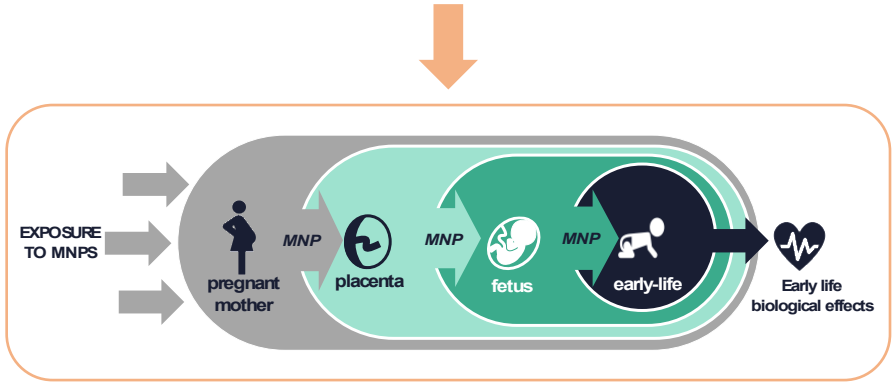


Where do we stand on risk assessment of MNPs for early life health?

Jarlath Hynes, AURORA Researcher, Institute of Occupational Medicine

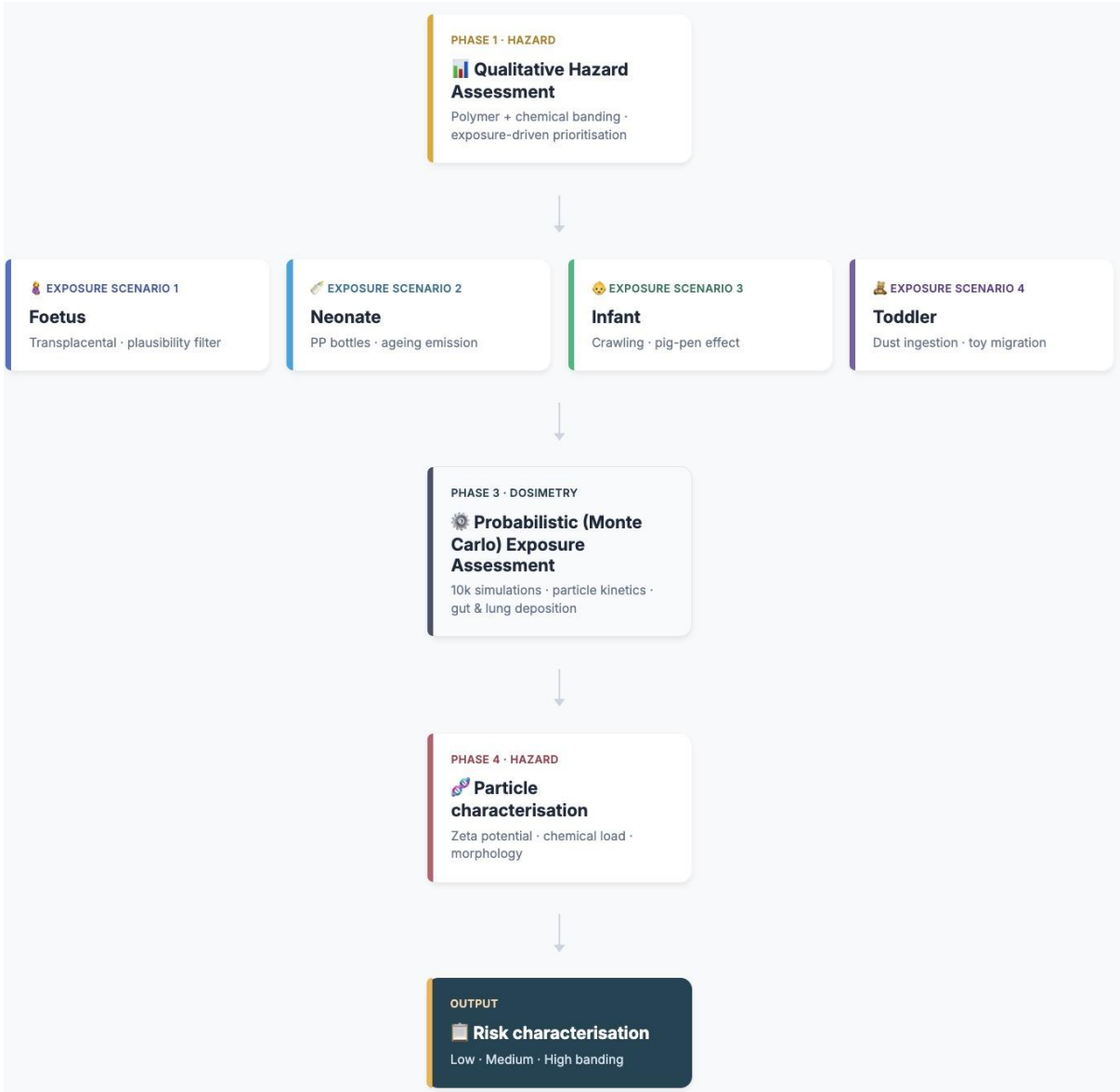
Quantifying MNP Risks: From Challenges to Solutions

$$Risk \propto Hazard \times Exposure$$

- MNPs present unique risks due to their extreme diversity in **size, shape,** and **composition**.
- Currently we cannot quantify MNP hazards, but we can make **conservative assumptions** based on polymer composition.
- We can *reasonably* quantify external dose, systemic exposure and internal kinetics by **modelling** based on particle number, size distributions (PSD) and shape.
- **Exposure-led** risk assessment is a pragmatic starting point for vulnerable early-life stages.

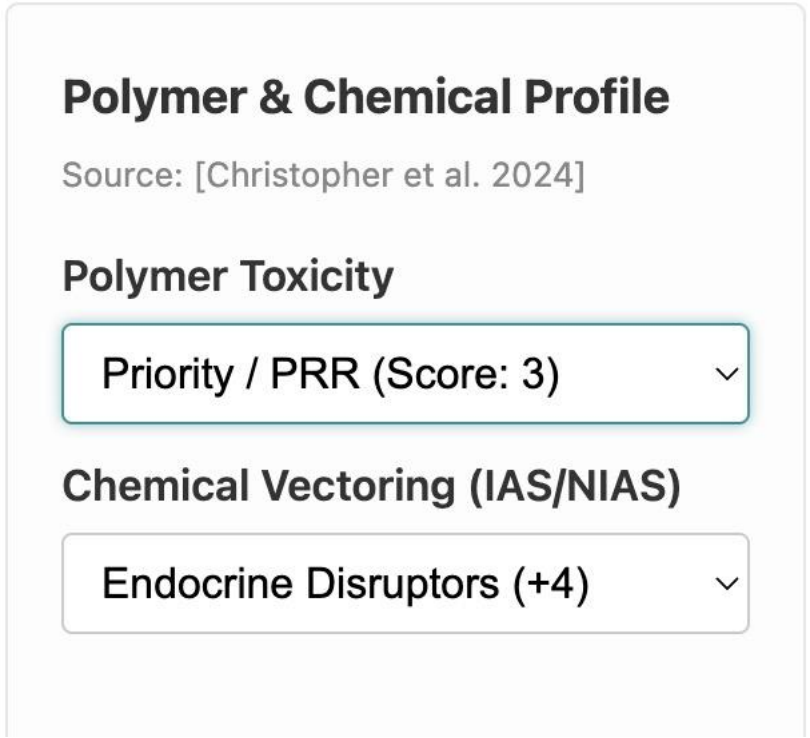
The AURORA Risk Assessment Framework

- **Modular & Extensible,** tailored for early life stage risk assessments.
- **Conceptual database** collects standardised particle data.
- **Interactive Exposure Scenarios** available as web-based models.
- All parameters are **empirically anchored**.
- **Phased roadmap** targets current data gaps and critical uncertainties.



Particle / Hazard Characterisation

- Initially we apply a conservative **hazard-banding** approach.



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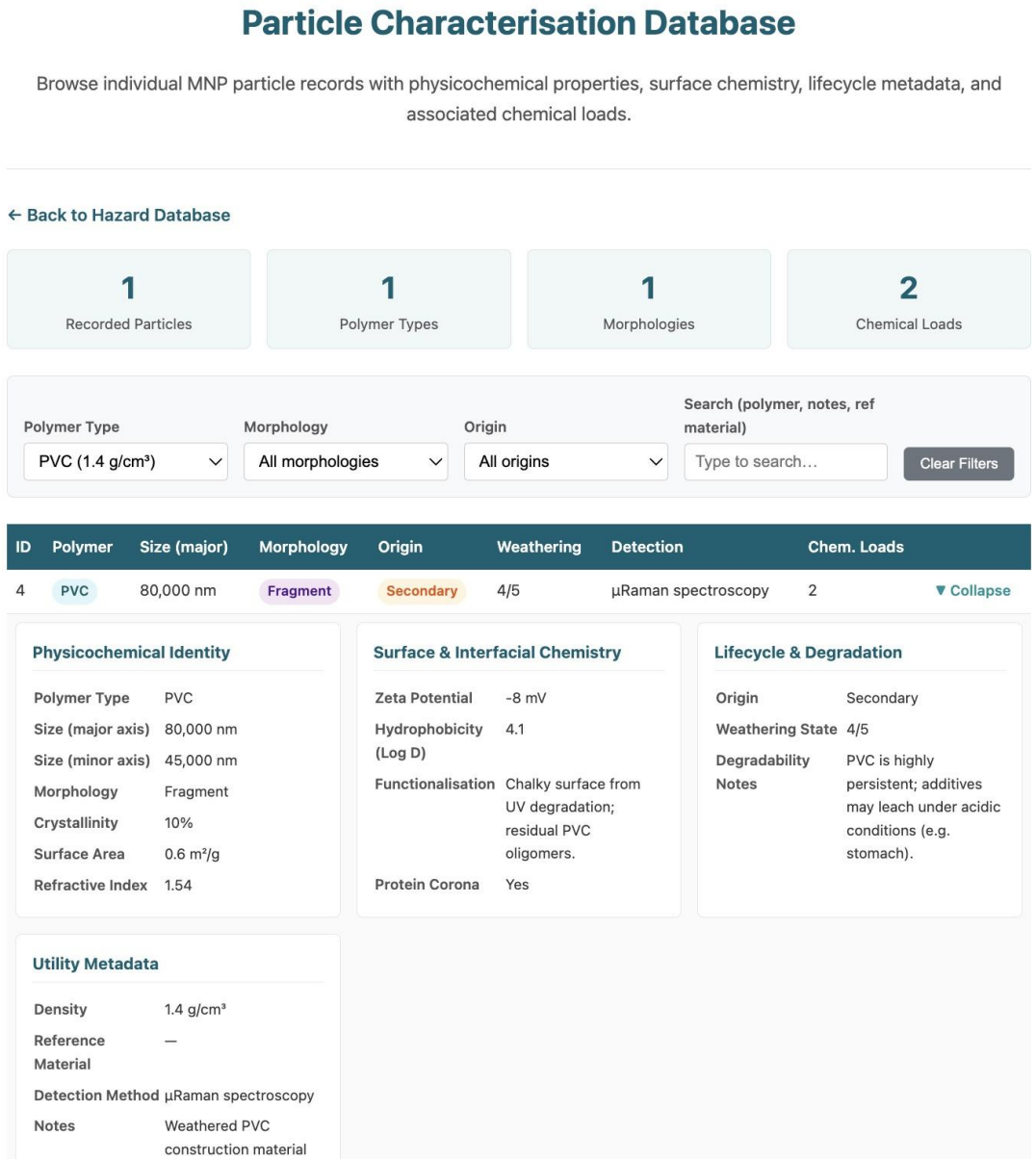
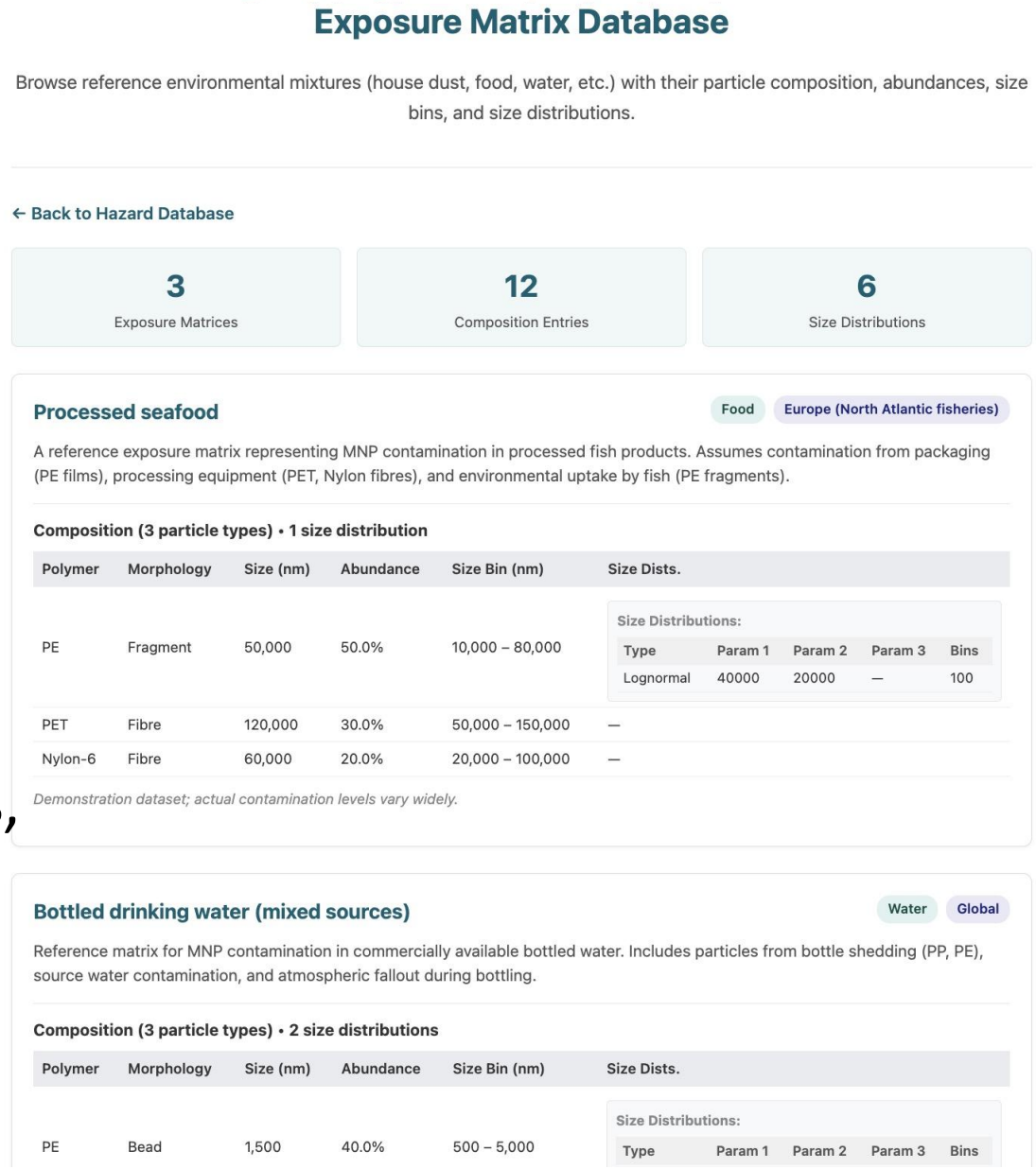
- The **Particle Database** provides a central MNP data repository.



Particle / Hazard Characterisation

- Initially we apply a conservative **hazard-banding** approach.
- The **Particle Database** provides a central MNP data repository.
- Particles can be grouped into reference **Exposure Matrices** (e.g. dusts, water, foodstuffs).
- Facilitates modelling of **cellular interactions, agglomeration, protein corona,** and **'Trojan Horse'** effects.



Exposure Matrix Database

Browse reference environmental mixtures (house dust, food, water, etc.) with their particle composition, abundances, size bins, and size distributions.

← Back to Hazard Database

3	12	6
Exposure Matrices	Composition Entries	Size Distributions

Processed seafood

Food · Europe (North Atlantic fisheries)

A reference exposure matrix representing MNP contamination in processed fish products. Assumes contamination from packaging (PE films), processing equipment (PET, Nylon fibres), and environmental uptake by fish (PE fragments).

Composition (3 particle types) • 1 size distribution

Polymer	Morphology	Size (nm)	Abundance	Size Bin (nm)	Size Dists.
PE	Fragment	50,000	50.0%	10,000 – 80,000	Size Distributions: Type: Lognormal; Param 1: 40000; Param 2: 20000; Param 3: —; Bins: 100
PET	Fibre	120,000	30.0%	50,000 – 150,000	—
Nylon-6	Fibre	60,000	20.0%	20,000 – 100,000	—

Demonstration dataset; actual contamination levels vary widely.

Bottled drinking water (mixed sources)

Water · Global

Reference matrix for MNP contamination in commercially available bottled water. Includes particles from bottle shedding (PP, PE), source water contamination, and atmospheric fallout during bottling.

Composition (3 particle types) • 2 size distributions

Polymer	Morphology	Size (nm)	Abundance	Size Bin (nm)	Size Dists.
PE	Bead	1,500	40.0%	500 – 5,000	Size Distributions: Type:

Early-Life Stage Exposure Scenarios

- 4 proof-of-concept scenarios have been modelled.
- Each model addresses unique exposure pathways per life stage.

Scenario 1: Maternal / Foetal Exposure

Modelled Pathways

- **Maternal Ingestion:** MNP uptake via food and water sources.
- **Airway Deposition:** Systemic absorption following inhalation and mucociliary clearance
- **Placental Translocation:** Direct transfer across the blood-placenta barrier.

Early-Life Stage Exposure Scenarios

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Scenario 2: Neonate (0-6 Months) Exposure

Feeding Risks

- **Bottle Shedding:** MNP release from Polypropylene (PP) feeding bottles.
- **Bottle Ageing:** Increased particle release from repeated heating, sterlisation.
- **Crib Environment:** Resting inhalation within immediate sleep micro-areas.

Early-Life Stage Exposure Scenarios

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Scenario 3: Infant (6-12 Months) Exposure

Environmental Interaction

- **Crawling Activity:** Mechanical resuspension of floor-bound dust.
- **Hand-to-Mouth:** Oral uptake during exploratory behaviors.
- **Dust Concentration:** High exposure density near floor levels.

2

Early-Life Stage Exposure Scenarios

- 4 proof-of-concept scenarios have been modelled.
- Each model addresses unique exposure pathways per life stage.

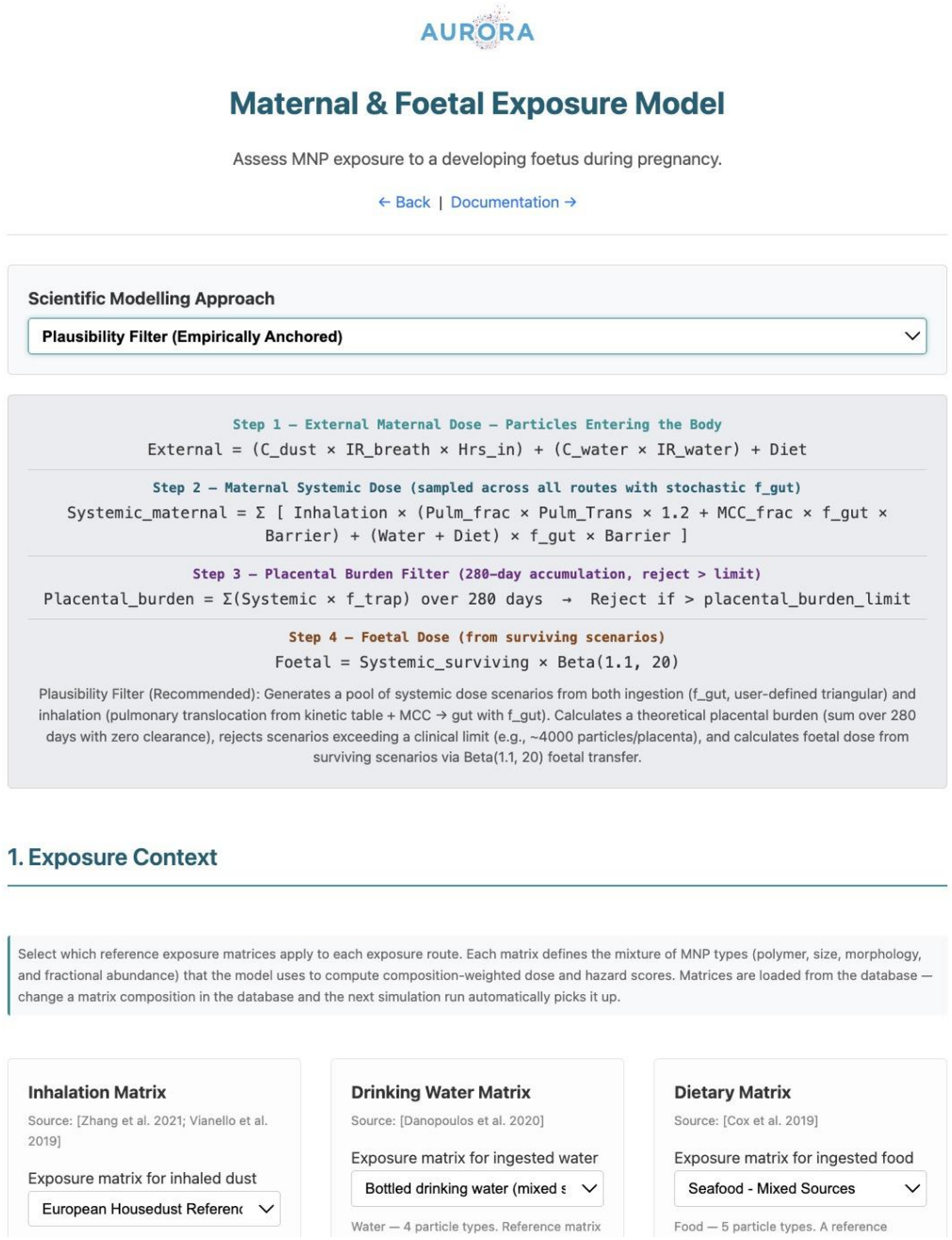
Scenario 4: Toddler (1-3 Years) Exposure

Dual Pathway Modeling

- **Dual Pathways:** Combined modelling of dust ingestion and inhalation.
- **Toy Mouthing:** Direct ingestion of MNPs from plastic toys. *Data poor**
- **Chemical Migration:** Leaching of additives through saliva contact. **Methodological Placeholder**

How the Models Work

- Inputs are reference matrices and parameter ranges (e.g. breathing rates, water consumption)



How the Models Work

- Inputs are reference matrices and parameter ranges (e.g. breathing rates, water consumption)
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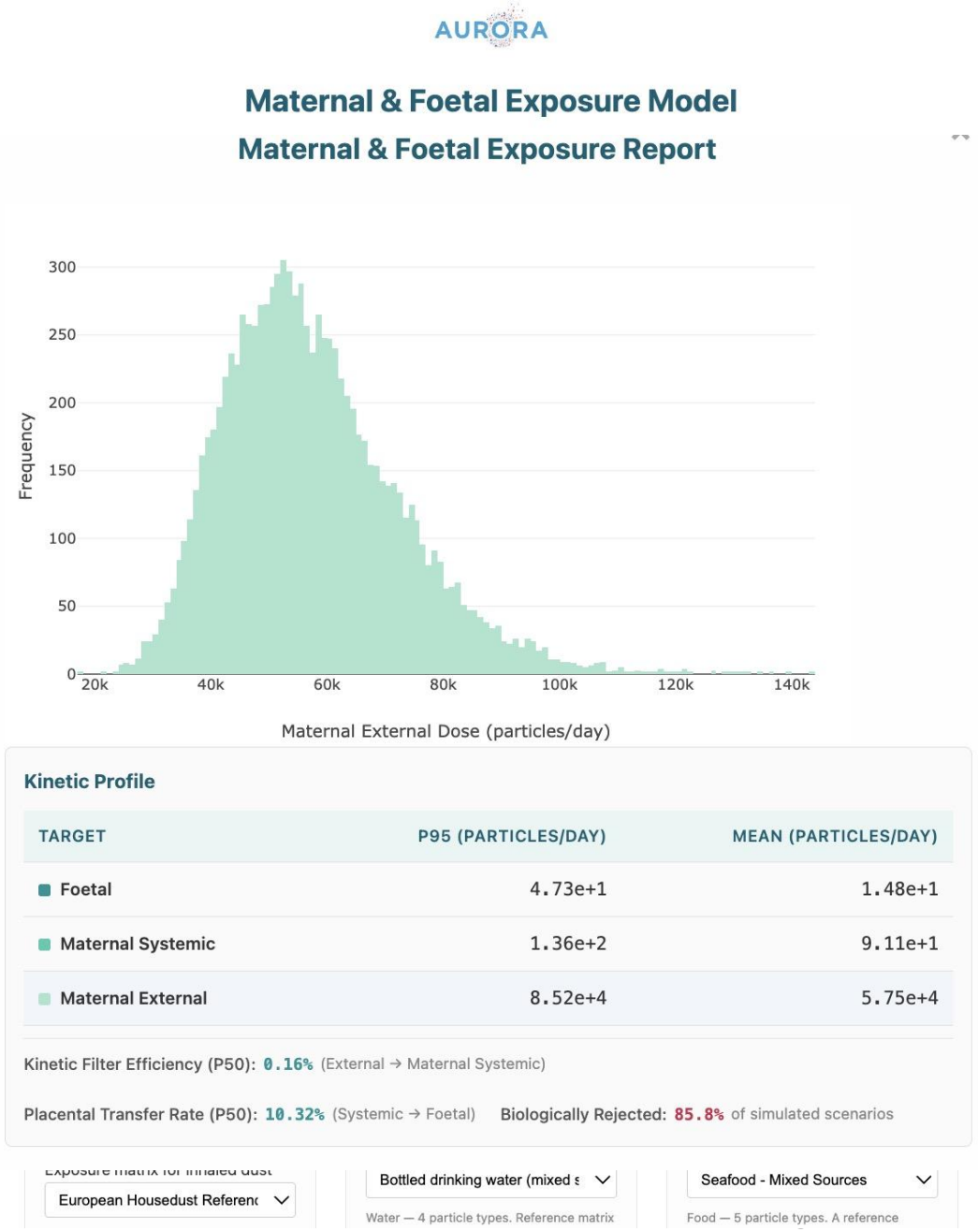

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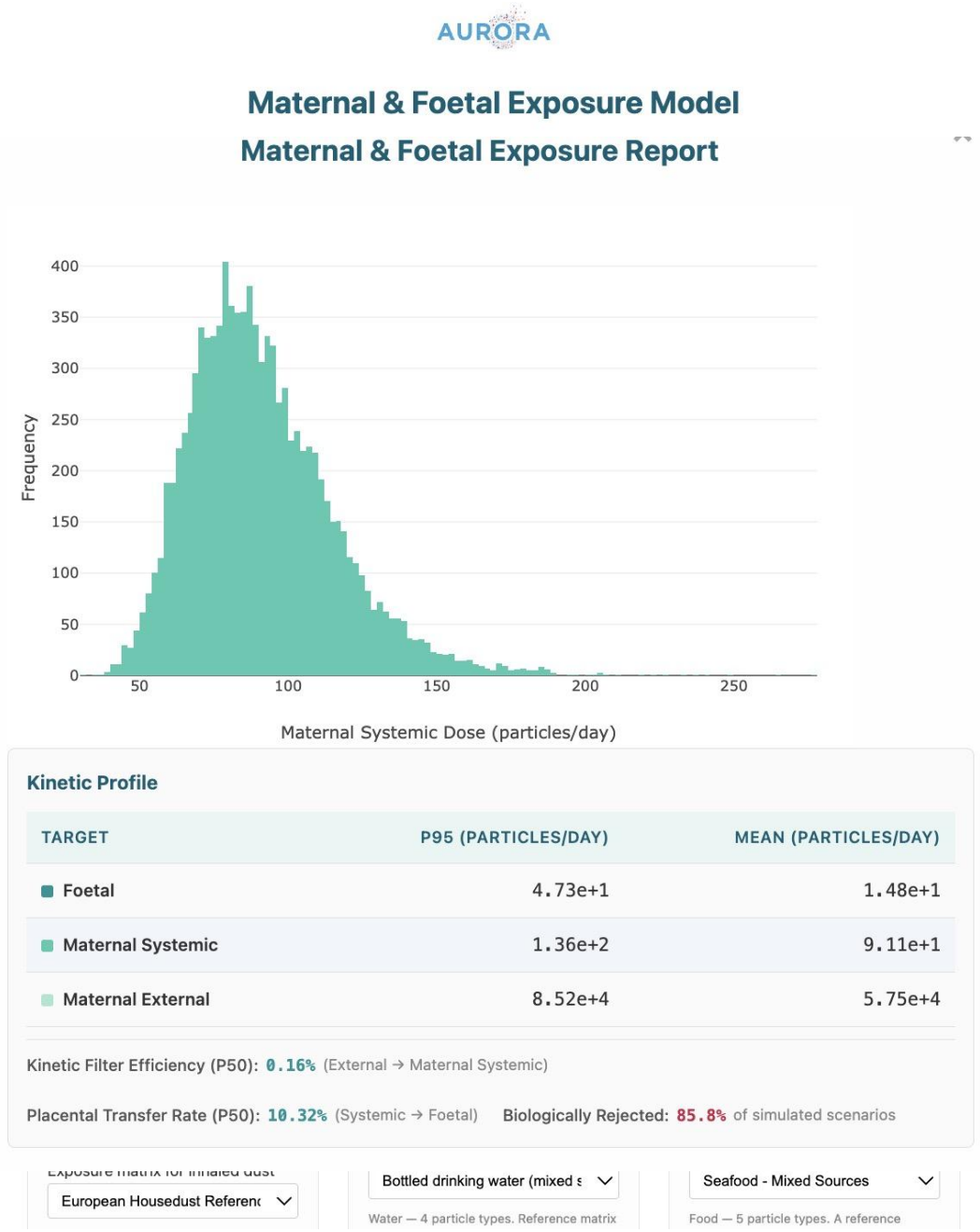

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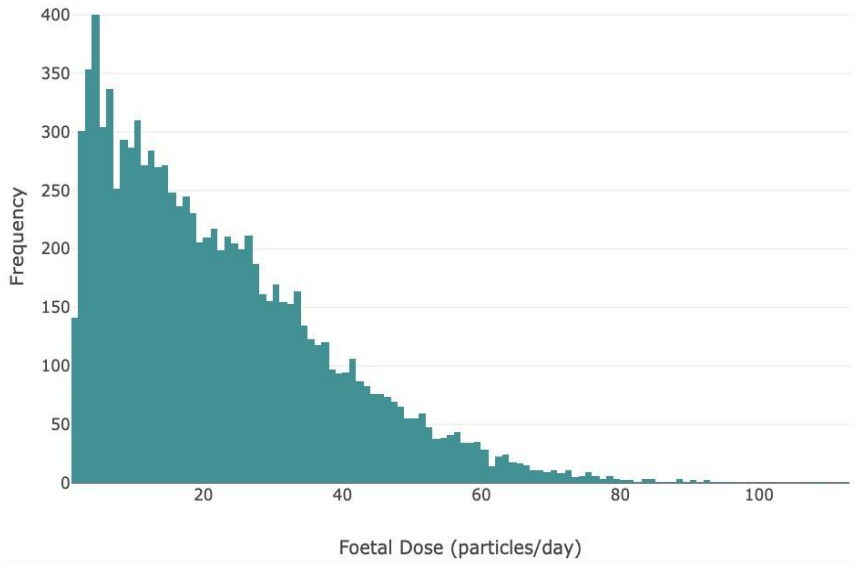
AURORA

Maternal & Foetal Exposure Model

Maternal & Foetal Exposure Report



Kinetic Profile

TARGET	P95 (PARTICLES/DAY)	MEAN (PARTICLES/DAY)
Foetal	5.36e+1	2.23e+1
Maternal Systemic	1.37e+2	9.14e+1
Maternal External	8.56e+4	5.76e+4

Kinetic Filter Efficiency (P50): **0.16%** (External → Maternal Systemic)

Placental Transfer Rate (P50): **21.57%** (Systemic → Foetal)

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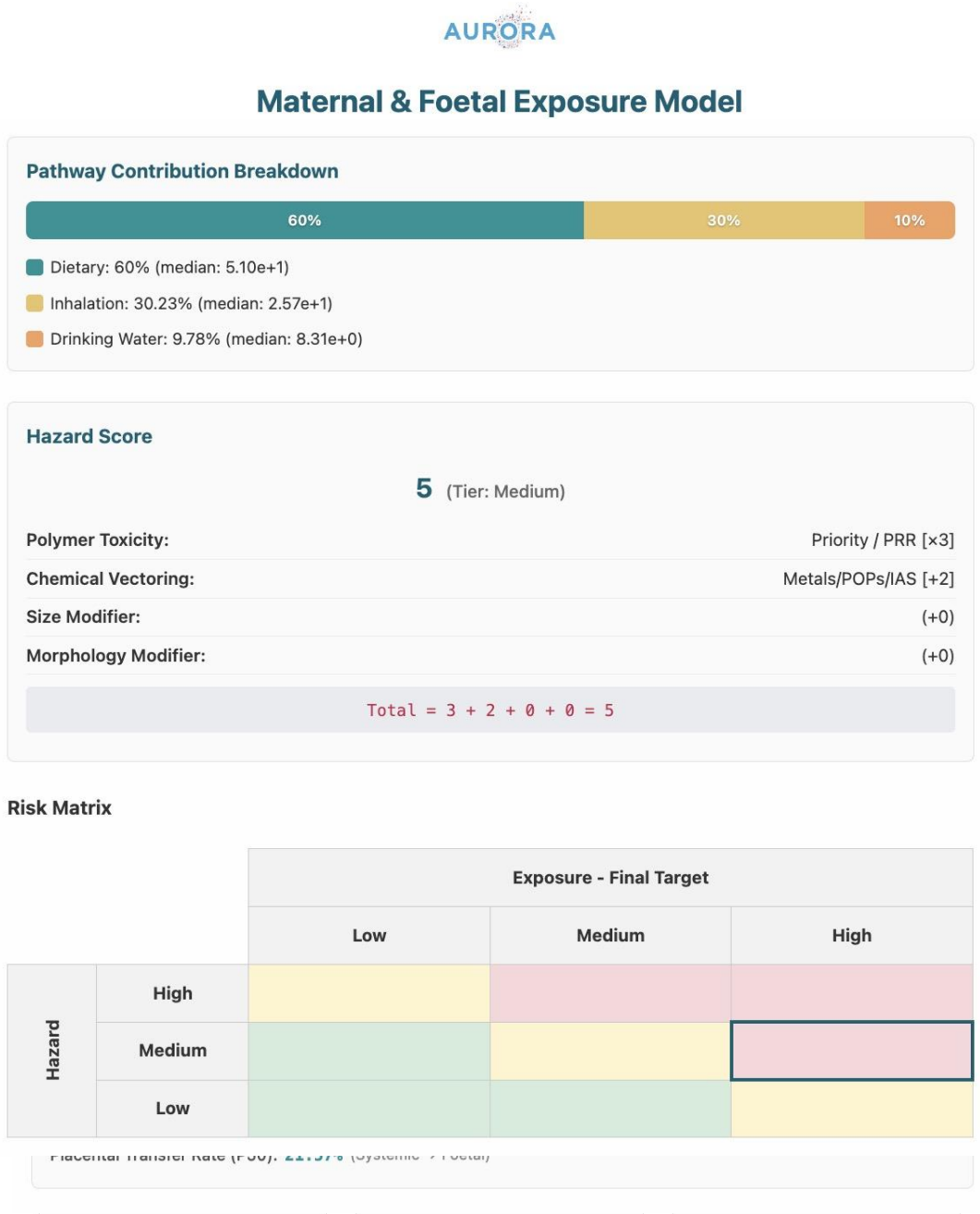
- Particle **size and morphology aware**, allows modelling of deposition & translocation kinetics.



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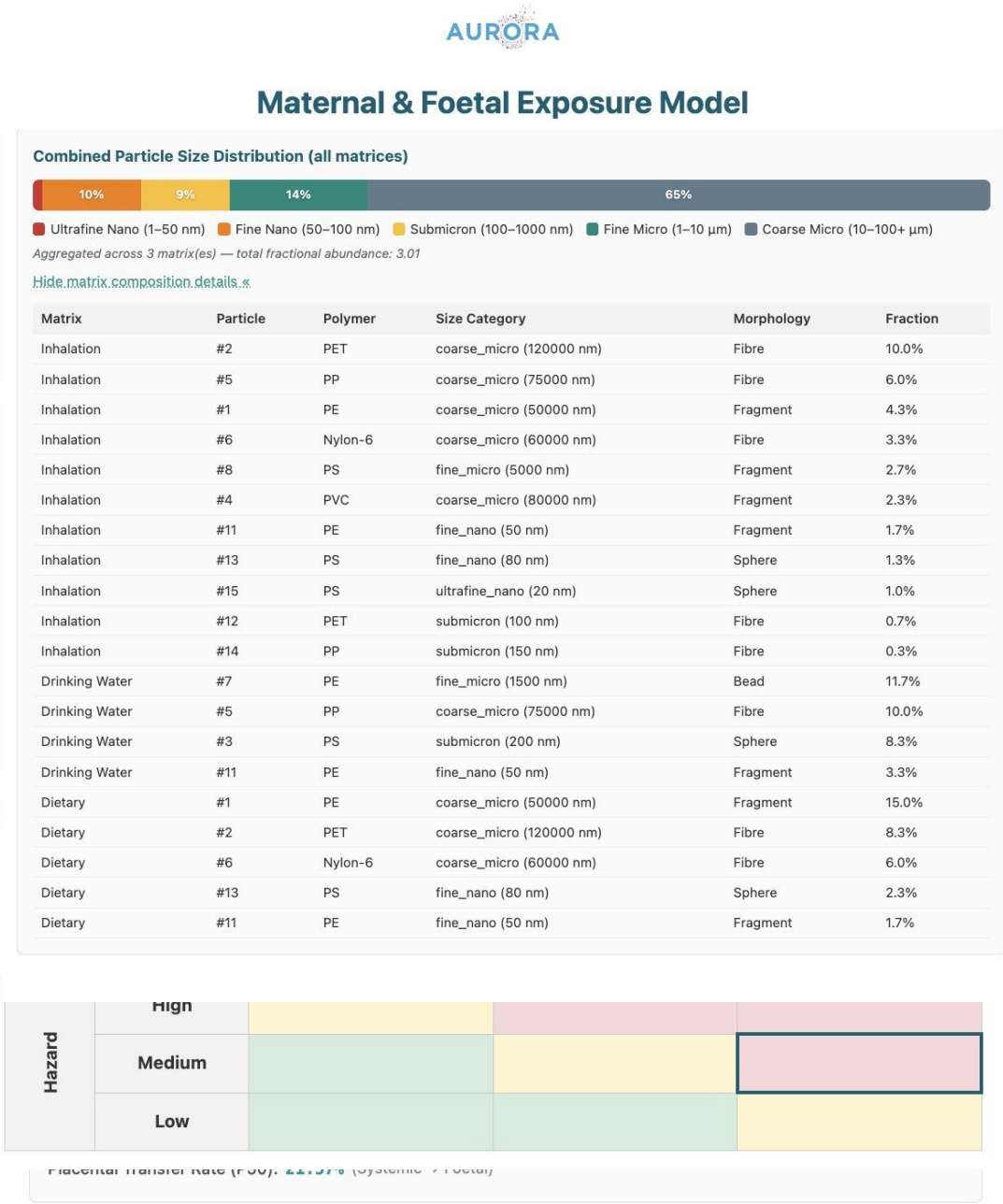
- Inputs are reference matrices and parameter ranges (e.g. breathing rates, water consumption)
- The models simulate 10,000 'days in the life' to calculate **average** and **worst-case exposures**.
- Particle **size and morphology aware**, allows modelling of deposition & translocation kinetics.
- Elucidation of **priority exposure pathways** (dust ingestion, feeding bottles).
- Risk (Hazard x Exposure) indicated in a 3x3 **Matrix**.



A Scalable Risk Assessment Framework

- Applies exposure models to derive **actionable risk mitigation strategies**.
- Delivers an infrastructure for **standardised MNP datasets**.
- Incentivises **high quality data generation**.
- Enforces scientific **transparency** that **confronts uncertainty**.
- Charts a **roadmap** to fully **quantitative** and **cumulative** risk assessments.
- Offers a clear **strategic direction** for researchers and policy makers.

Thank You...