Aggregate exposure assessment for PFAS using environmental data and human biomonitoring

Partnership for the Assessment of the Risks from Chemicals

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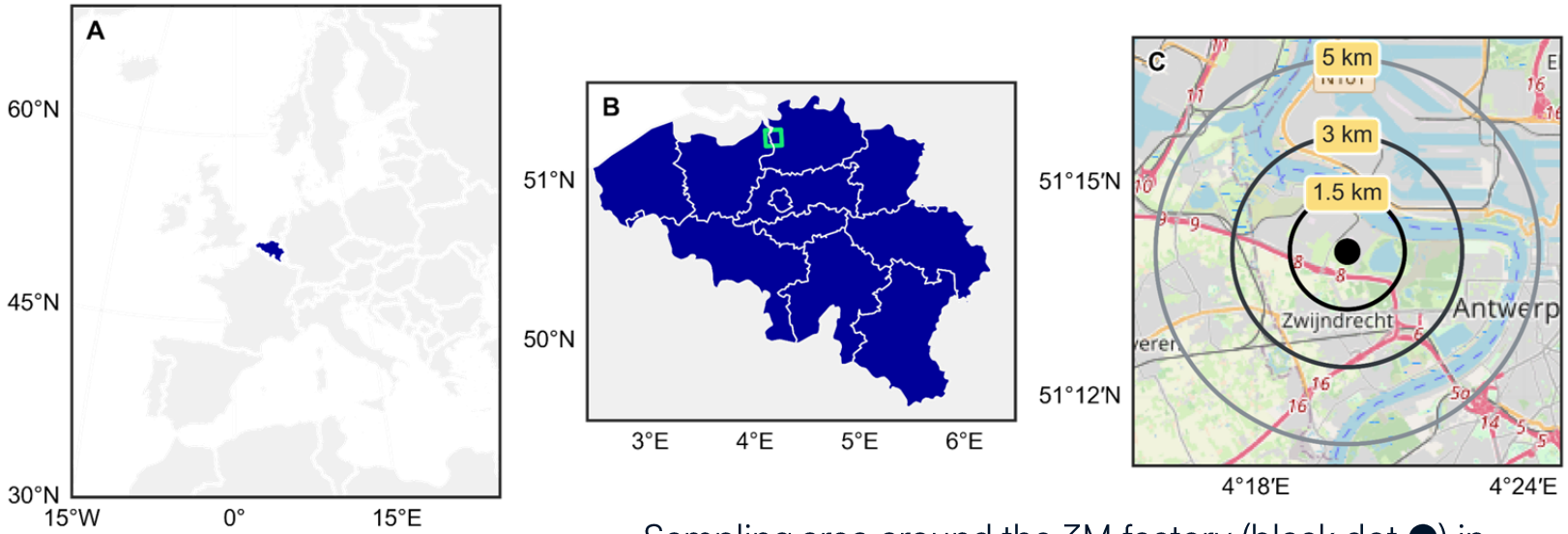
PARC

Study overview

Soil contamination rediscovery in 2019 accelerates PFAS action plan

- Around the 3M factory in Zwijndrecht Belgium
- In 2021, temporary no-regret measures were announced
- New environmental and human biomonitoring study started

The Brussels Times' article, 29/06/2021

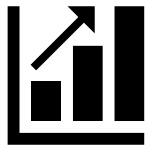


Sampling area around the 3M factory (black dot ●) in Zwijndrecht, Belgium

Research questions

Human biomonitoring

To what extent have adolescents around 3M been exposed to PFAS?



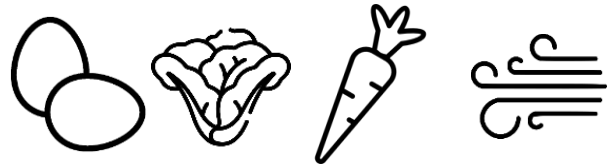
→ Information on the level of PFAS in the bodies of adolescents around 3M

What does this exposure do to adolescents' bodies?

→ Information on health outcomes of adolescents around 3M

Environmental sampling

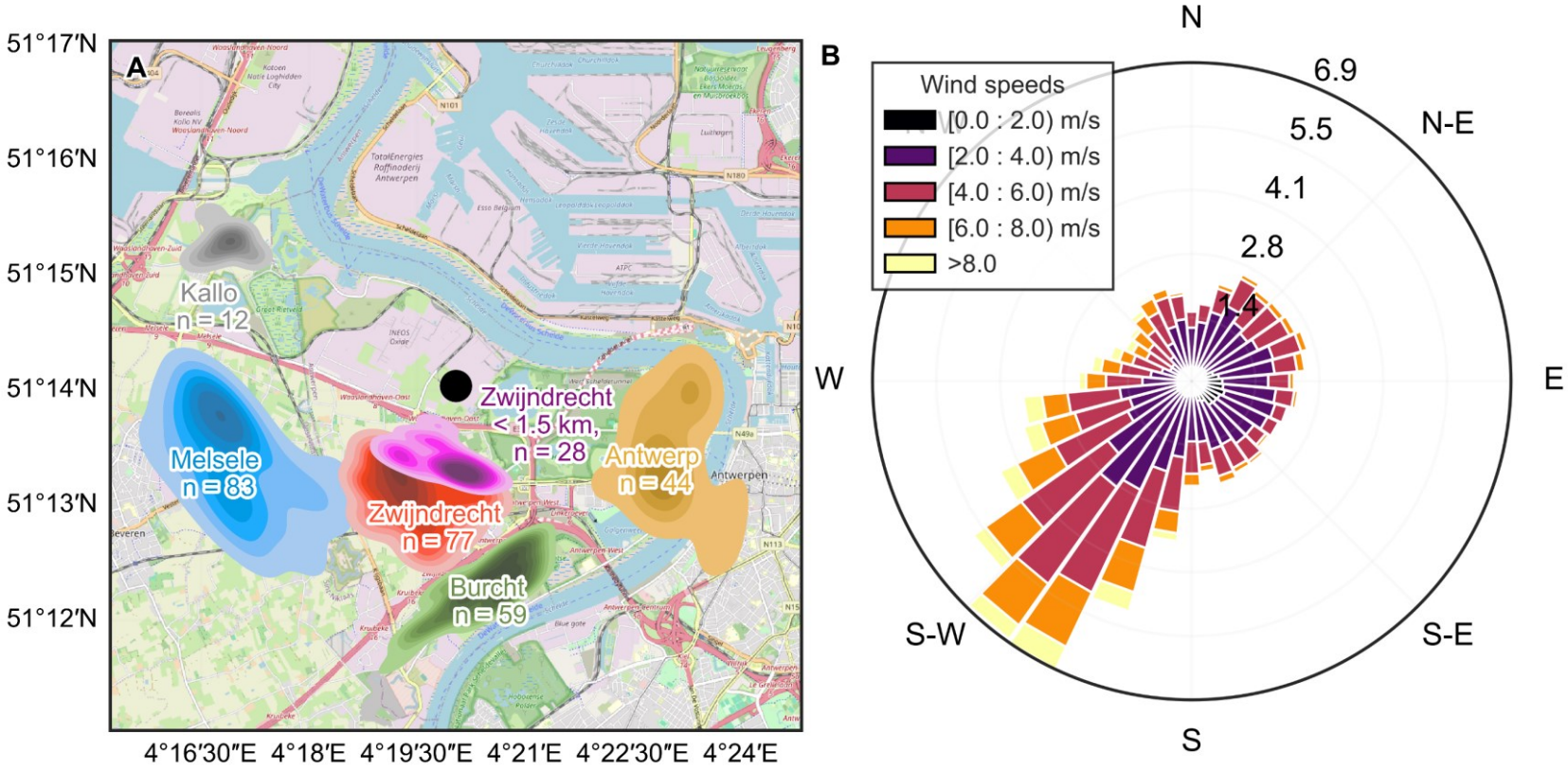
How do PFAS enter the body?



→ Information on the relative importance of different exposure routes for the adolescents

Human biomonitoring and environmental study

- *n* = 303 adolescents (12-17y, 155 ♀, 148 ♂) from <5 km from the plant, living there for >5y
- Subdivided into 6 clusters based on municipality
- Blood and environmental samples collected and analyzed for 21 PFAS compounds



6 spatial clusters of the participants (**A**) and the dominant wind direction in the area (**B**)

Samples and information collected

- Human samples
  - Blood/serum from 301 participants
- Environmental samples

Household dust

n = 129

Rainwater

n = 54

Soil vegetable garden / chicken coop / greenhouse

n = 62/38/10

Compost

n = 36

Eggs

n = 37

Vegetables / fruit / nuts

n = 61

Potato, *n* = 3
Leafy v., *n* = 8
Stem v., *n* = 17
Root v., *n* = 6
Bulbous v., *n* = 5
Cabbages, *n* = 6
Legumes, *n* = 6
Small fruit, *n* = 29
Tree fruit, *n* = 33
Nuts, *n* = 6

- Other information:
  - Length, weight, abdominal- and waist circumference, blood pressure
  - Questionnaires
  - Geographic information

Modelling

External and internal exposure

Modelling workflow

- Model **external exposure** using **S-Risk*** model
  - Based on measured levels in soil, house dust, vegetables and eggs; as well as levels in commercial food

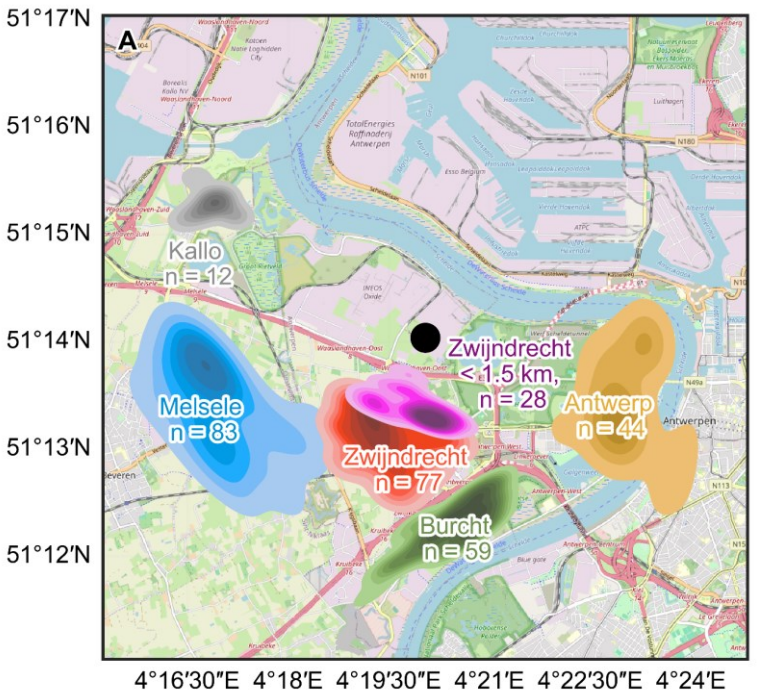
- Model **internal exposure** using **MERLIN-Expo**** model
  - Based on modelled external exposure
  - Comparison with measured serum levels

- Focus on **oral** exposure

Modelling workflow — external exposure

- Scenario-based, per spatial cluster* (using geometric means)
  - Local egg consumption either 2/week for adolescents (current for areas without known pollution) or 4/week**

Routes of exposure → / Scenario ↓	Soil	House dust	Local vegetables	Local eggs	Commercial food background	Drinking water
Ornamental garden	✓	✓	✗	✗	✓	✓
Vegetable garden	✓	✓	✓	✗	✓	✓
Chicken coop	✓	✓	✗	✓	✓	✓
Vegetable garden + chicken coop	✓	✓	✓	✓	✓	✓



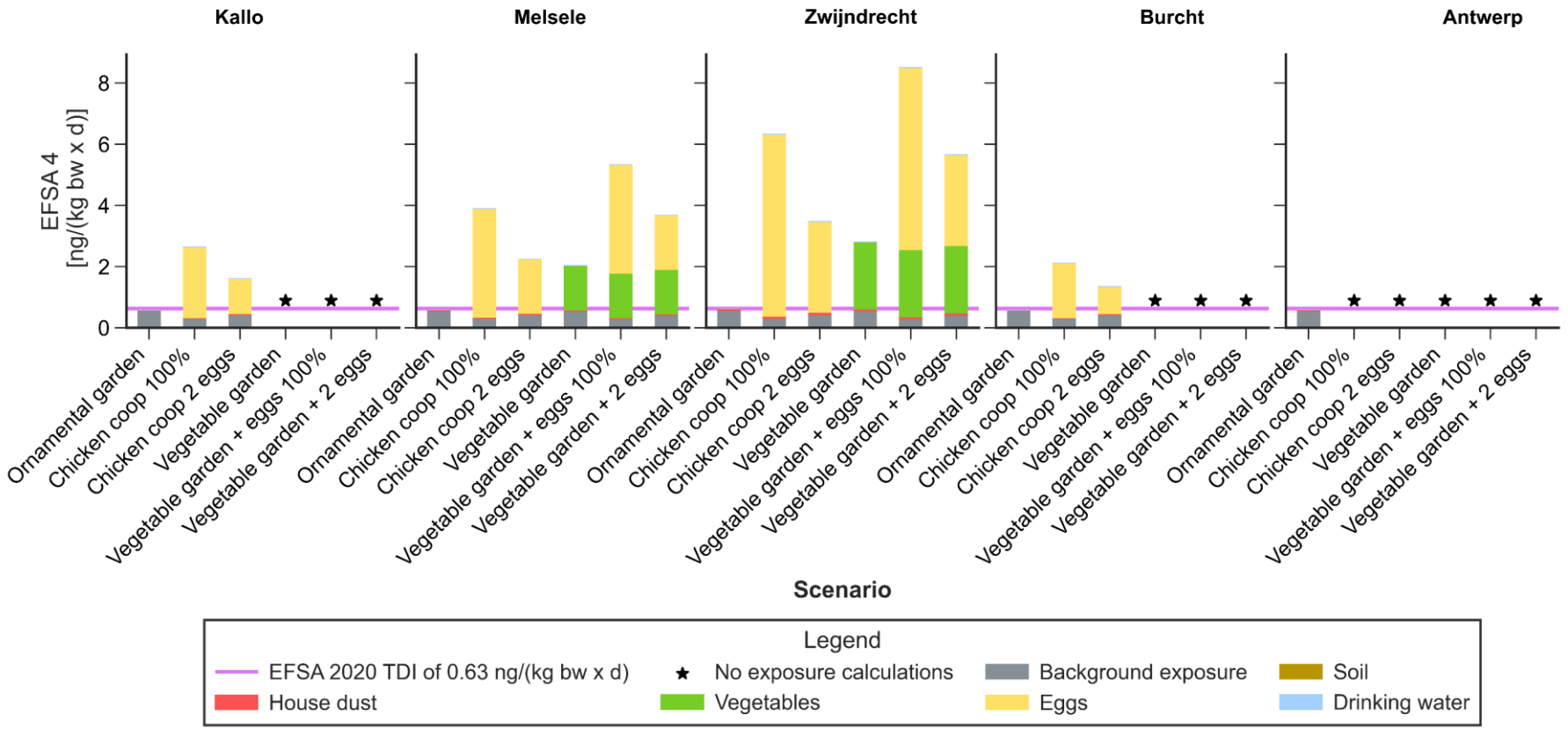
*Zwijndrecht <1.5 km not modelled due to limited number of environmental samples, **no-regret measures in Zwijndrecht: advice to not eat local eggs

Modelling workflow — external exposure

- Number of scenarios per cluster based on available environmental measurements
- Selected compounds
  - EFSA 4*: $PFOS_{total}$, $PFOA_{total}$, $PFHxS_{total}$ and PFNA
  - 2 additional PFAS associated with eggs and vegetables: PFBA and PFDA

*EFSA CONTAM Panel (2020), https://doi.org/10.2903/j.efsa.2020.6223

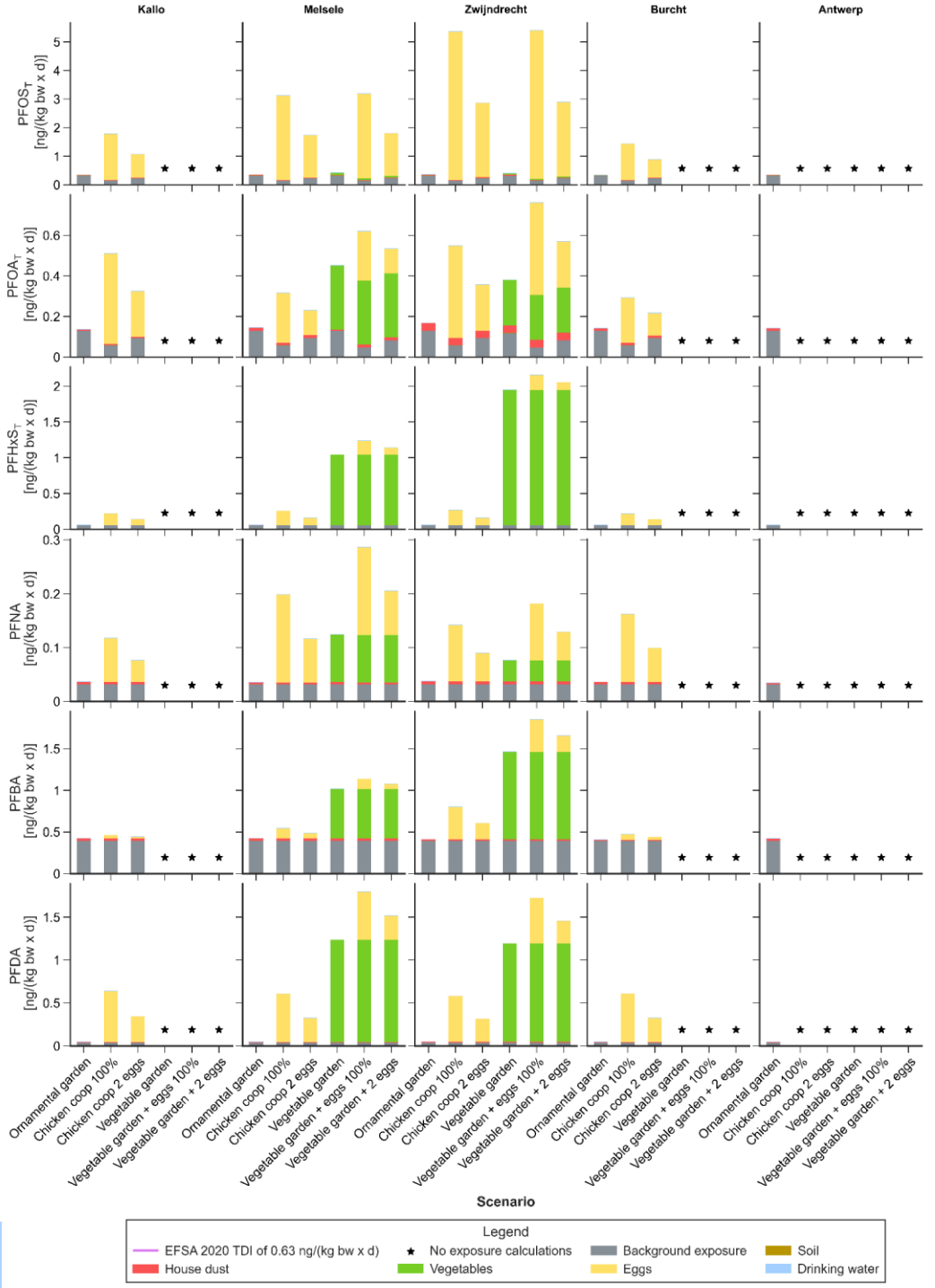
Modelling workflow — external exposure



- Age group 6-15 years
- Consumption of local vegetables and/or eggs → oral exposure > EFSA 2020 TWI
- Local eggs > local vegetables > background commercial food > soil, dust and drinking water
- Despite high levels in dust, oral exposure is limited due to low intake

Modelling workflow — external exposure

- $PFOS_{total}$ dominates oral exposure through consumption of local eggs(■), even though production stopped in 2002*,**
- PFNA has lowest contribution
- $PFHxS_{total}$ becomes important when local vegetables (■) are considered, as well as PFBA and PFDA



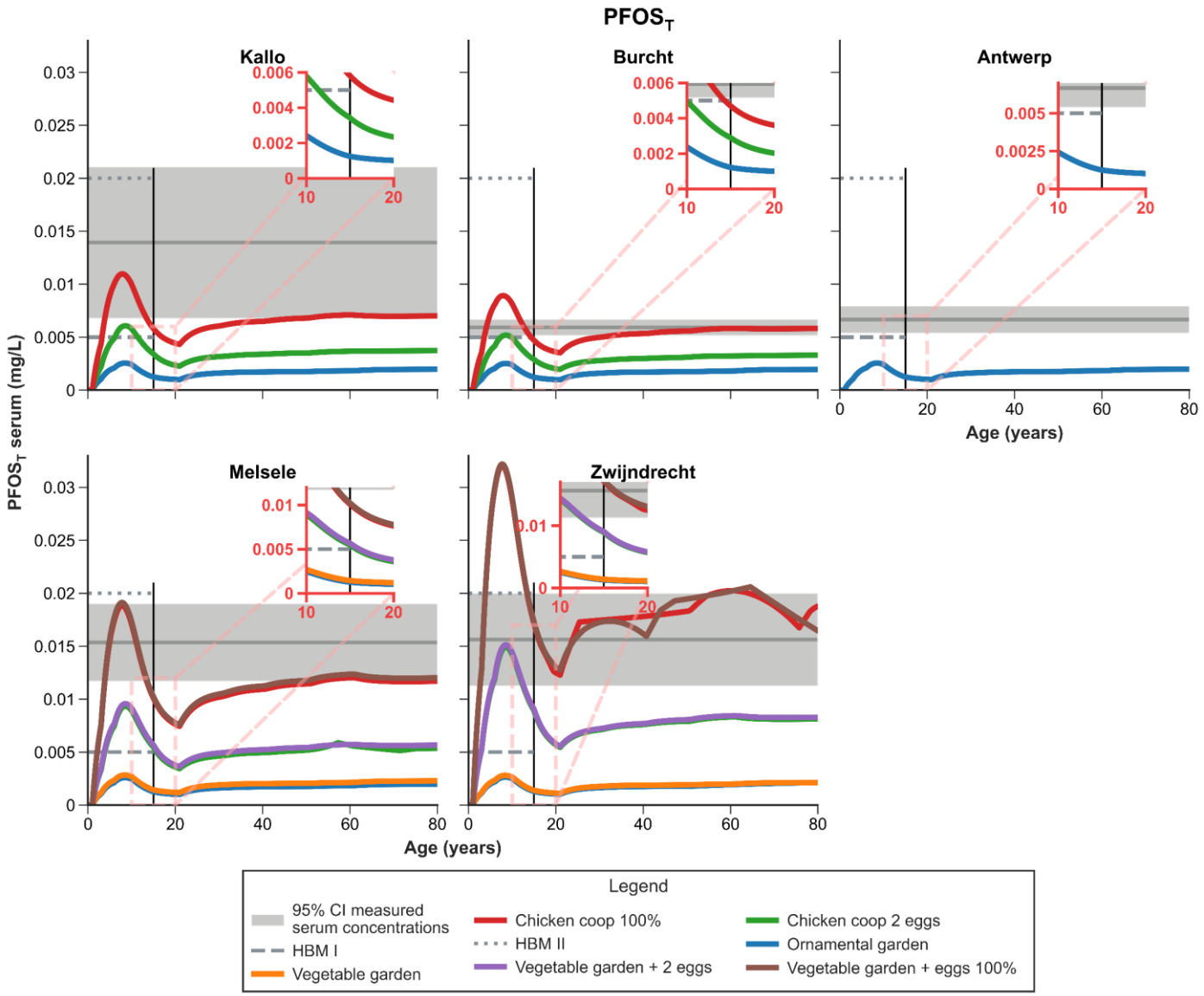
*EPA and 3M announce phase out of PFOS (2000), https://www.epa.gov/archive/epapages/newsroom_archive/; **they did keep discarding contaminated water, https://www.vrt.be/vrtnws/nl/2021/07/05/3m-loosde-grote-hoeveelheden-pfos-in-de-schelde

Modelling workflow — internal exposure

- Input for the PBK model from MERLIN-Expo is the output of S-Risk
- Modelling over entire lifetime: external exposure calculated per age group; environmental levels assumed constant
- Only for $PFOS_{total}$ and $PFOA_{total}$: model parameter values only available for those 2 compounds*
- PBK model output at age 15 compared to the average adolescent serum values (± 95% CI) per spatial cluster

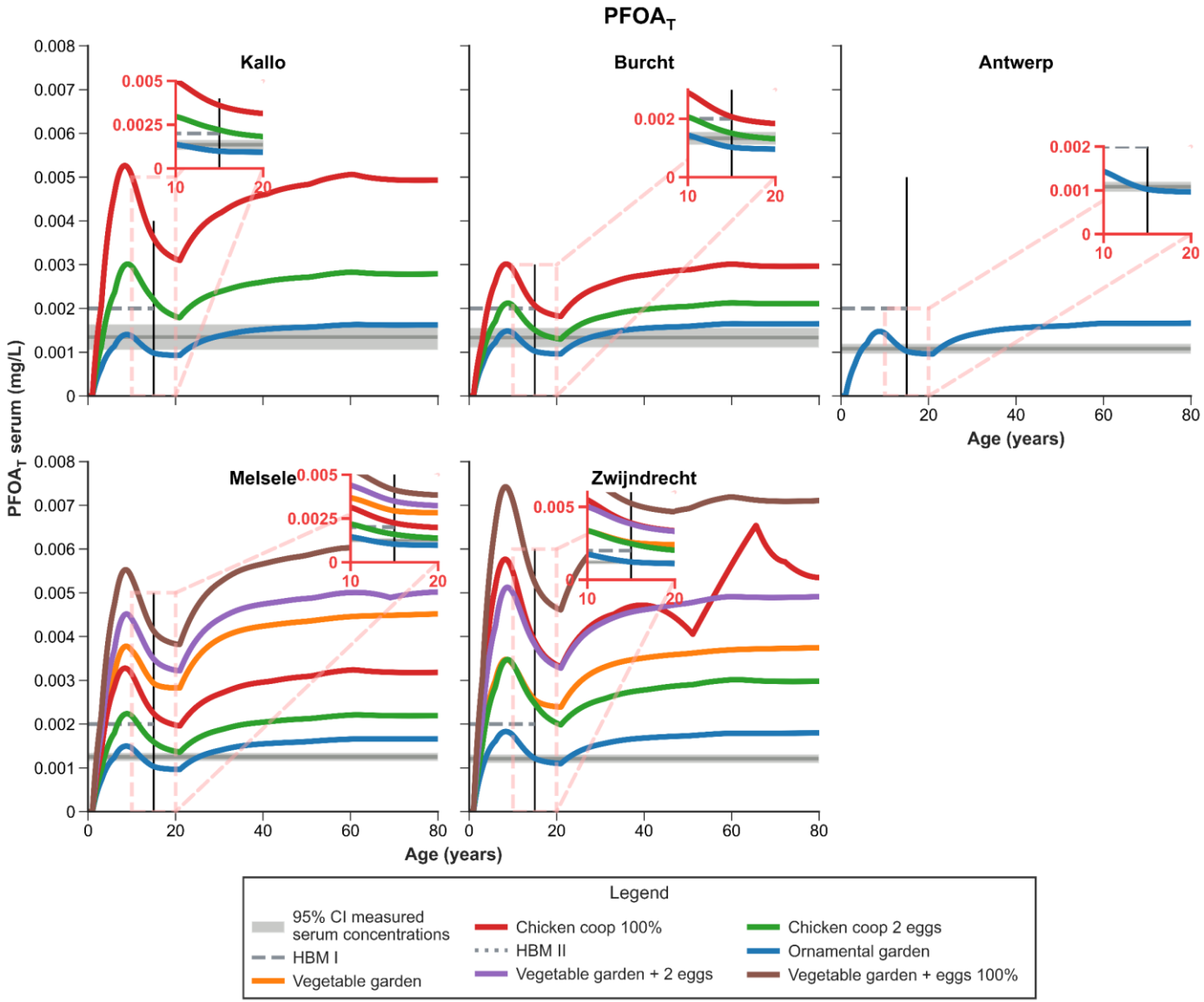
*Brochot C. and Quindroit P. (2018), https://doi.org/10.1007/978-3-319-59502-3_10, based on Loccisano A.E. *et al.* (2011), https://doi.org/10.1016/j.yrtph.2010.12.004

Modelling workflow — internal exposure $PFOS_{total}$



- Predicted serum concentrations < measured serum concentrations
- Impact of eggs > vegetable garden, same as for external exposure
- Average values per spatial cluster, no individual calculations (for now)

Modelling workflow — internal exposure $PFOA_{total}$



- Predicted serum concentrations > measured serum concentrations
- Serum levels less variable than for $PFOS_{total}$
- Impact of vegetable garden larger than for $PFOS_{total}$
- Average values per spatial cluster, no individual calculations (for now)

Conclusion

- Limited number of environmental samples in certain spatial clusters → high uncertainty on exposure route attribution
- The general no-regret measures (limit local egg and vegetable intake) still hold
  - Background from commercial food is already close to EFSA TWI for the EFSA 4 compounds
- Working with averages per spatial cluster provides insight for measures per cluster
- Working with averages discards a lot of the information of individual measurements → ongoing work

Contact & acknowledgments

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Modelling workflow — internal exposure $PFOS_{total}$ — possible reasons underestimation of the model

- Exposure through consumer products (cosmetics, cookware, PFAS sprays,…) and breastfeeding not considered in the model
- Possible underestimation of exposure through drinking water:
  - Considered part of the 'background' exposure from EFSA, uses a lower bound level of 0.61 ng/L for PFOS
  - Levels can vary between 0.5-1 ng/L up until 10 ng/L → analysis of drinking water recommended
- PFOS is a breakdown product of several precursors, which are not considered
- Some clusters: scenarios calculated with limited exposure, but some participants likely do eat home-grown vegetables and/or eggs