

Effects of Microplastic Exposure on Human Digestive, Reproductive, and Respiratory Health: A Rapid Systematic Review

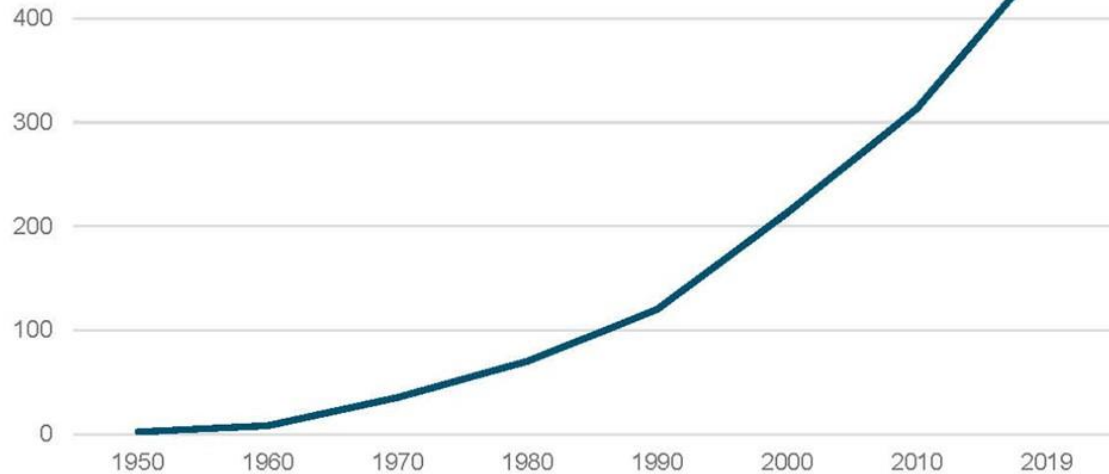
March 11th, 2025



We have no conflicts to disclose

Plastics production has been increasing exponentially

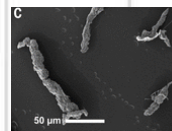
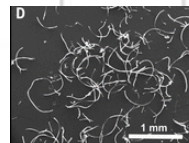
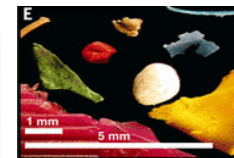
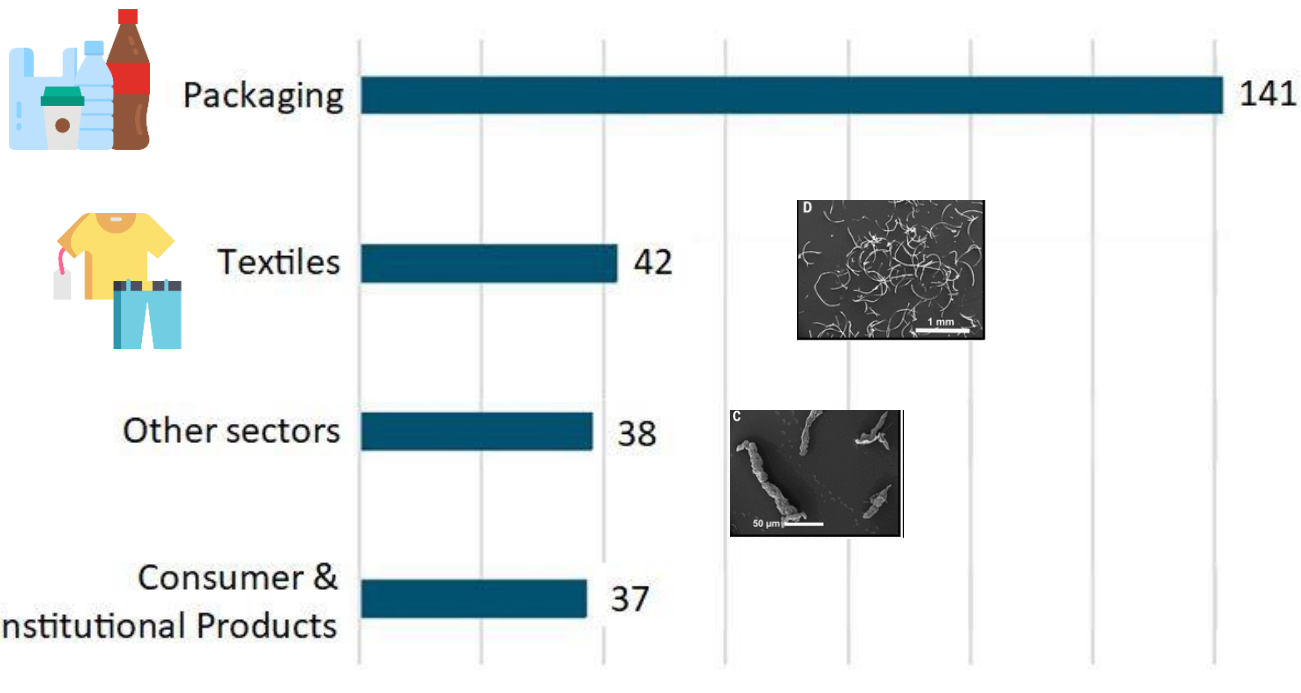
Global Annual Plastics Production
(annual production of polymer resins and fibers in million tons)



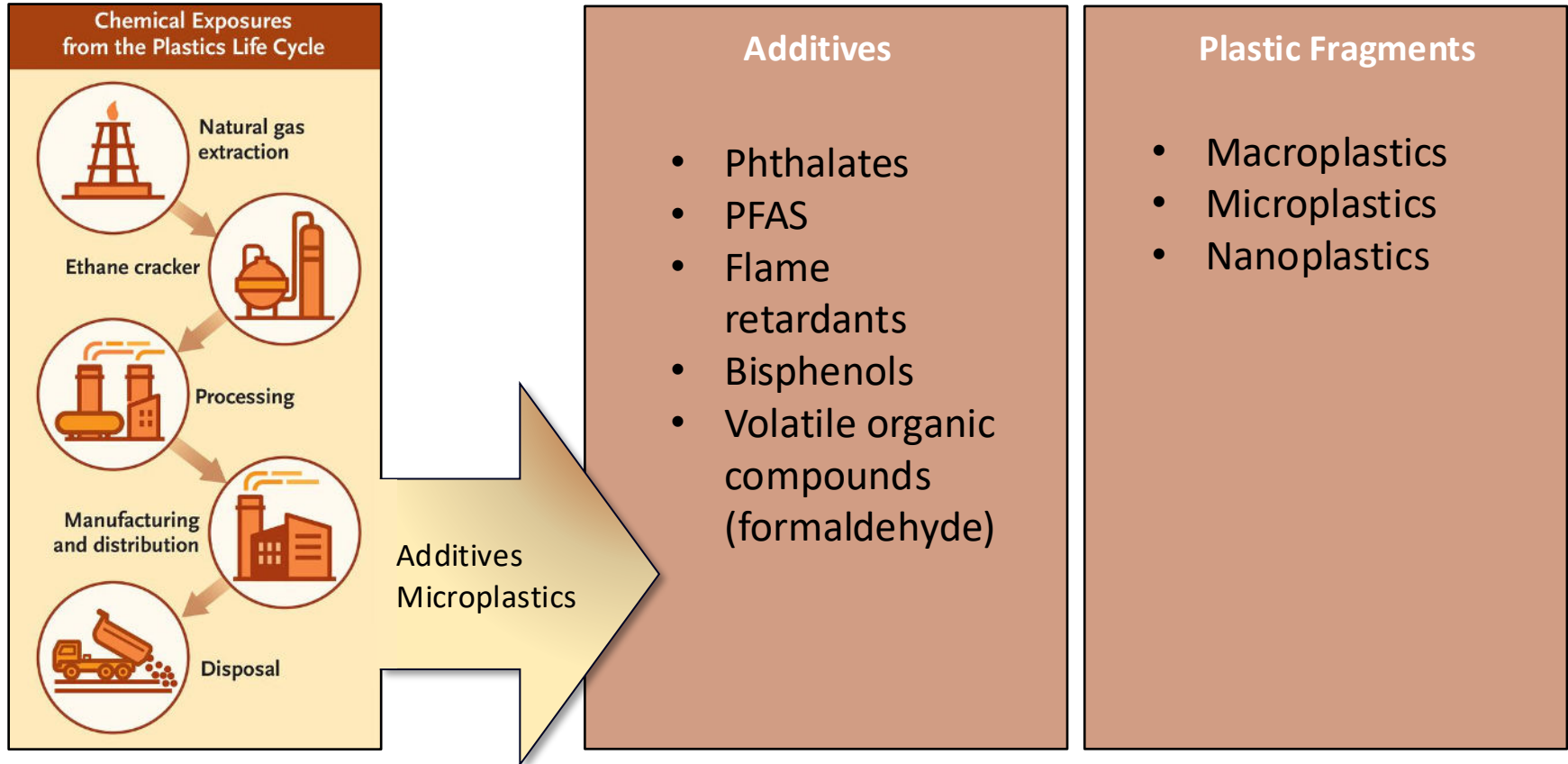
Source: CalSPEC, 2023, based on Ritchie and Roser, 2018, and Geyer et al., 2020.

Largest sources of plastic waste by industry

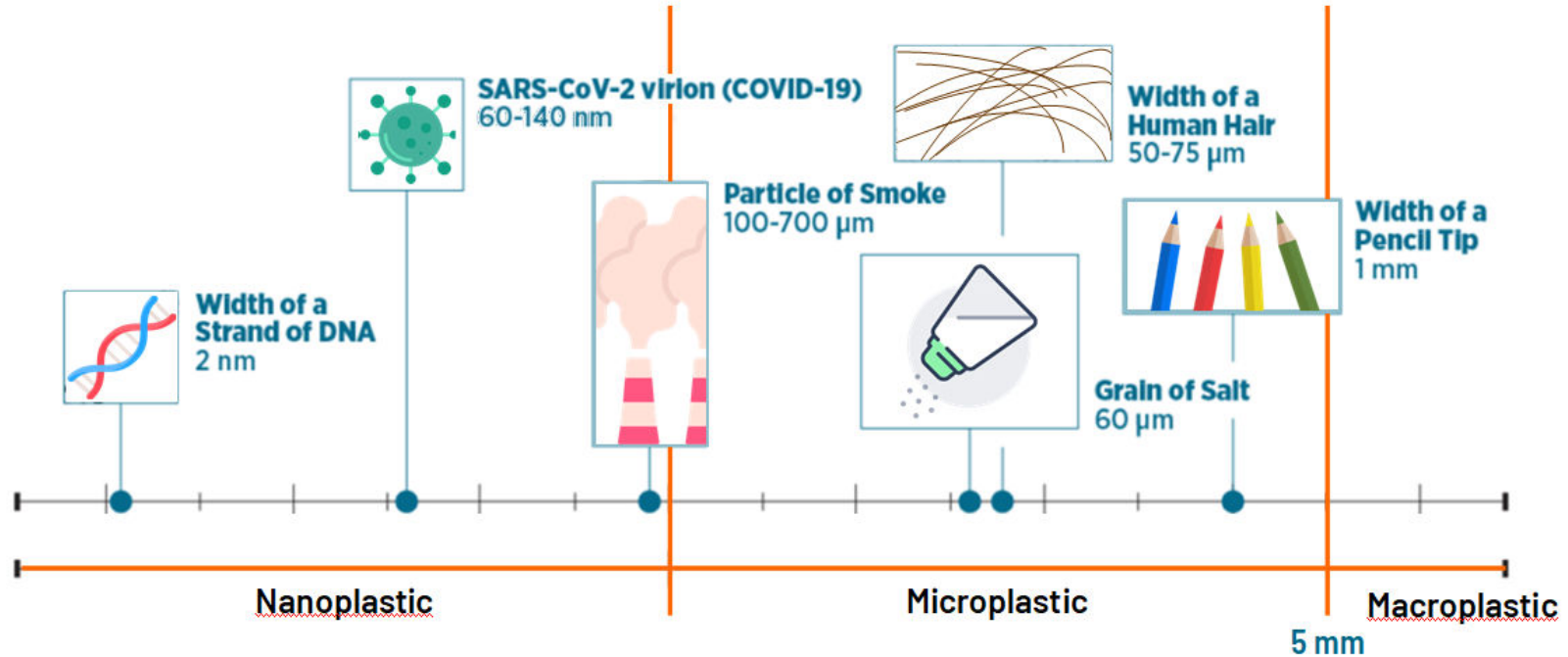
(in million metric tons)



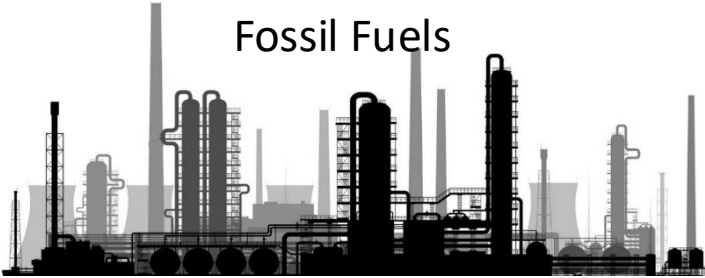
The plastics lifecycle



Microplastics are invisible to the human eye



Where do microplastics come from?



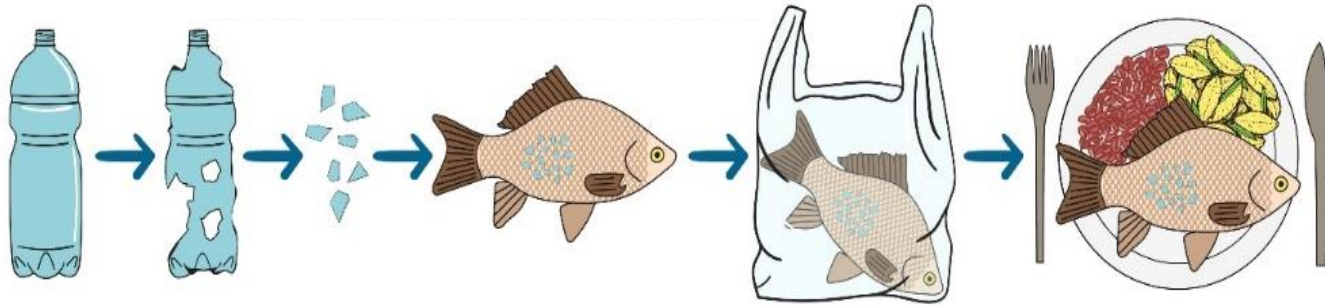
Primary
Manufacturing



Secondary
Degradation



How are we exposed? Air, water, food, touch



We eat a “credit card” worth of microplastics every week



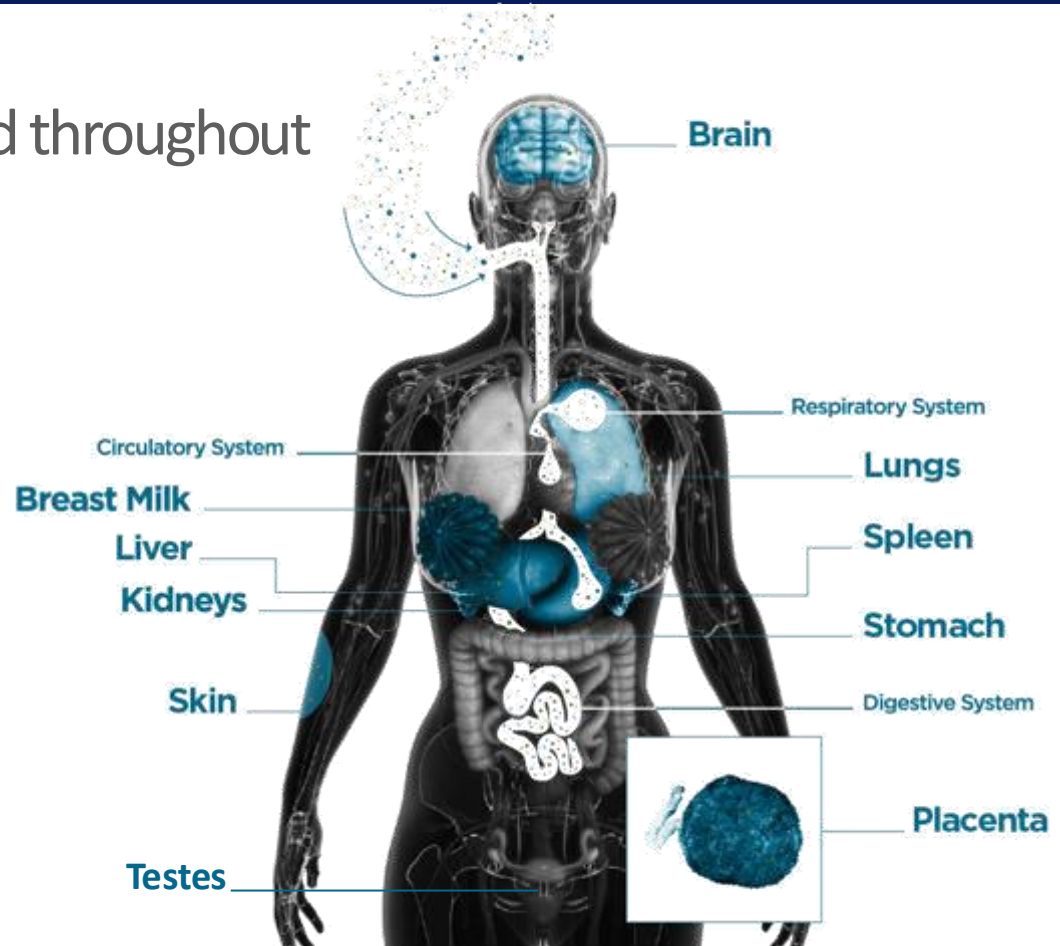
You could think of them as the sixth basic food group. Oh, you certainly wouldn't eat them, but plastic packaging does help protect our food in many ways. • To help lock in freshness, plastic wrap clings tightly to surfaces. To help lock out moisture, resealable containers provide a strong seal. And plastic wrap helps extend the shelf life of perishable produce, poultry, fish and meats. • To prevent spoilage and contamination, some varieties of plastics help keep air out. While others let air in to help the food we eat stay fresher longer. Plastics also let you see what you're buying, taking the mystery out of shopping. All of which makes them versatile, durable, light, weight and shatter-resistant. • To learn more, call the American Plastics Council at 1.800.777.9500 for a free booklet, *Plastics. One part of your diet you may never break.*

Plastics. An Important Part Of Your Healthy Diet.

PLASTICS MAKE IT POSSIBLE.™
Visit us at <http://www.plasticsresource.com>

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Microplastics are found throughout the human body



Concerns about human exposure

Evidence that MPs are bio-accumulative

MPs have been linked to:

- Oxidative stress
- Inflammation
- Cardiovascular & respiratory outcomes
- Metabolic disorders
- Gastrointestinal effects
- Cancer

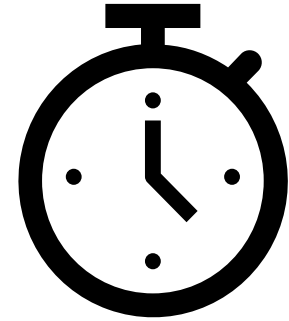
METHODS

Primary objectives

- **Evaluate** the human & animal evidence
- **Rate** the quality and strength of evidence
- **Integrate** the human and animal evidence streams
- **Develop** a final bottom line statement regarding the health effects of microplastics



Rapid systematic review

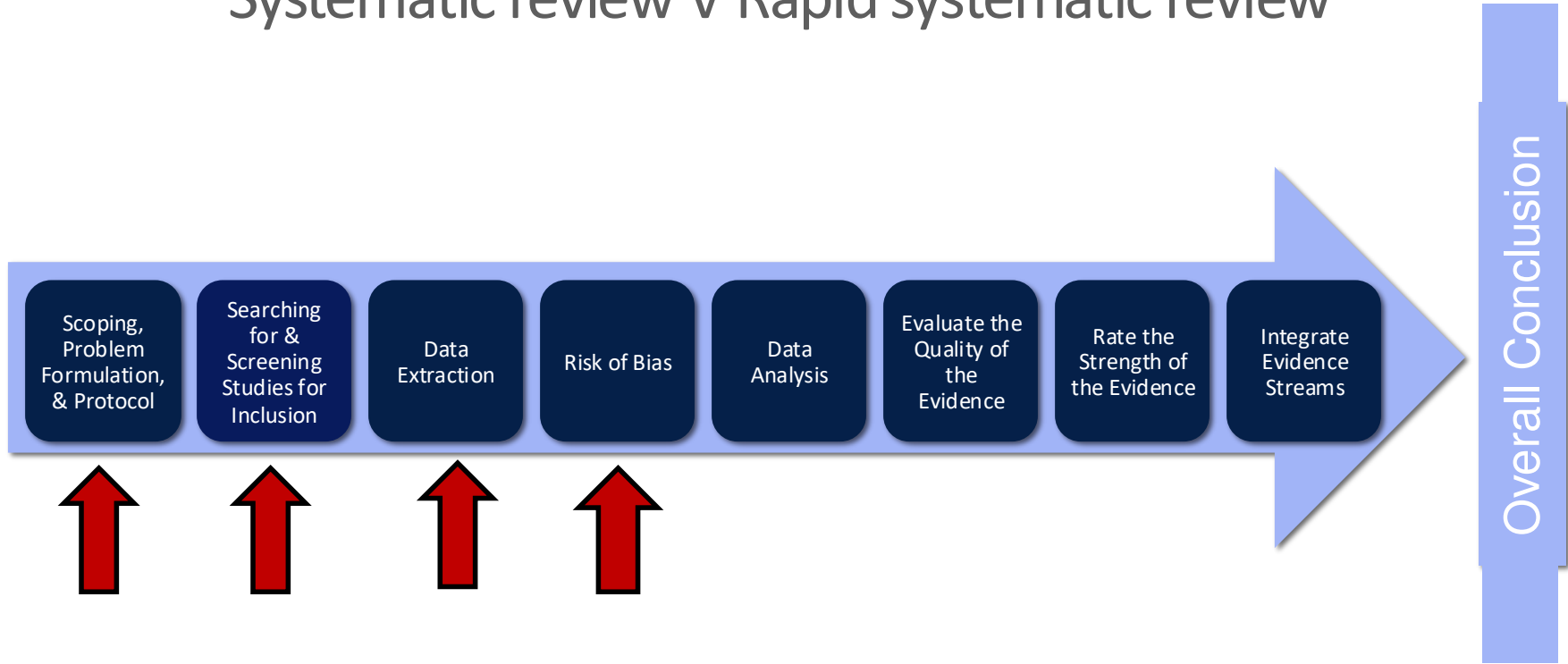


Rapid systematic review = certain steps are modified to speed up the process of conducting a systematic review



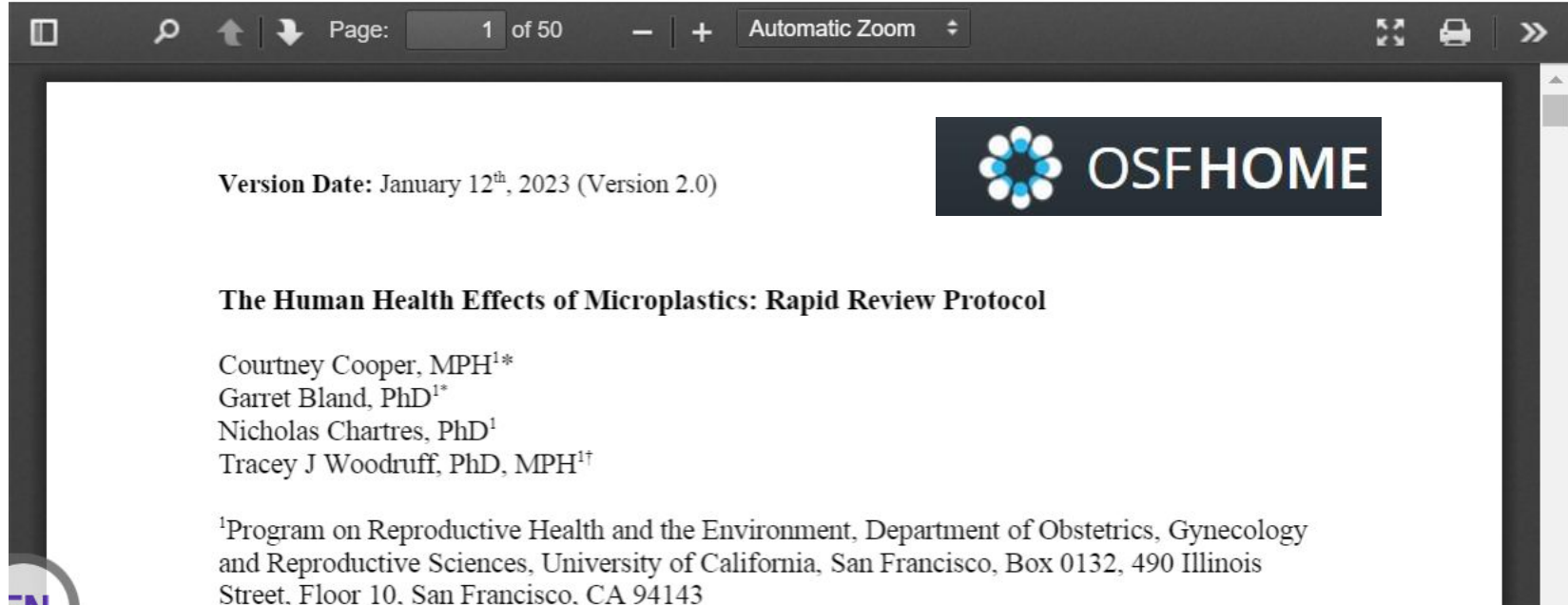
National Toxicology Program
U.S. Department of Health and Human Services

Systematic review V Rapid systematic review




SCOPING, PROBLEM FORMULATION, AND PROTOCOL DEVELOPMENT

Rapid review protocol



Page: 1 of 50 Automatic Zoom

Version Date: January 12th, 2023 (Version 2.0)



The Human Health Effects of Microplastics: Rapid Review Protocol

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PECO Statement

P: Humans and animals of any age or health status.

E: Any exposure to MPs, that occurred prior or concurrent to diagnosis, exacerbation, or other measure of any health outcome. Exposures can be from any route (air, water, or food), any duration, and any exposure pathway (inhalation, ingestion, or direct contact) and can be measured on the basis of biosamples or from exposure estimates.

C: Humans and animals, exposed to lower levels of MPs than the more highly exposed subjects or treatment groups, or vehicle-only treatment.

O: Any adverse health outcome, as defined by the US EPA.

Microplastics definition

A solid and polymeric material to which chemical additives or other substances have been added, which are particles that are <5000 μm in one dimension.

Adverse outcome definition

U.S. Environmental Protection Agency

“A biochemical change, functional impairment, or pathological lesion that affects the performance of the whole organism, or reduces an organism’s ability to respond to an additional environmental challenge”

California law hazard trait regulation

“Adverse effect” for toxicological hazard traits and end points means a biochemical change, functional impairment, or pathologic lesion that negatively affects the performance of the whole organism, or reduces an organism’s ability to respond to an additional environmental challenge”



We prioritized



Digestive
Outcomes



Reproductive
Outcomes



Respiratory
Outcomes

Eligible outcomes

System	Outcome
<i>Digestive</i>	Apical end points (gross or microanatomic colon and intestine effects)
	KC's of carcinogens (chronic inflammation, oxidative stress, immunosuppressive effects, cell proliferation, & receptor-mediated effects)
<i>Reproductive</i>	Apical end points (sperm-related outcomes, follicle/ovarian reserve capacity, oocyte meiotic progression, blastocyst development, and angiogenital distance)
	Apical end points (birth outcomes weight of fetus and placenta & litter size)
	KC's of reproductive toxicants (alterations in reproductive hormones)
<i>Respiratory</i>	Apical end points (total cell count, lung injury, and pulmonary function)
	KC's of carcinogens (chronic inflammation and oxidative stress)

SEARCHING FOR & SCREENING STUDIES FOR INCLUSION

Search Strategy



Worked with an information specialist



Searched PubMed, EMBASE, ProQuest, and Web of Science



Did not limit by publication year



Conducted search in July 2022 & April 2024

Studies were required to meet the following criteria



Repeated exposure to microplastics (chronic)



Exposed via food or water (digestive and reproductive studies)



Exposed via nasal passages or trachea (respiratory studies)

ANALYSIS

EVALUATE QUALITY AND STRENGTH OF THE EVIDENCE

Quality of the Evidence

- **Quality** is rated *across all studies*.
- Human evidence begins at "moderate quality" and can be downgraded 1 or 2 factors.
- Animal evidence begins at "high quality" and can be downgraded 1 or 2 factors.

Factors

Options: Downgrade Rating (1 or 2 factors) or Don't Change

1. Risk of Bias across studies
2. Indirectness
3. Inconsistency
4. Imprecision
5. Publication Bias

Options: Upgrade Rating (1 or 2 factors) or Don't Change

6. Large magnitude of effect
7. Dose response
8. Confounding minimizes effect

Rating

- High Quality
- Moderate Quality
- Low Quality
- Very Low Quality

Strength of the Evidence

- **Strength** is rated across all studies.
- The final rating represents the level of certainty about the toxicity of the exposure.

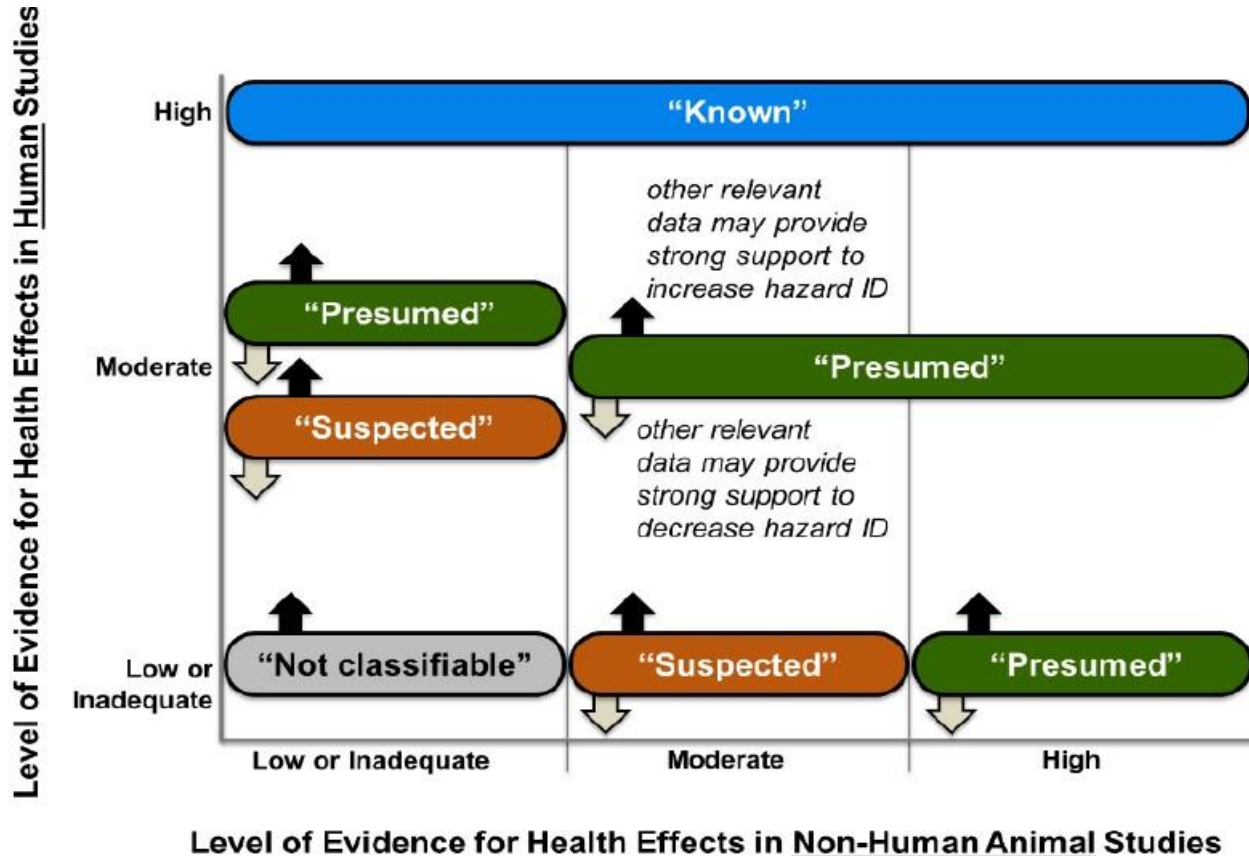
Considerations

- **Quality of the body of evidence**
- Direction of effect estimates
- Confidence in effect estimates
- Other compelling attributes of the data that may influence certainty

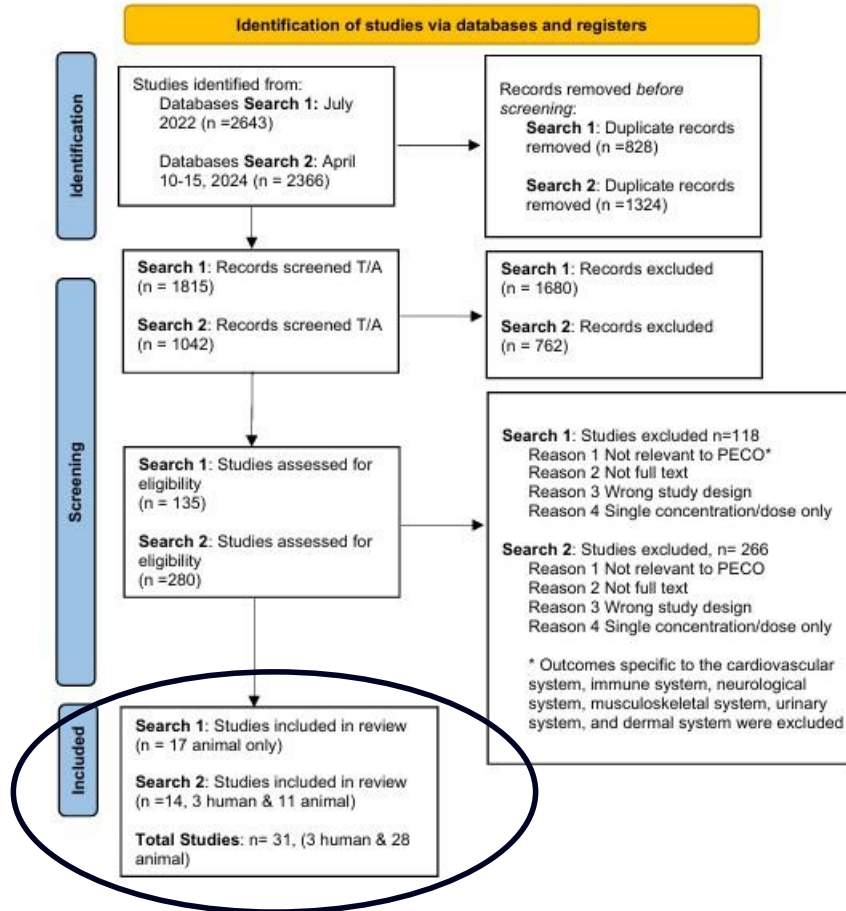
Hazard Identification Conclusion

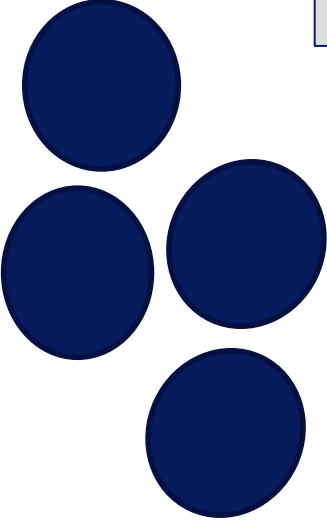
- Known to be a hazard to humans
- Presumed to be a hazard to humans
- Suspected to be a hazard to humans
- Not classifiable as a hazard to humans

NTP OHAT approach - Hazard identification conclusion



RESULTS



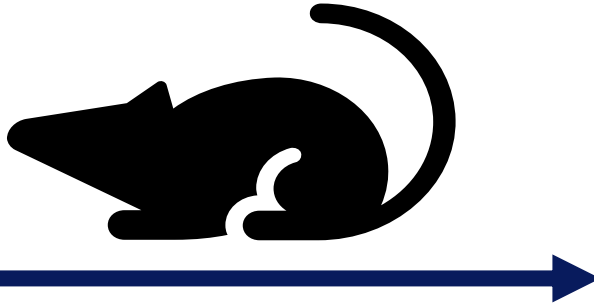


**Food =
5 (18%)**

**Water
= 16
(57%)**

**Air = 7
(25%)**

Rodents per study = 15 to
180



*Length of Exposure: 14 days to
32 weeks*

Plastic type

- Polystyrene $n = 22(79\%)$
- Polyethylene
- Polypropylene
- Tire wear particles

Size range

Between 0.1 and 467.85 μm



DIGESTIVE RESULTS



Overall

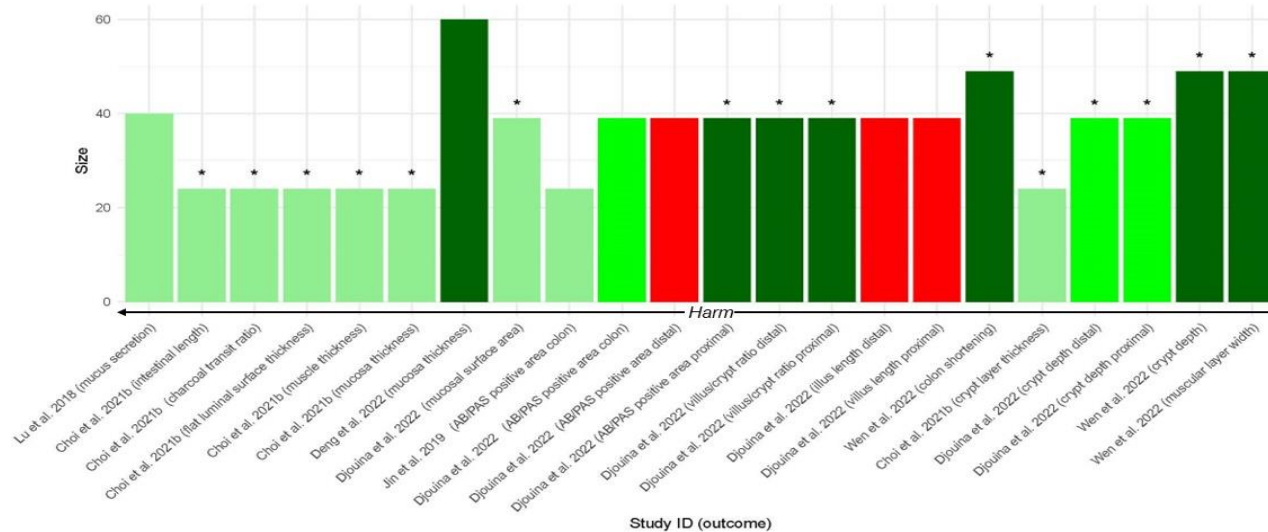
We concluded microplastic exposure is “suspected” to adversely impact:

- **immunosuppression** (high quality evidence)
- **gross or microanatomic colon/small intestine effects** (moderate)
- **cell proliferation & cell death** (moderate)
- **chronic inflammation** (moderate)

We concluded that microplastic exposure is “not classifiable” for impacting:

- intestinal oxidative stress (low quality evidence)
- digestive hormones (low)

Apical outcomes (colon and small intestine)



Key:

Direction of effect: All included study results show change in the direction of 'harm'

Y axis = sample size

Dark green = $P < 0.001$, Green = $P < 0.01$, Light green = $P \leq 0.05$, Red = $P \geq 0.05$

*= Dose response identified in the study

Apical outcomes (colon and small intestine)

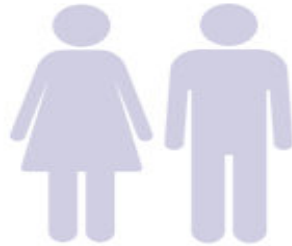
Estimate of the proportion of effects showing microplastics are harmful equals 1.00 [95% confidence interval (CI) of 0.85–1.00]
[n = 22 (positive study results)/22 (total study results)]

Apical outcomes (colon and small intestine)

We concluded that exposure to microplastics is “*suspected*” to adversely impact the colon and small intestine in humans on the basis of

- (a) the “**moderate**” **quality** of the body of **evidence**
- (b) the **direction of the effect** (i.e., evidence of an increasing adverse health effect with an increasing level of microplastic exposure)
- (c) the **confidence in the association**, considering factors including the number and size of studies.

REPRODUCTIVE RESULTS



Overall

We concluded microplastic exposure is “suspected” to adversely impact:

- **sperm quality** (high quality evidence)
- **female follicles** (moderate)
- **reproductive hormones** (moderate)

We concluded that microplastic exposure is “not classifiable” for impacting:

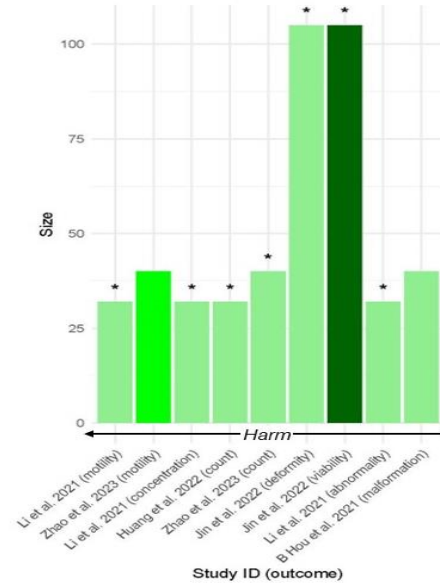
Humans

- chronic rhinosinusitis (very low-quality evidence)

Animals

- total cell counts (very low)

Apical outcomes (sperm quality)



Key:

Direction of effect: All included study results show change in the direction of 'harm'

Y axis = sample size

Dark green = $P < 0.001$, Green = $P < 0.01$, Light green = $P \leq 0.05$, Red = $P \geq 0.05$

*= Dose response identified in the study

Apical outcomes (sperm quality)

Estimate of the proportion of effects showing microplastics are harmful = 1.00 (95% CI of 0.70–1.00) ($n = 9/9$).

Apical outcomes (sperm quality)

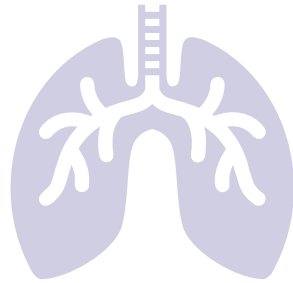
We concluded that exposure to microplastics is “**suspected**” to adversely impact sperm quality and testicular health in humans on the basis of

(a) the “**high**” **quality** of the body of **evidence**

(b) the **direction of the effect** (i.e., evidence of an increasing adverse health effect with an increasing level of microplastic exposure)

(c) the **confidence in the association** considering factors including the number and size of studies.

RESPIRATORY RESULTS



Overall

We concluded microplastic exposure is “suspected” to adversely impact:

- **pulmonary function** (moderate quality evidence)
- **lung injury** (moderate)
- **chronic inflammation** (moderate)
- **oxidative stress** (moderate)

We concluded that microplastic exposure is “not classifiable” for impacting:

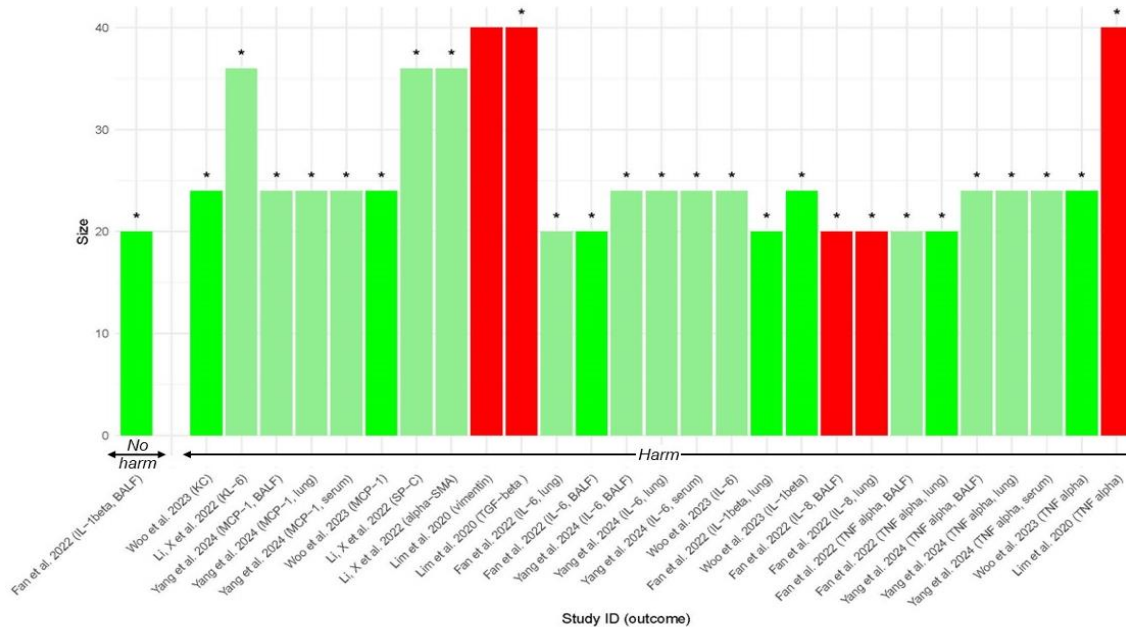
Human

- chronic rhinosinusitis (very low quality evidence)

Animals

- total cell count (very low)

Key characteristic (chronic inflammation)



Key:

Direction of effect: All included study results show change in the direction of 'harm'

Y axis = sample size

Dark green = P < 0.001, Green = P < 0.01, Light green = ≤ 0.05, Red = ≥ 0.05

*= Dose response identified in the study

Key characteristic (chronic inflammation)

Estimate of the proportion of effects showing microplastics are harmful = 0.96 (95% CI of 0.82–0.99) ($n = 27/28$)

Key characteristic (chronic inflammation)

We concluded that exposure to microplastics is “**suspected**” to induce chronic inflammation and lung fibrosis in humans on the basis of

(a) the “**moderate**” **quality** of the body of **evidence**

(b) the **direction of the effect** (i.e., evidence of an increasing adverse health effect with an increasing level of microplastic exposure)

(c) the **confidence in the association** considering factors including the number and size of studies.

DISCUSSION

Action is necessary to protect public health

Investment Opportunities

Research

- Rapid screening studies on health effects
- Biomonitoring and epidemiological studies
- Improved measurement tools

Policy

- Use legal authority to assess and regulate microplastics and mitigate microfiber release and prohibit the use of intentionally added microplastics in products
- International Plastic Treaty - Focus on capping/reducing plastic production
- Phase out most toxic harmful plastic additives/most difficult to recycle polymers
- Phase out nonessential plastics

Education for Clinicians and the Public

5 Ways to Avoid Toxic Chemicals in Plastics

- Try not to eat or drink food in plastic
- Never microwave in plastic
- Choose glass, stainless steel or ceramic to store food
- Avoid single-use and soft plastics
- Select alternatives to dishwasher pods and microfiber cloths



bit.ly/toxicmatters



Toxic Matters

Ways to Protect You and Your Family From Harmful Exposures

10 Ways to Avoid Harmful Chemicals

There are many chemicals that we are exposed to in everyday life that are harmful, particularly during pregnancy. A list of these chemicals and how they impact our health is on the other side. Here's how to avoid them:

1. Avoid eating, drinking or storing food in plastic containers.
2. Cook with cast iron or stainless steel rather than non-stick pans.
3. Do not microwave food or drink in plastic.
4. Eat fresh, organic foods whenever possible.
5. Avoid eating fish high in mercury or PCBs (like tuna and swordfish).
6. Limit cosmetics use and opt for fragrance-free products.
7. Avoid dry cleaning or stain treating clothes.
8. Remove shoes before entering your home.
9. Clean with water and vinegar, use a wet mop, and avoid harsh cleaners and fragrance (where companies hide chemicals).
10. Avoid products with flame retardants/electronics, check labels for flame retardants in furniture and mattresses.



Change Policy + Products



- ✓ Support policies to prevent exposure to toxic environmental chemicals.
- ✓ Call companies whose products you like and ask them to remove harmful chemicals and plastic packaging.
- ✓ Use your purchasing power and avoid buying products with harmful chemicals or plastics.

For more tips: pche.uscd.edu/toxicmatters • [UCSF PRHE](#) • [UCSF PRHE](#) • [UCSF PRHE](#)

Strengths

- We prioritized outcomes most relevant to human health
- We applied the concepts of key characteristics
- We used best practices for synthesizing and presenting data when Meta-analysis is not possible
- We used rigorous methods to evaluate the data and develop a succinct bottom line summary of the evidence



Limitations

- Conclusions of this rapid review are **likely an underestimation** of the human health harms from microplastic exposure:
 - Only evaluated 3 outcome types, studies on other outcomes may also find effects
 - Rodents in studies exposed to manufactured, pure microplastics and not chemicals that degrade from plastic
 - These include known harmful chemicals such as PFAS, phthalates, BPA
 - The studies only evaluated one route of exposure at a time
 - People are exposed via multiple routes of exposure
 - We could not do quantitative dose-response analysis nor meta-analysis



Conclusion



Microplastics are a ***digestive hazard*** potentially linked to colon **cancer**



Microplastics are a ***reproductive hazard*** and linked to **poor sperm quality**



Microplastics are a ***respiratory hazard*** linked to **chronic inflammation and lung cancer**

THANK YOU!



For more information

prhe.ucsf.edu

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