Human biomonitoring teenagers study in the area of 3M

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study commissioned by

Flanders
State of the Art

study conducted by

Universiteit Antwerpen
UHASSELT
KNOWLEDGE IN ACTION
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Participants

303 teenagers

- **live within a 5 km radius of 3M**
- **live in the area for at least 5 years**
- **age: 12 to 17 years**

Main goal

Assessing what it means in terms of environmental health for teenagrs to grow up in the region near 3M's PFAS production site in Zwijndrecht

Divided into 4 sub-goals

Goal 1

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

→ measuring PFAS in the body

Goal 2

What does this exposure do in teenagers' bodies?

→ biological and health effects

All participants

→ **Human biomonitoring** (HBM)

blood/serum

urine

Other data:

- Height, weight, abdominal and hip circumference, blood pressure
- Questionnaires
- Geographical data based on their home address

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Goal 3

innovative

How are participants exposed to PFAS?

→ measuring PFAS in the environment at their home address

In subpopulations

→ environmental measurements

house 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

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Goal 4

How do teenagers experience the problem?
What are their concerns on PFAS as ”forever chemicals’?

perception

All participants

- Are they worried? About what?
- What are their information needs?
- Who do they trust most to inform them?
- …

Which PFAS were measured?

start list of 43 PFAS

- **results of 50 soil samples**
- **results of 50 serum samples**
- **information from other PFAS projects**

selection of PFAS

- **21 linear PFAS**
- **5 PFAS (total) – linear + branched**

total = 26

Selection PFAS
Perfluorocarboxyl acid (13)
PFBA, PFPeA, PFHxA, PFHpA, PFOA linear, PFOA linear and branched,
PFNA, PFDA, PFUnA, PFDoA, PFTrDA, PFTeDA, PFHxDA
Perfluorosulfonate acid (6)
PFBS, PFHxS linear, PFHxS linear and branched,
PFHpS, PFOS linear, PFOS linear and branched
Precursors and substitute products (7)
FBSA, MePFOSAA linear, MePFOSAA linear+branched
EtPFOSAA linear, EtPFOSAA linear+branched, 6:2 FTS, 6:2 diPAP

Which health effects were measured?

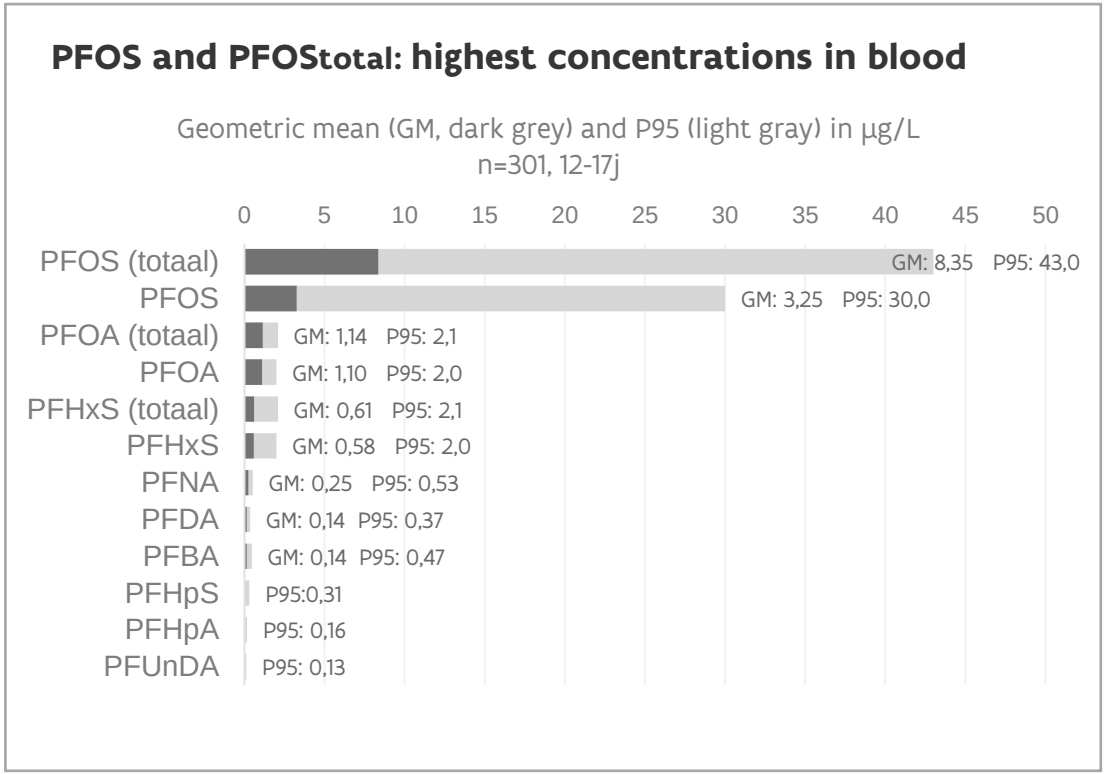
innovative

selection based on scientific literature

Immune system	Defense cells, antibodies, cytokines, C-reactive protein asthma, allergy, infections
Blood fat	Cholesterol, HDL, LDL, triglycerides
Thyroid function	Hormones involved in thyroid function
Puberty development	Sex hormones (boys), questionnaire (boys and girls)
DNA repair	8-oxo-deoxyguanosine
Cardiometabolic	Blood pressure, waist and abdominal circumference, BMI
Diabetes	Glycosylated hemoglobin
Kidney function	Cystatin C, alfa-1-microglobulin
Liver function	Liver enzymes

Main messages

1. Teenagers' exposure in the region mainly to PFOS (linear) and PFOStotal (linear + branched forms)



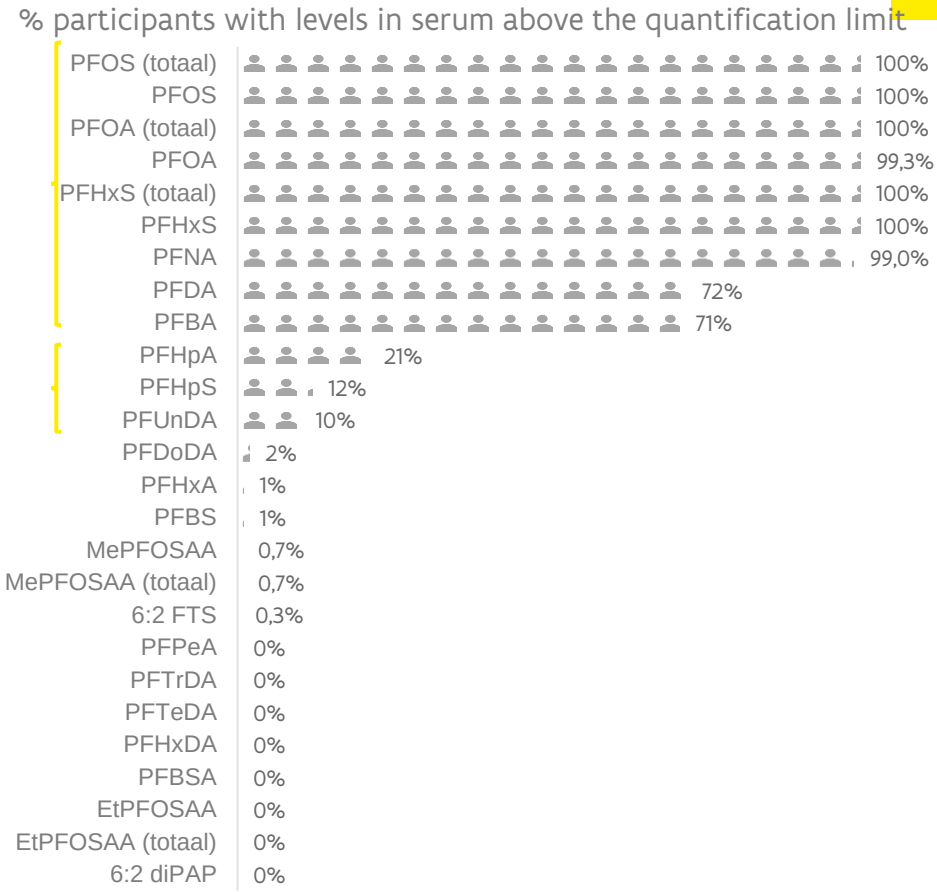
1.Teenagers' exposure in the region mainly to PFOS (linear) and PFOS total (linear + branched forms)

Action limit exceeded for PFOS, not for PFOA

	Under HBM-I **Control level** *No adverse health effects expected* PFOS: 5 µg/l PFOA: 2 µg/l	**Between HBM-I en -II** *Adverse health effects ncannot be excluded*	**Above HBM-II** **Action level** *Long term adverse health effects possible* PFOS: 20 µg/l (boys), 10 µg/l (girls) PFOA: 10 µg/l (boys), 5 µg/l (girls)
	% participants	**% participants**	**% participants**
PFOS	72,4%	13,0%	14,6%
$PFOS_{total}$	26,9%	48,2%	24,9%
PFOA	93,4%	6,6%	0%
$PFOA_{total}$	91,0%	9,0%	0%

2.Teenagers in the region around 3M also exposed to a mixture of other PFAS

In serum also: PFHxS, PFOA, PFNA, PFDA, PFBA, PFHpA, PFHpS, PFUnDA



(Almost) all participants

Some participants

Few participants

None of the participants

2.Teenagers in the region around 3M also exposed to a mixture of other PFAS

% observations above LOQ in the different environmental samples

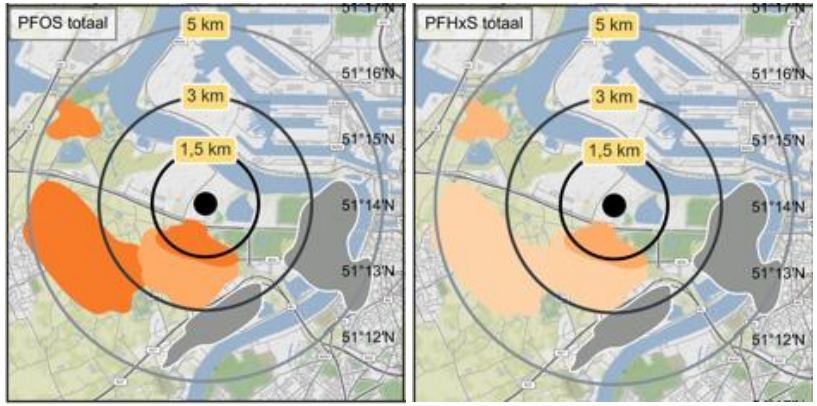
In environmental samples: strong variation depending on type of sample

	0%
	<25%
	25-75%
	>75%

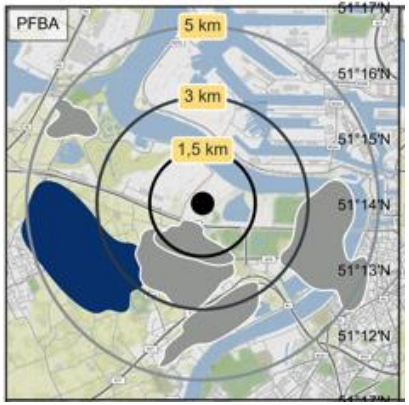
	soil vegetable garden	soil chicken coop	soil greenhouse	compost	egg	small fruit	tree fruit	leaf vegetables	stem vegetables	fruity vegetables	pods	nuts	rain water	house dust
N total	62	38	10	36	37	29	33	8	17	22	6	7	54	129
PFBA	89	64		100	24	24	33	25	6	9	83	14	59	85
PFPeA	65	37	100	36	3	59		25	6	9	50	100	43	75
PFHxA	76	55	90	33	51	48	64	25	71	41	50	29	77	56
PFHpA	68	50	70	11	3		9		12	9	67		79	77
PFOA	100	100	100	81	76	69	61	88	65	55	33	71	94	92
PFOAtotal	100	100	100	81	76	69	61	88	65	55	33	71	98	92
PFNA	87	71	80	11	57	10	9	12	18	14	17		57	90
PFDA	87	84	80	19	100	97	97	100	100	91	100	100	56	94
PFUnDA	45	37	40	6	51	31	61	25	41	32	50	86	4	60
PFDoDA	48	32	30	8	81	72	76	75	76	64	50	100	3	46
PFTrDA	5	11			65	31	27	38	29	23	50			71
PFTeDA	15	8		6	70	3			6					96
PFHxDA					16	59	85	75	88	77	83	86		75
PFBS	90	89	100	100	76	66	52	50	35	41	33	14	59	94
PFHxS	24	37	50	6	8			12					11	95
PFHxStotal	34	45	60	6	8			12					11	96
PFHpS		3			3									64
PFOS	100	100	100	97	86	17	12	62	41	9	17	14	58	89
PFOStotal	100	100	100	100	86	17	12	62	41	9	17	14	64	93
PFBSA	94	97	100	83						5			76	23
MePFOSAA		3			24	69	42	62	59	59	67	14	11	75
MePFOSAAtotal		3			24	69	42	62	59	59	67	14	13	81
EtPFOSAA	13	18	20		14	3	3	12	6	14	17		8	86
EtPFOSAAtotal	15	18	20		14	3	3	12	6	14	17		9	88
6:2 FTS	6	13			14		21	12	12	14	50	14	24	61
6:2 diPAP	5	11												

3.Geographical differences in PFAS serum levels

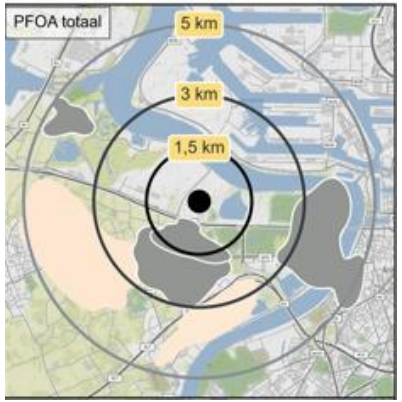
% difference compared to cluster Antwerpen (darker = more difference)



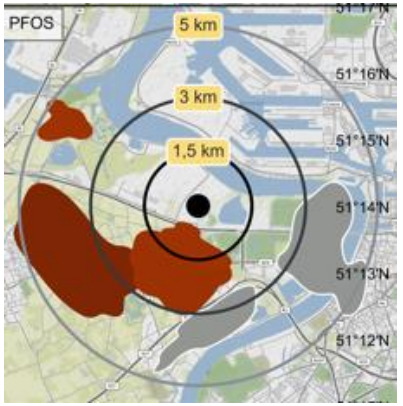
Higher closer to 3M, ex. PFOStotal and PFHxStotal



PFBA lower in Melsele

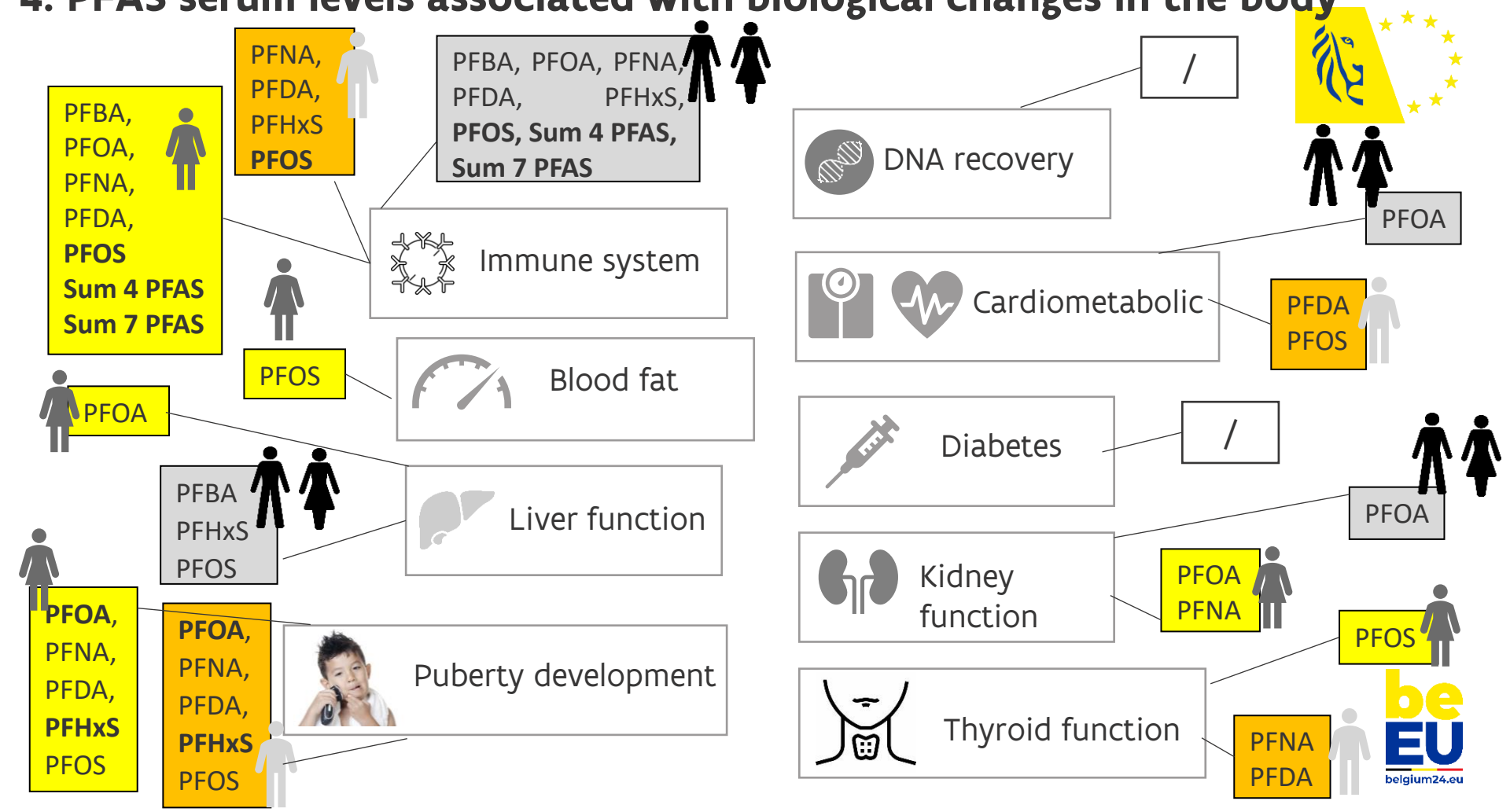


PFOA slightly higher in Burcht



Higher in Melsele and Kallo, vb. PFOStotal, PFOS en PFHxStotal

4. PFAS serum levels associated with biological changes in the body



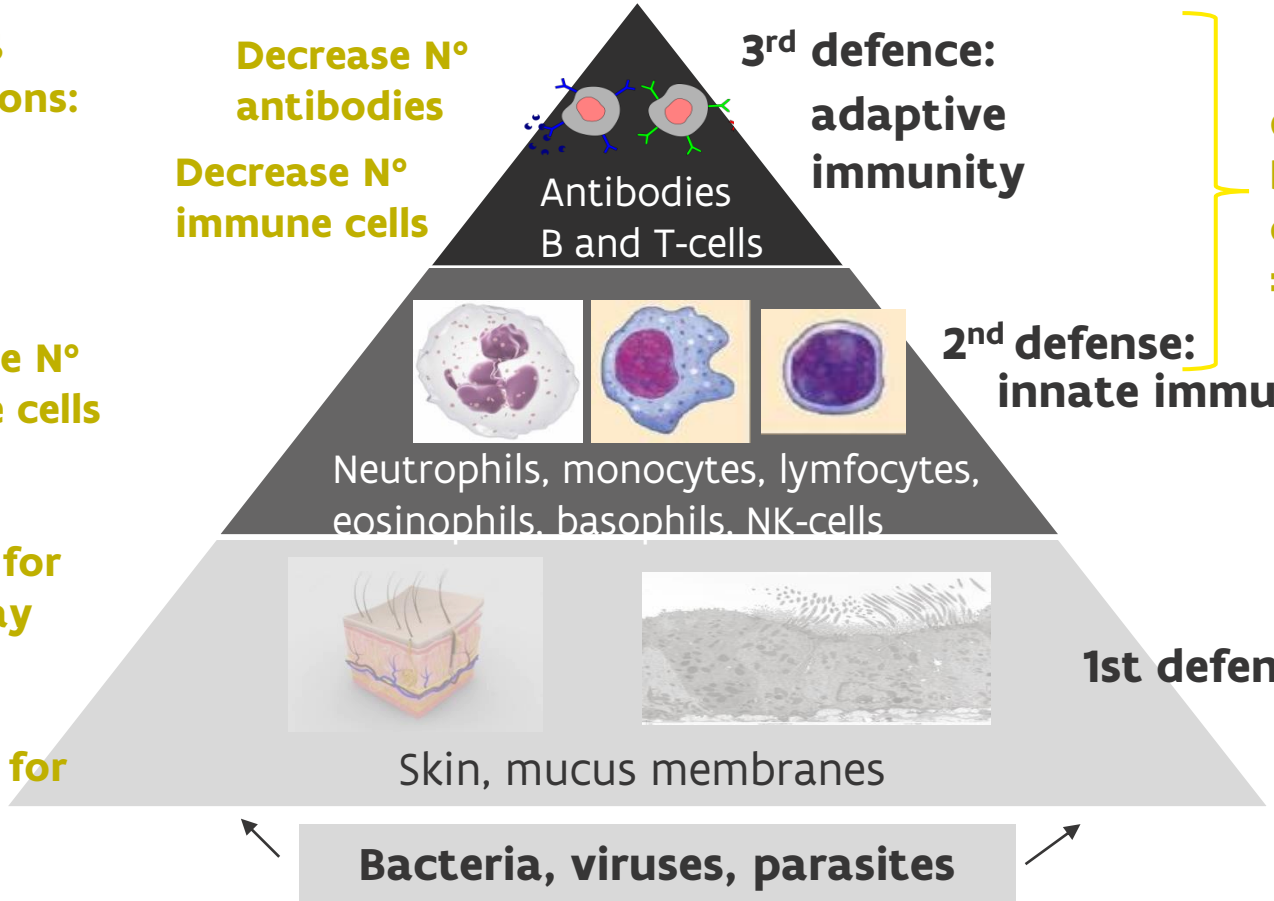
5.Higher PFAS serum levels associated with early warnings for a reduced immune respons

Higher PFAS concentrations:

- **Decrease N° antibodies**
- **Decrease N° immune cells**
- **Decrease N° immune cells**

Also:

- **Lower risk for asthma, hay fever and eczema**
- **Higher risk for infections**



3rd defence: adaptive immunity

2nd defense: innate immunity

1st defense: barrier

Communication between cells: cytokines = disturbed

6. PFAS disturb the hormonal balance during puberty

With an increase in PFAS, we observe:

HORMONES

↓ **Luteinising hormone (LH)**
Folicle stimulating hormone (FSH)

Boys

↑ **Sex hormone binding globulin (SHBG)**

↓ **Progesteron**
↓ **Testosteron**
Inhibine B
Oestradiol

Indication of a central disturbance of the production of LH in the brain (boys)

↓ **Boys**
- **Facial hair**
- Voice change

↓ **Girls**
- **Breast development**
- Menstruation

↓ **Boys and girls**
- **Growth spurt**
- **Body hair**
- Skin change
- **Length**

↓ **Puberty**
- **Achieved puberty stadium (by age)**

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7. Locally grown food (home or other gardens) = important exposure route

Soil chicken coop

- → **PFOS-total: 24% > guidance value**
- → PFOA-total: no exceedance

Soil vegetable garden

- → **PFOS-total: 32% > guidance value**
- → PFOA-total: no exceedance

Eggs: > max. conc. commercial eggs

- → **PFOS-total: 78%**
- → **PFOA-total: 57%**
- → PFHxS-total: 8%
- → PFNA: 3%

Home-grown vegetables, fruit and nuts: diverse PFAS-pattern for different kind of crops

Calculated oral intake PFOS + PFOA + PFHxS + PFNA above EFSA-guidance value when:

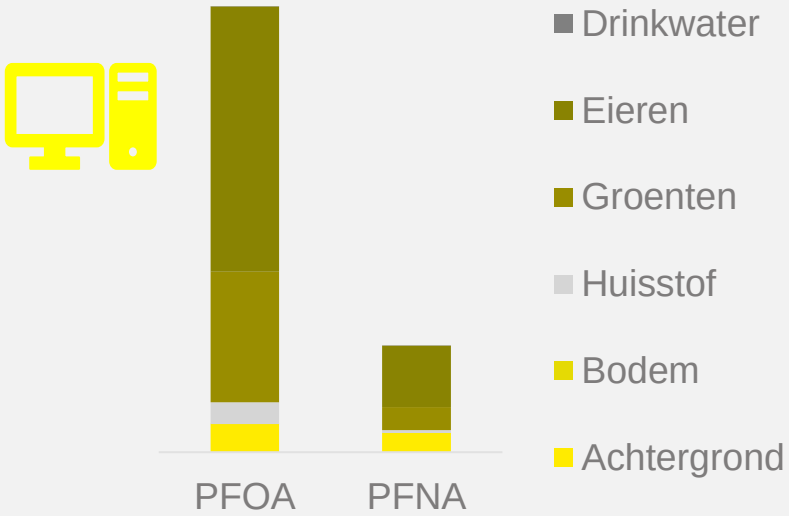
- → Consumption local eggs
- → Consumption local vegetables

8. Ingestion of house dust less important exposure route for teenagers in comparison to food

Calculation oral intake

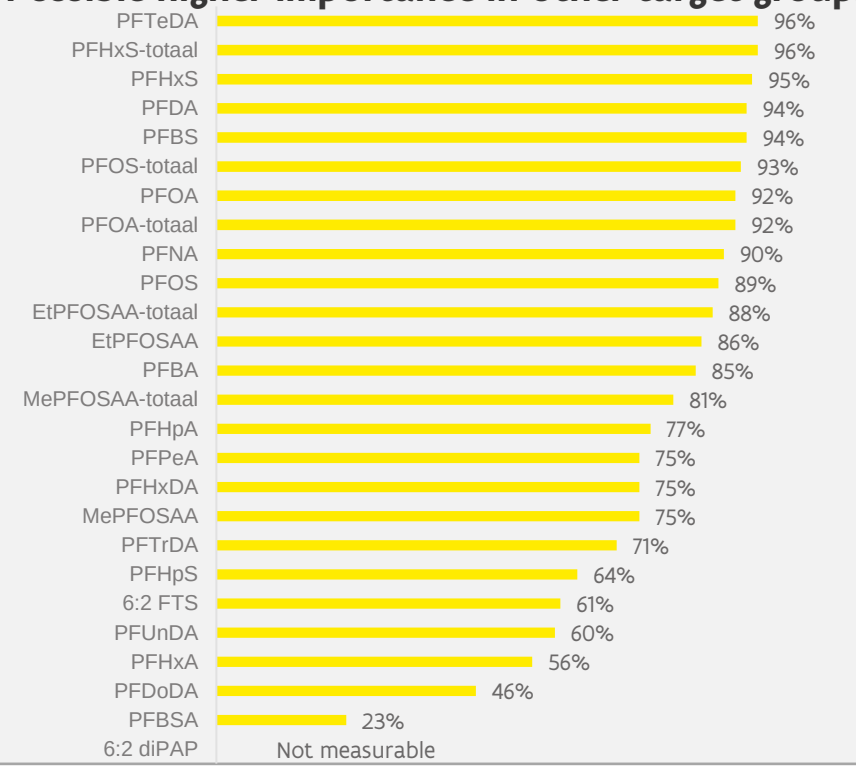
→ Contribution of dust ingestion lower than food

ng/kg body weight x day



25/26 measured PFAS observed

Possible higher importance in other target groups



9. Other sources

PFAS results in rain water are very low
→ can be used as irrigation water

Background exposure due to food from the supermarket is also important

Consumer products are also important: use of lubricants or PTFE-products for hobbies (ex. bike, horse saddle, music instruments)

10. Perception of the teenagers

- **28% of the participants say they are worried about PFAS pollution in their environment**

- **Participants need more information about**
  - → Possible effects on their own health
  - → How to protect their health

- **Participants like to receive the information from parents, school media and scientists**

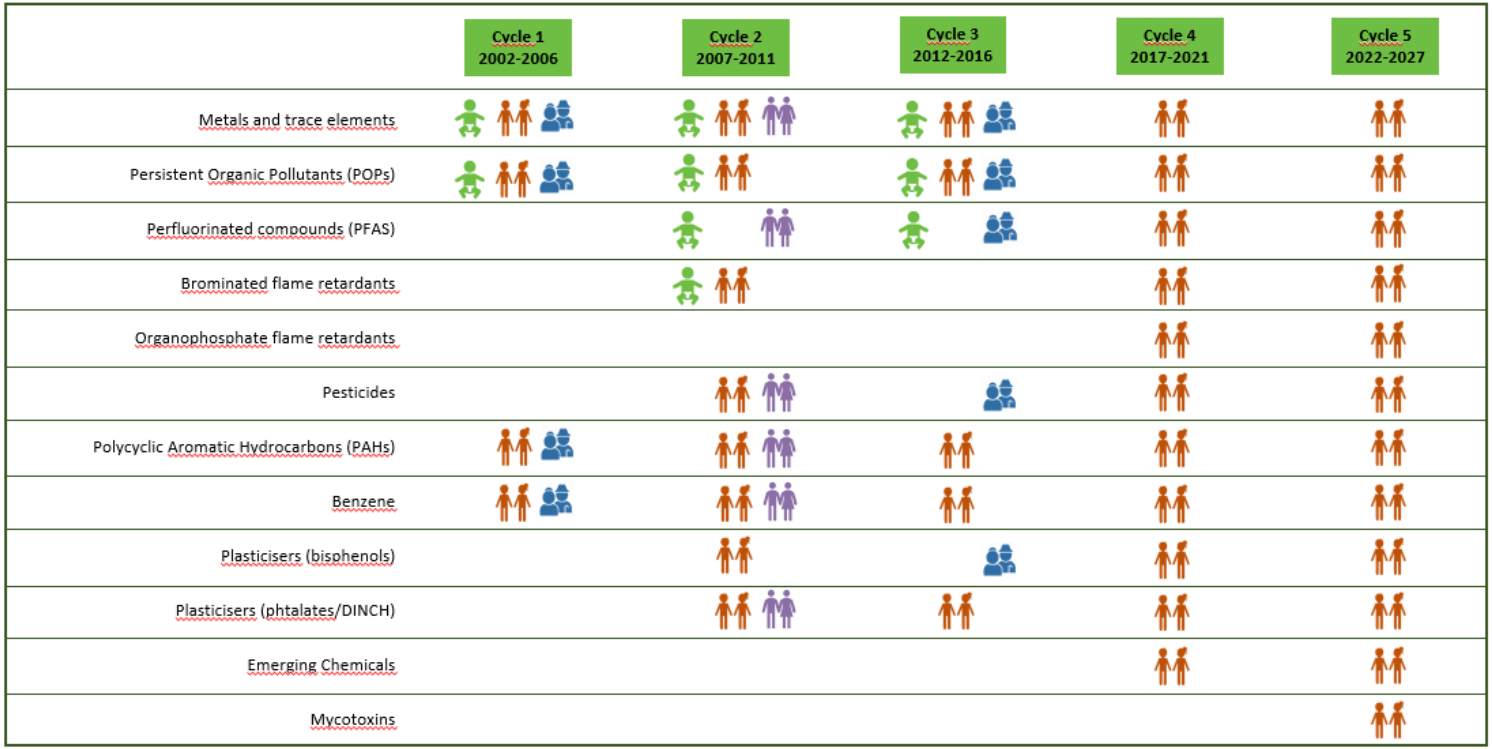
- **Participants trust parents, scientists, GP, family and friend the most**

Policy recommendations

- **Advice to government and industry: need for structural measures**
  - → Source control
  - → Regulating production
  - → Remediation of environment
  - → Health monitoring
- **Advice to inhabitants**
  - → No regret measures
  - → Healthy life style

Goal: support citizens to limit their PFAS exposure
NOT placing responsibility with young people and their parents

HBM in Flanders – FLEHS – more than 20 years



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FLEHS – Cycle 5 (2022-2027)

- Exposure biomarkers: metals and trace elements, POPs, PFAS, BFRs, OFRs, pesticides, PAHs, benzene, bisphenols, phtalates, DINCH, emerging chemicals, mycotoxins
- Biomarkers of effect: endocrine disruption, immunity disturbance, biologcla stress, mental health, kidney function, liver function, cardiometabolic function, DNA recovery, puberty development
- Questionnaires
- Environmental samples (at the participants house): soil vegetable garden and chicken coop, house dust, indoor air, other environmental samples
- Extra study on healthy living environment (e.g. noise disturbance, air pollution, green space) and nature connection

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Suspect screening analysis of short-chain PFAS

- PFAS screening in urine (based on samples of FLEHS IV, not developed for PFAS)
  - Urine is not the preferred matrix for PFAS
  - ✓ need for high sensitivity to achieve detection
  - ✓ suspect screening methods identify a wide range of contaminants (detection limit is higher than for quantitative methods)

This combination leads to low PFAS detection

Results:

- Trifluooacetic acid detected in 30% of samples (estimated concentration >20ng/ml (LOD)
- No other PFAS detected, more then 50 identified

Planned:

- **Screening of 3M serum samples**

1. **Kim et al. 2022**
2. **Roggeman et al. 2022**

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Thank you

- Participants
- Local advisory group
- Contractors

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