Mono-ethyl phthalate
MiBP	Mono-isobutyl phthalate
MiNP	Mono-isononyl phthalate
MMP	Mono-methyl phthalate
MnBP	Mono-n-butyl phthalate
MnOP	Mono-n-octyl phthalate
sumDEHP	composite measure of multiple DEHP metabolite exposures
sumDNP	composite measure of all DNP metabolite exposures
sumHMWP	composite measure of all measured High molecular weight phthalate metabolite exposures
sumLMWP	composite measure of all measured Low molecular weight phthalate metabolite exposures
Total Phthalates	composite measure of all measured phthalate and metabolite exposures

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

6:2CL-PFESA	6: :2 chlorinated polyfluorinated ether sulfonate
8:2CL-PFESA	8:2 chlorinated polyfluorinated ether sulfonate
EtFOSAA	N-ethylperfluorooctane sulfonamidoacetic acid
MeFOSAA	N-methylperfluoro-1-octanesulfonamidoacetic acid
n-PFOA	composite measure of all straight chain PFOA exposures
n-PFOS	composite measure of all straight chain PFOS exposures
PFBS	Perfluorobutanesulfonic acid
PFDA	Perfluorodecanoic acid
PFDoDA	Perfluorododecanoic acid
PFHpA	Perfluoroheptanoic acid
PFHpS	Perfluoroheptanesulfonic acid
PFHxA	Perfluorohexanoic acid
PFHxS	Perfluorohexanesulfonic acid
PFNA	Perfluorononanoic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
PFOSA	Perfluorooctanesulfonamide
PFPeA	Perfluorovaleric acid
PFTDA	Perfluorotetradecanoic Acid
PFTrDA	Perfluorotridecanoic Acid
PFUnDA	Perfluoroundecanoic acid
sumPFCAs	composite measure of all Perfluoroalkyl carboxylic acids
sumPFSAs	composite measure of all Perfluoroalkyl Sulfonic acids
Total PFAS	composite measure of all Per- and Polyfluoroalkyl Substances exposures

Health outcomes

ADHD	Attention Deficit Hyperactive Disorder
ASD	Autism Spectrum Disorder
SDQ	Strengths and Difficulties Questionnaire
BSID	Bayley Scales of Infant Development
PDI	Psychomotor Development Index
MDI	Mental Development Index
WISC	Wechsler Intelligence Scale for Children
FSIQ	Full Scale IQ
IQ	Intelligence Quotient
DBP	Diastolic Blood Pressure
SBP	Systolic Blood Pressure

ApoB	Apolipoprotein B
HDL	High-Density Lipoprotein
LDL	Low-Density Lipoprotein
TC	Total Cholesterol
TG	Triglycerides
NAFLD	Non-alcoholic Fatty Liver Disease
GI	Gastrointestinal
LRTI	Lower Respiratory Tract Infections
CRP	C-Reactive Protein
IFN-a	Interferon-alpha
IL-1b	Interleukin-1 beta
IL-10	Interleukin-10
IL-6	Interleukin-6
IL-8	Interleukin-8
MCP-1	Monocyte Chemoattractant Protein-1
TNF-a	Tumor Necrosis Factor-alpha
fT4	Free Thyroxine
fT3	Free Triiodothyronine
T3	Triiodothyronine
T4	Thyroxine
TT3	Total T3
TT4	Total T4
TSH	Thyroid Stimulating Hormone
HOMA-IR	Homeostatic Model Assessment of Insulin Resistance
IGT	Impaired Glucose Tolerance
PCOS	Polycystic Ovary Syndrome
E2	Estradiol
TT	Total Testosterone
SHBG	Sex Hormone Binding Globulin
LH	Luteinizing Hormone
FT	Free Testosterone
FSH	Follicle Stimulating Hormone
FAI	Free Androgen Index
PROL	Prolactin
PROG	Progesterone
AMH	Anti-Mullerian Hormone
T/LH	Testosterone/Luteinizing Hormone ratio
TBLH BMD	Total Body Less Head Bone Mineral Density
BMD	Bone Mineral Density
BMI	Body Mass Index
ACR	Albumin-to-Creatinine Ratio
eGFR	Estimated Glomerular Filtration Rate
FEF 25-75%	Forced Expiratory Flow between 25% and 75% of FVC
FEV1	Forced Expiratory Volume in 1 second
FVC	Forced Vital Capacity
PEF	Peak Expiratory Flow
NHL	Non-Hodgkin's Lymphoma

CLL	Chronic Lymphocytic Leukemia
DLBCL	Diffuse Large B-cell Lymphoma
FL	Follicular Lymphoma

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 and Epistemonikos were searched on 1 September 2025 (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, AL, HK) considering the eligibility criteria. Full text of potentially relevant reviews and syntheses were retrieved and reviewed (YM, AL, HK); 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, SS, ZT) 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). Effect size is not portrayed within the hover box for each bar, and in the table below.

Search Strategy

EPISTEMONIKOS search (1 September 2025)

Plastics and plastic polymers	“Plastic*” OR “ microplastic*” OR “polyethylene*” OR “polypropylene*” OR “polyethylene terephthalate*” OR “polystyrene*” OR “polyvinyl chloride*” OR “polycarbonate*” OR “polylactide*” OR “teflon”
Plastic-associated chemicals	
Bisphenols	"bisphen*" OR "diphen*" OR "BPA" OR "BPS" OR "BPF" OR "4,4'-isopropylidenediphenol" OR "2,2-Bis(4-hydroxyphenyl)propane" OR "Diphenylolpropane" OR "4,4'-(propane-2,2-diyl)diphenol"
Plasticisers	“plasticiser*" OR "plasticizer*" OR "phthalate*" OR "phthalic acid" OR "orthophthal*" OR "ortho-phthal*" OR "benzene-1,2-dicarboxy" OR "benzenedicarboxy*" OR "DEHP" OR "terephthalate*" OR "adipate*" OR "sebacate*" OR "trimellitate*" OR "tricresyl*" OR "cresyldiphenyl*" OR "cyclohexanoate*" OR "dibenzoate*" OR "Acetyl tributyl citrate"
Flame retardants & PFAS	“flame retardant*" OR "fire retardant*" OR "fire proof*" OR "fireproof*" OR "polycholorinated biphenyl*" OR "PCB" OR "PCBs" OR "polycholorinated*" OR "tetradecachloro*" OR "polybrominated biphenyl*" OR "Polybrominated Diphenyl Ether*" OR "PBDE" OR "PBDEs" OR "polybrom*" OR "decabromo*" OR "hexabromocyclododecan*" OR "HBCD" OR "tetrabromobisphenol*" OR "TBBP-A" OR "TBBPA" OR "TBBP" OR "tetrabrom*" OR "organophosphate ester*" OR "triphenyl phosphate*" OR "Triphenylphosphate" OR "triphenyl ester" OR "tricresyl*" OR "trixylyl*" OR "trixylenyl*" OR "tris(2-chloroethyl)phosphate" OR "TCEP" OR "tris(chloropropyl)phosphate" OR "TCPP" OR "tris(1,3-dichloro-2-propyl)phosphate" OR "TDCPP" OR "resorcinol bis*" OR "RDP" OR "bisphenol A diphenyl phosphate" OR "BADP" OR "melamine polyphosphate*" OR "diphenylcresylphosphate*" OR "Tetrachlorophthal*" OR "fluoropolymer*" OR "Polyfluor*" OR "Perfluor*" OR "PFOA" OR "PFOS" OR "PFAS" OR "hexafluoropropylene" OR "GENX" OR "polytetrafluoroethylene" OR "PTFE"
Endocrine disrupting chemicals	"endocrine-disrupting" OR "endocrine disrupting" OR "environmental endocrine disrupting" OR "endocrine disruptor" OR "endocrine-disruptor”
Limits	NOT surgery Systematic reviews only

PubMed search (1 September 2025)

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

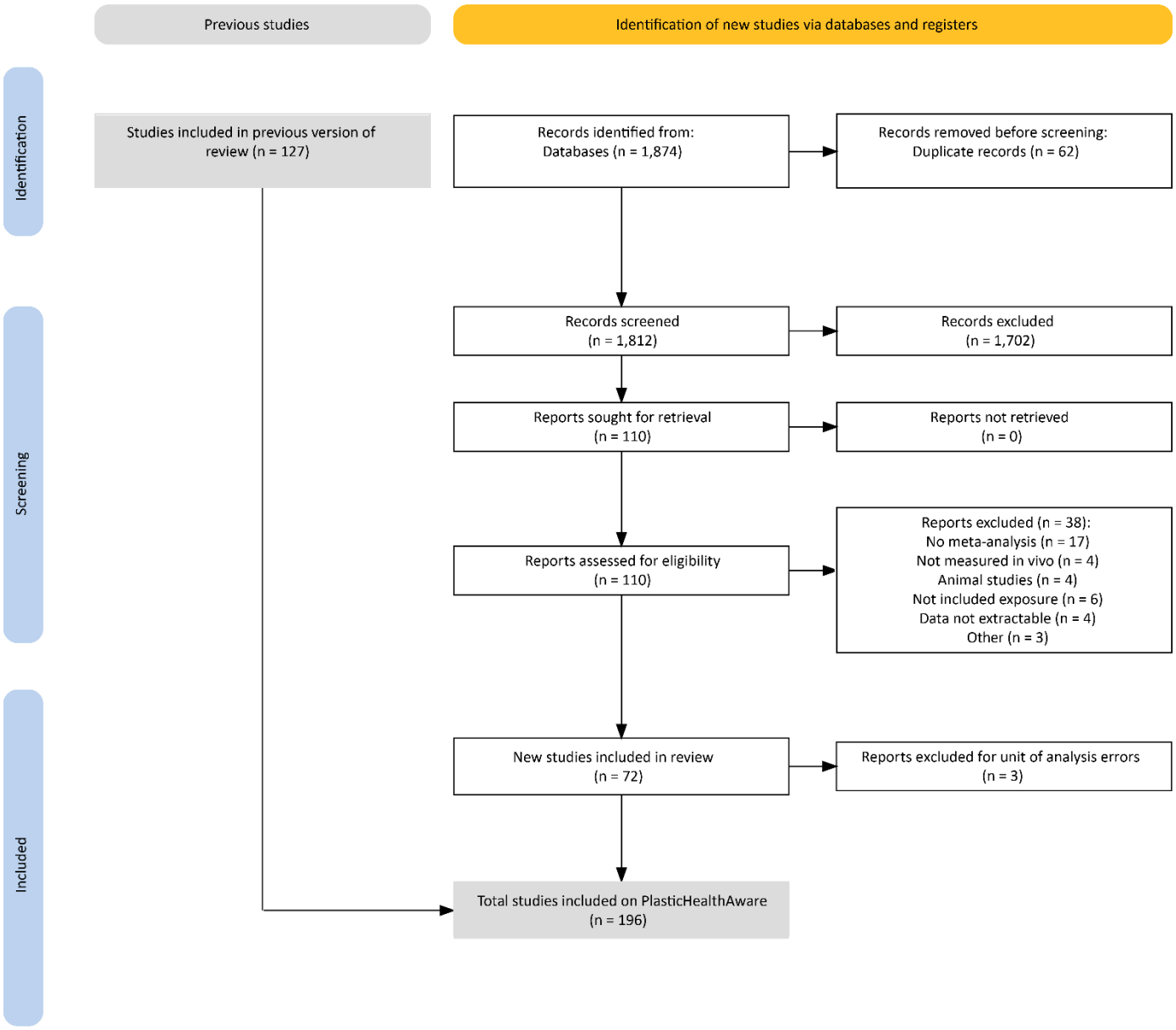

Figure 1: PRISMA diagram presenting process of study identification, selection and final inclusion in the PlasticHealthAwareV2.0 dashboard. Created using PRISMA2020.[11]

Excluded studies list

Table 1. References excluded after full text assessment against eligibility criteria for papers evaluated for PlasticHealthAwareV2.0

Reference	Exclusion reason
(RefID: 2165) Rhee, Jongeun, Loftfield, Erikka, Albanes, Demetrius, Layne, Tracy M., Stolzenberg-Solomon, Rachael, Liao, Linda M., Playdon, Mary C., Berndt, Sonja I., Sampson, Joshua N., Freedman, Neal D., Moore, Steven C., Purdue, Mark P. (2023). A metabolomic investigation of serum perfluorooctane sulfonate and perfluorooctanoate.	Data not in extractable format
(RefID: 2168) Urbanetz, Lorena Ana Mercedes Lara, Soares-Junior, José Maria, Dos Santos Simões, Ricardo, Maciel, Gustavo Arantes Rosa, Baracat, Maria Candida Pinheiro, Baracat, Edmund Chada (2024). Bisphenol A and polycystic ovary syndrome in human: A systematic review.	No meta-analysis
(RefID: 2210) Rocabois, Audrey, Sanchez, Margaux, Philippat, Claire, Crépet, Amélie, Wies, Blanche, Vrijheid, Martine, Nieuwenhuijsen, Mark, Slama, Rémy (2024). Chemical exposome and children health: Identification of dose-response relationships from meta-analyses and epidemiological studies.	No meta-analysis
(RefID: 2231) Coelho, Sónia D., Maricoto, Tiago, Taborda-Barata, Luís, Annesi-Maesano, Isabella, Isobe, Tomohiko, Sousa, Ana C. A. (2024). Relationship between flame retardants and respiratory health- A systematic review and meta-analysis of observational studies.	Not measured in vivo
(RefID: 2240) Bennett, K. A., Sutherland, C., Savage, A. L. (2024). A systematic review and meta-analysis of environmental contaminant exposure impacts on weight loss and glucose regulation during calorie-restricted diets in preclinical studies: Persistent organic pollutants may impede glycemic control.	Animal studies
(RefID: 2254) Wang, Xin, Nag, Rajat, Brunton, Nigel P., Harrison, Sabine M., Siddique, Md Abu Bakar, Cummins, Enda (2023). Multilevel meta-analysis and dose-response analysis for bisphenol A (BPA) exposure on metabolic and neurobehavioral effects.	Animal studies
(RefID: 2327) Zamora, Zacary, Wang, Susanna, Chen, Yen-Wei, Diamante, Graciel, Yang, Xia (2024). Systematic transcriptome-wide meta-analysis across endocrine disrupting chemicals reveals shared and unique liver pathways, gene networks, and disease associations.	Not measured in vivo
(RefID: 2389) Maia, Arminda, Vieira-Coelho, Maria Augusta (2024). The impact of exposure to phthalates in thyroid function of children and adolescents: a systematic review.	No meta-analysis
(RefID: 2412) Ozga, Magdalena, Jurewicz, Joanna (2025). Environmental exposure to selected non-persistent endocrine disrupting chemicals and polycystic ovary syndrome: a systematic review.	No meta-analysis
(RefID: 2438) Junaid, Muhammad, Sultan, Marriya, Liu, Shulin, Hamid, Naima, Yue, Qiang, Pei, De-Sheng, Wang, Jun, Appenzeller, Brice M. R. (2024). A meta-analysis highlighting the increasing relevance of the hair matrix in exposure assessment to organic pollutants.	No health outcome
(RefID: 2481) Stüfchen, Isabel, Schweizer, Júnia R. O. L., Völter, Friederike, Nowak, Elisabeth, Braun, Leah, Kocabiyik, Julien, Mederos Y Schnitzler, Michael, Williams, Tracy Ann, Kunz, Sonja, Bidlingmaier, Martin, Reincke, Martin (2025). The impact of endocrine disrupting chemicals on adrenal corticosteroids - A systematic review of epidemiological studies.	No meta-analysis

(RefID: 2522) Ali-Hassanzadeh, Mohammad, Arefinia, Nasir, Ghoreshi, Zohreh-Al-Sadat, Askarpour, Hedyeh, Mashayekhi-Sardoo, Habibeh (2025). The effects of exposure to microplastics on female reproductive health and pregnancy outcomes: A systematic review and meta-analysis.	Microplastic exposure not appropriately measured
(RefID: 2640) Mondal, Riashree, Sarkar, Dhruba Jyoti, Bhattacharyya, Subarna, Raja, Ramij, Chaudhuri, Punarbasu, Biswas, Jayanta Kumar, Kumar Das, Basanta (2025). Health risk assessment of microplastics contamination in the daily diet of South Asian countries.	Not measured in vivo
(RefID: 2814) Petroff, Rebekah L., Dolinoy, Dana C., Wang, Kai, Montrose, Luke, Padmanabhan, Vasantha, Peterson, Karen E., Ruden, Douglas M., Sartor, Maureen A., Svoboda, Laurie K., Téllez-Rojo, Martha M., Goodrich, Jaclyn M. (2024). Translational toxicoepigenetic Meta-Analyses identify homologous gene DNA methylation reprogramming following developmental phthalate and lead exposure in mouse and human offspring.	Animal studies
(RefID: 3012) Suthar, Himal, Manea, Tomás, Pak, Dominic, Woodbury, Megan, Eick, Stephanie M., Cathey, Amber, Watkins, Deborah J., Strakovsky, Rita S., Ryva, Brad A., Pennathur, Subramaniam, Zeng, Lixia, Weller, David, Park, June-Soo, Smith, Sabrina, DeMicco, Erin, Padula, Amy, Fry, Rebecca C., Mukherjee, Bhramar, Aguiar, Andrea, Geiger, Sarah Dee, Ng, Shukhan, Huerta-Montanez, Gredia, Vélez-Vega, Carmen, Rosario, Zaira, Cordero, Jose F., Zimmerman, Emily, Woodruff, Tracey J., Morello-Frosch, Rachel, Schantz, Susan L., Meeker, John D., Alshawabkeh, Akram N., Aung, Max T. (2024). Cross-Sectional Associations between Prenatal Per- and Poly-Fluoroalkyl Substances and Bioactive Lipids in Three Environmental Influences on Child Health Outcomes (ECHO) Cohorts.	Data not in extractable format
(RefID: 3052) Sassano, Michele, Zhang, Sirui, Kappil, Elizabeth Maria, Zheng, Tongzhang, Boffetta, Paolo, Seyyedsalehi, Monireh Sadat (2025). Exposure to per- and poly-fluoroalkyl substances and hematological cancer: A systematic review and meta-analysis.	Not measured in vivo
(RefID: 3061) Lyrou, Maria, Karampas, Grigorios, Metallinou, Dimitra, Athanasiadou, Chrysoula Rozalia, Gourounti, Kleanthi, Jotautis, Vaidas, Georgakopoulou, Vasiliki Epameinondas, Spandidos, Demetrios A., Sarantaki, Antigoni (2025). Association between prenatal exposure to perfluoroalkyl and polyfluoroalkyl substances and the incidence of infant and childhood respiratory infections: A systematic review.	No meta-analysis
(RefID: 3237) Antoniou, Evangelia E., Otter, Rainer (2024). Phthalate Exposure and Neurotoxicity in Children: A Systematic Review and Meta-analysis.	No meta-analysis
(RefID: 3264) Chen, Jiawen Carmen, Baumert, Brittney O., Li, Yijie, Li, Yiping, Pan, Shudi, Robinson, Shante, Rubbo, Bruna, Costello, Elizabeth, He, Jie, Hampson, Hailey, Beglarian, Emily, Rock, Sarah, Goodrich, Jesse A., Eckel, Sandrah P., Aung, Max T., McConnell, Rob, Conti, David V., Chatzi, Lida (2023). Associations of per- and polyfluoroalkyl substances, polychlorinated biphenyls, organochlorine pesticides, and polybrominated diphenyl ethers with oxidative stress markers: A systematic review and meta-analysis.	Data not in extractable format
(RefID: 3278) Ru, Hongyu, Lee, Alexandra L., Rappazzo, Kristen M., Dzierlenga, Michael, Radke, Elizabeth, Bateson, Thomas F., Wright, J. Michael (2024). Systematic review and meta-analysis of birth weight and perfluorohexane sulfonate exposures: examination of sample timing and study confidence.	Data not in extractable format
(RefID: 3280) Bartoletti, Michele, Montico, Marcella, Lorusso, Domenica, Mazzeo, Roberta, Oaknin, Ana, Musacchio, Lucia, Scambia, Giovanni, Puglisi, Fabio, Pignata, Sandro (2024). Incorporation of anti-PD1 or anti PD-L1 agents to platinum-based chemotherapy for the primary treatment of advanced or recurrent endometrial cancer. A meta-analysis.	Not included exposure

(RefID: 3409) Li, Dailong, Liu, Siqi, Cheng, Chunlai, Xu, Lu, Zhao, Pingfan (2023). Efficacy and safety of transarterial chemoembolization plus lenvatinib in the treatment of advanced hepatocellular carcinoma: A meta-analysis.	Not included exposure
(RefID: 3480) Kim, Jinchul, Cho, Jinhyun, Lim, Joo Han, Lee, Moon Hee (2025). Relative efficacy of systemic treatments for patients with relapsed/refractory chronic lymphocytic leukemia: a network meta-analysis according to 17p deletion/TP53 mutations.	Not included exposure
(RefID: 3660) Almeida-Toledano, Laura, Navarro-Tapia, Elisabet, Sebastiani, Giorgia, Ferrero-Martínez, Sílvia, Ferrer-Aguilar, Patricia, García-Algar, Óscar, Andreu-Fernández, Vicente, Gómez-Roig, María Dolores (2024). Effect of prenatal phthalate exposure on fetal development and maternal/neonatal health consequences: A systematic review.	No meta-analysis
(RefID: 3731) Neuvonen, Roosa, Huovinen, Marjo, Dorman, David C., Laitinen, Heikki, Sahlman, Heidi (2023). Phthalates and polycystic ovary syndrome - Systematic literature review.	No meta-analysis
(RefID: 4027) Weteska M, Zwolińska A, Pisarska-Troczyńska K, Janc M, Polańska K, Jerzyńska J, Jankowska A (2023). Relationship between prenatal and postnatal exposure to BPA and its analogues (BPS, BPF) and allergic diseases.	No meta-analysis
(RefID: 4082) Tzouma Z, Dourou P, Diamanti A, Harizopoulou V, Papalexis P, Karampas G, Liepinaitienė A, Dėdelė A, Sarantaki A (2025). Associations Between Endocrine-Disrupting Chemical Exposure and Fertility Outcomes: A Decade of Human Epidemiological Evidence.	No meta-analysis
(RefID: 4214) A Balalian A, Stingone JA, Kahn LG, Herbstman JB, Graeve RI, Stellman SD, Factor-Litvak P (2024). Perinatal Exposure to Polychlorinated Biphenyls (PCBs) and Child Neurodevelopment: A Comprehensive Systematic Review of Outcomes and Methodological Approaches.	No meta-analysis
(RefID: 4224) Jorge BC, da Silva JP, Santos STCD, Barbosa F, Sandrim VC, Arena AC (2025). Potential Role of Endocrine Disrupting Chemicals in Preeclampsia: A Hypothesis Based on Integration of Epidemiological and Experimental Evidence.	No meta-analysis
(RefID: 4375) Abouhamzeh B, Zare Z, Mohammadi M, Moosazadeh M, Nourian A (2023). Bisphenol-S Influence on Oxidative Stress and Endocrine Biomarkers of Reproductive System: A Systematic Review and Meta-Analysis	Animal studies
(RefID: 4434) Peinado FM, Artacho-Cordón F, Barrios-Rodríguez R, Arrebola JP (2020). Influence of polychlorinated biphenyls and organochlorine pesticides on the inflammatory milieu. A systematic review of in vitro, in vivo and epidemiological studies.	No meta-analysis
(RefID: 4456) Nelson W, Wang YX, Sakwari G, Ding YB (2020). Review of the Effects of Perinatal Exposure to Endocrine-Disrupting Chemicals in Animals and Humans.	Not published in peer reviewed journal
(RefID: 4481) Migliorini F, Betsch M, Maffulli N, Schäfer L, Hildebrand F, Kubach J, Pasurka M (2024). Rate of revision and wear penetration in different polyethylene liner compositions in total hip arthroplasty: a Bayesian network meta-analysis.	Not included exposure
(RefID: 4519) Dai J, Wang G, Wu C, Pan Z, Li H, Shen L, Wu Y (2024). Exposure to Endocrine-Disrupting Chemicals and Congenital Heart Diseases: The Pooled Results Based on the Current Evidence.	Not included exposure
(RefID: 4611) Di Lorenzo M, Aurino L, Lonardo MS, Cacciapuoti N, Nasti G, Belfiore A, Guida B, Chiurazzi M (2025). Obesity and obesity related disease in adulthood: the dark side of early life exposure to Environmental Chemical Disruptors.	No meta-analysis

(RefID: 4801) Grigoryan B, Kasyan G, Pivazyan L, Pushkar D (2022). Pentosan polysulfate in patients with bladder pain syndrome/interstitial cystitis with Hunner's lesions or glomerulations: systematic review and meta-analysis	Not included exposure
(RefID: 4913) Soave I, Occhiali T, Assorgi C, Marci R, Caserta D (2020). Environmental toxins exposure in PCOS women and possible ovarian neoplastic repercussion.	No meta-analysis
(RefID: 5108) Muñoz-Quezada MT, Iglesias V, Zúñiga-Venegas L, Pancetti F, Foerster C, Landeros N, Lucero B, Schwantes D, Cortés S (2025). Exposure to pesticides in Chile and its relationship with carcinogenic potential: a review.	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.

11 Haddaway NR, Page MJ, Pritchard CC, McGuinness LA. PRISMA2020: An R package and Shiny app for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and Open Synthesis. *Campbell Syst Rev* 2022; **18**: e1230.