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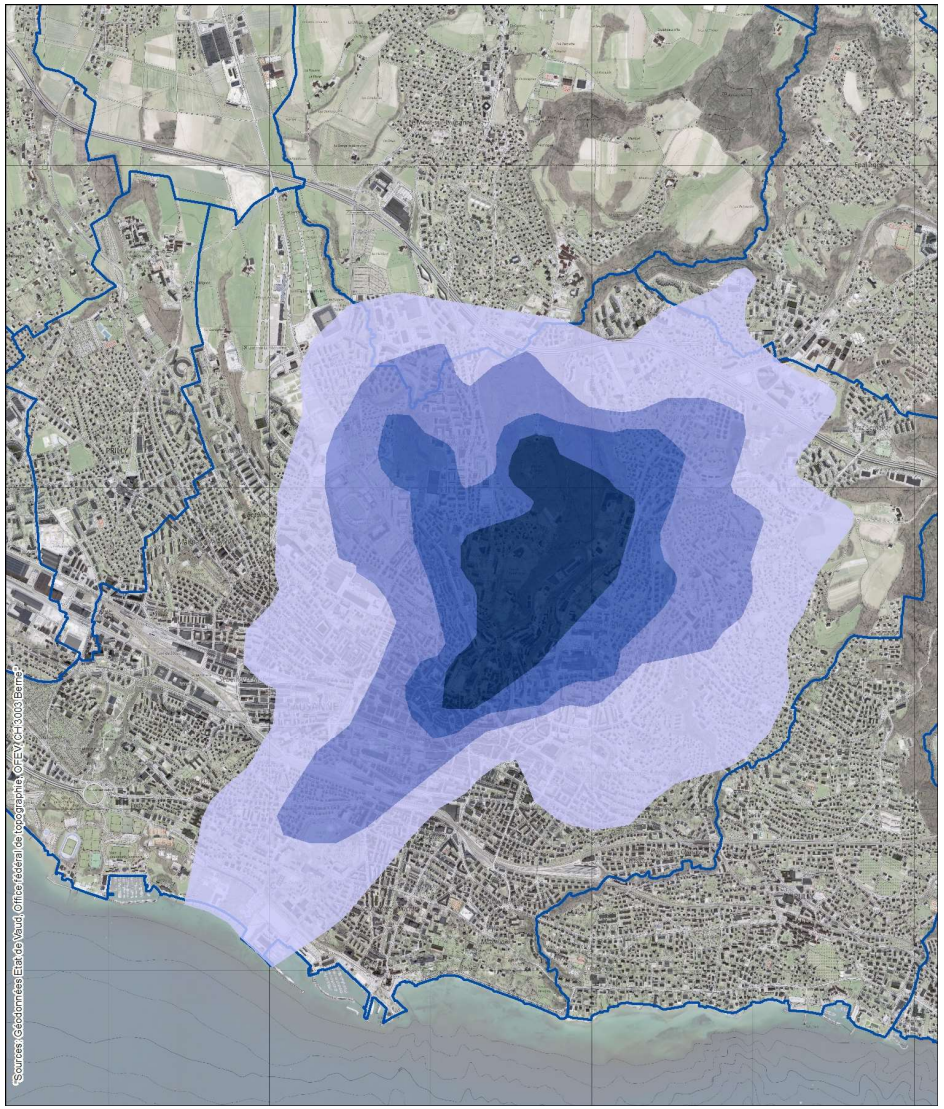
Environmental Health Interventions

Dioxins

Situation

Discovery of Dioxin/Furan contamination

- Redevelopment of a private plot of land on Avenue Victor-Ruffy in Lausanne
- PCDD/Fs levels in the order of magnitude of the OSol remediation value of 96 and 107 ng i-TEQ/kg
- Subsequent successive surveys for mapping (> 120)



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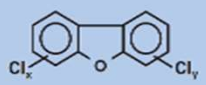
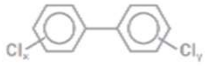
Dioxins and furans

- Set of congeners of similar structure
- Variable toxicity: reprotoxicity, cancerogenicity, immunotoxicity
- Environmental and human biopersistence

Name	Struktur	Anzahl Kongenere 1)	2)
Polychlorierte Dioxine (PCDD)		75	7
Polychlorierte Furane (PCDF)		135	10
Polychlorierte Biphenyle (PCB)		209	12

- Target value based on reprotoxic effects (most sensitive effect)

Toxic equivalent factors

- Calculation of toxic equivalent concentrations
- Ability to interact with AHR (aryl hydrocarbon receptor)

$$TEQ = \sum_{i=1}^{n} (C_i \cdot TEF_i)$$

Dioxins (PCDD)			
Congeneric	$TEF_{WHO\text{-}05}$ [1]	$TEF_{WHO\text{-}98}$ [1]	$TEF_{NATO\text{-}89}$ [2]
2,3,7,8-TCDD	1	1	
1,2,3,7,8-PeCDD	1	1	0.5
1,2,3,4,7,8-HxCDD	0.1	0.1	0.1
1,2,3,6,7,8-HxCDD	0.1	0.1	0.1
1,2,3,7,8,9-HxCDD	0.1	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.01	0.01	0.01
OCDD	0.0003	0.0001	0.001

Regulatory thresholds - soils

- Depending on the exposure scenario
- Playground sanitation threshold: based on unintentional ingestion of soil by children

Regulatory values for soils		Sources
Indicative value	5 ng i-TEQ /kg soil dry matter	OSol; SR 814.12
Investigation thresholds		
Ingestion risk	20 ng i-TEQ /kg dm soil	OSol; SR 814.12
Food or feed crops	20 ng i-TEQ /kg dm soil	OSol; SR 814.12
Sanitation values		
Playgrounds	100 ng i-TEQ /kg dm soil	OSol; SR 814.12
Private and allotment gardens	100 ng i-TEQ /kg dm soil	OSol; SR 814.12
Agriculture and horticulture	1000 ng i-TEQ /kg dm soil	OSol; SR 814.12

Regulatory Thresholds - Food

- Measurement in batches, when placed on the market

Regulatory values for foodstuffs		Sources
Mixed animal fats	1.5 pg TEQ_{WHO-05} /g fat	OCont; SR 817.022.15
Raw milk and dairy products	2.5 pg TEQ_{WHO-05}/g fat	OCont; SR 817.022.15
Sheep		
Sheepmeat and sheepmeat products	2.5 pg TEQ_{WHO-05}/g fat	OCont; SR 817.022.15
Sheep livers and derived products	1.25 pg TEQ_{WHO-05}/g fresh weight	OCont; SR 817.022.15
Sheep fat	2.5 pg TEQ_{WHO-05} /g fat	OCont; SR 817.022.15
Chicken eggs		
Hen eggs and egg products	2.5 pg TEQ_{WHO-05} /g fat	OCont; SR 817.022.15

The issues

Situation

- High soil concentrations (>100 ng/kg)
- Wide area (> 20 ng/kg)

Technical complexity

- Complex pollutant, non-specific toxicity
- Several units of measurement (I-TEQ, WHO-TEQ) and soil extraction methods
- Variability of ground level concentrations and exposure situations

Communication

- Dioxins associated with the Seveso and Agent Orange tragedy (Vietnam)
- Legal and financial issues
- Possible lowering of the sanitation limit from 100 to 20 ng/kg

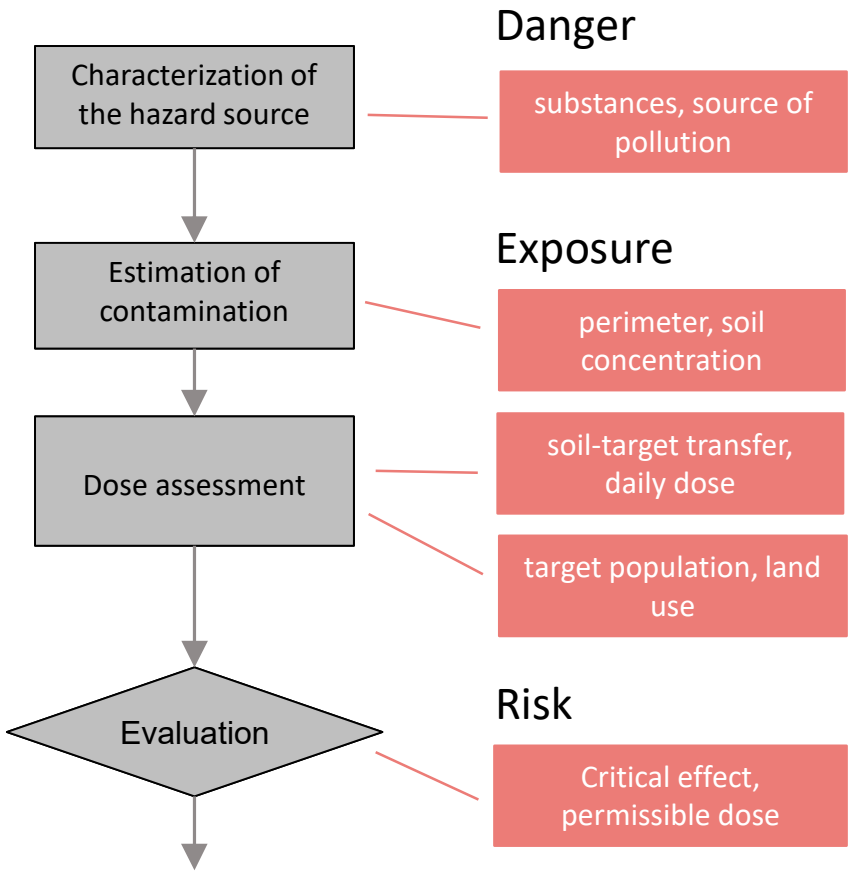
Health assessment

Mandate DGS

- Assessing the risk
- Supporting the authorities in the choice of preventive measures

Approach

- Classic health assessment
- Health working group



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Situations identified

Scenarios

- Direct ingestion of soil by children
  - hand to mouth exposure
- Consumption of vegetables grown on contaminated soil
  - cucurbits, unpeeled vegetables
- Consumption of food from animals that have fed on contaminated grass/fodder
  - sheep, woolly pig
  - eggs (private poultry houses)

Exposure assessment

Evaluation method

- Scenario of ingested doses
  - medium (conservative) scenarios
  - existing models / adaptations

- Limited sampling
  - sheep, rillettes, eggs, zucchini

- Modelling of serum concentrations
  - Different ground concentrations
  - Frequency of use/consumption

Computation	Model
Direct ingestion	Adaptation of the expert syst. (Mailänder and Hämmann 2005)
Vegetables	Bioconcentration factors (ADEME 2017)
Sheep	Adaptation of cow's model (Agroscope)
Eggs	RIVM model (Van Eijkeren et al. 2006)
Human (serum)	CADM (concentration- and age-dependent model) (Chain et al. 2018)

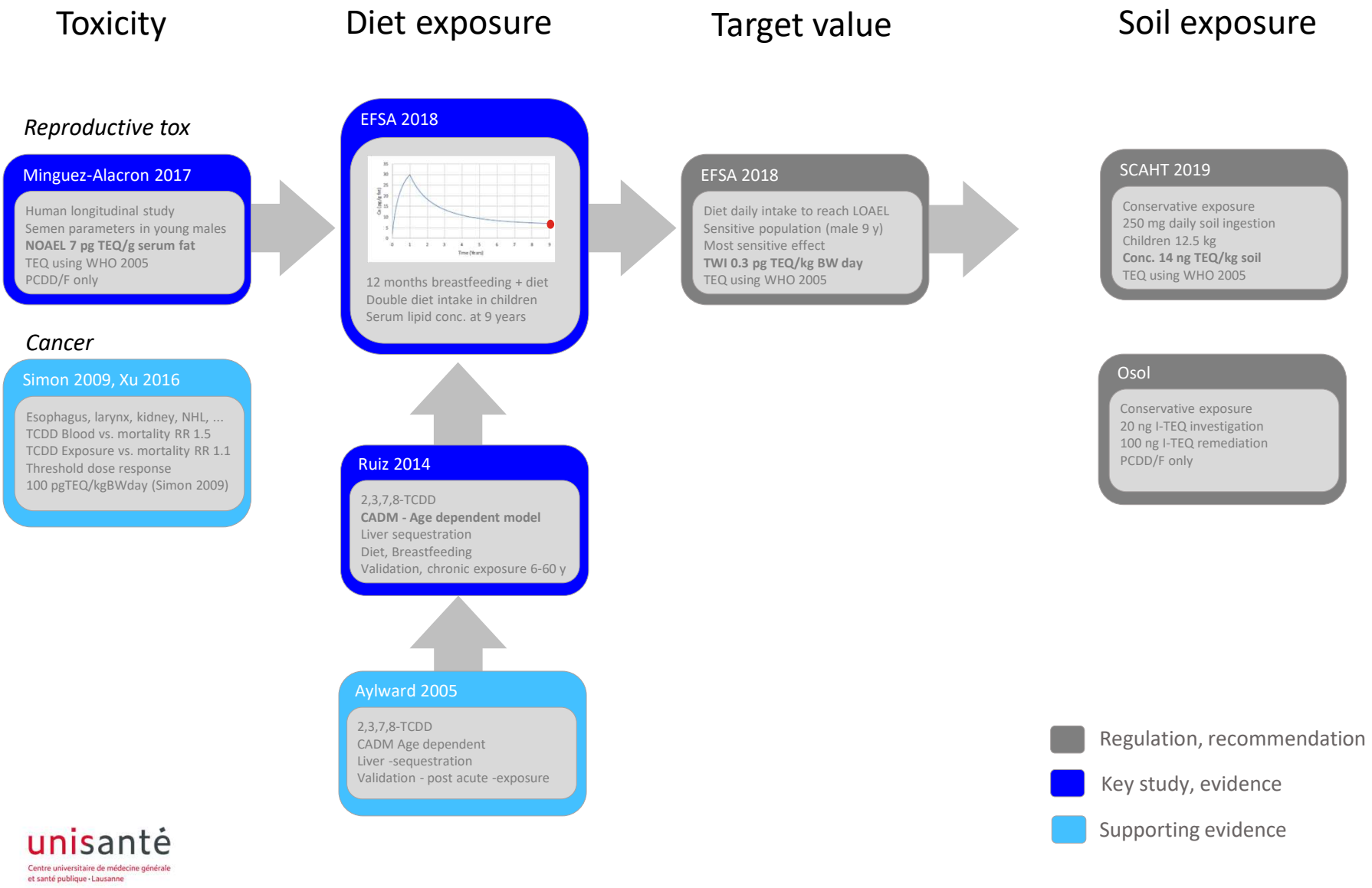
Target value

What is acceptable?

- Threshold without effect?
- Target value (WHO/EFSA) for daily intake: **0.3** pg TEQ/kg *body weight*.day
- Increased blood concentration in the general population

Present in our diet 0.6 pg TEQ/kg body weight.day (FOPH 2010)

Construction of target values (EFSA)



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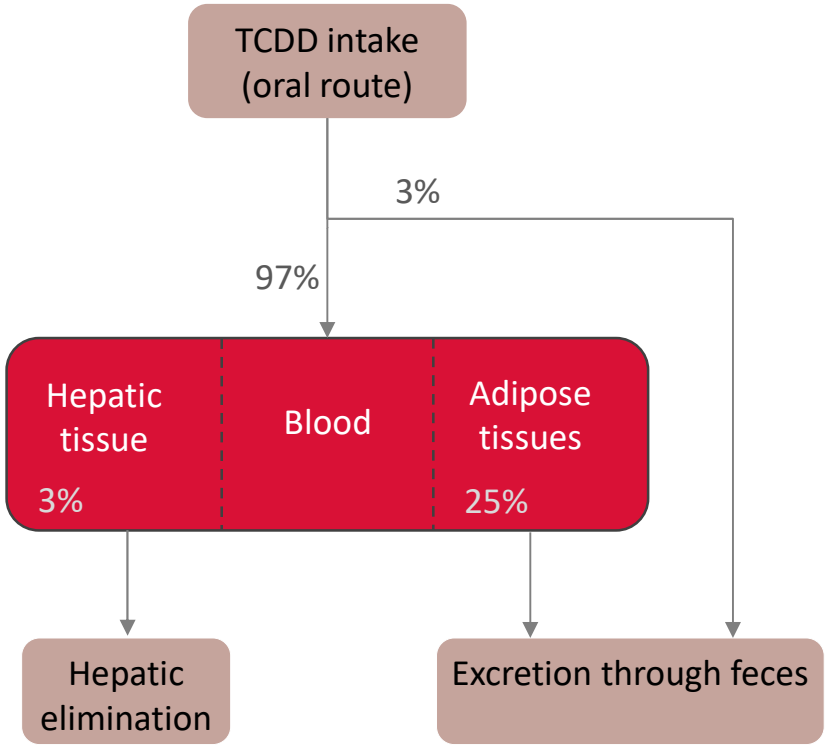
CADM Model

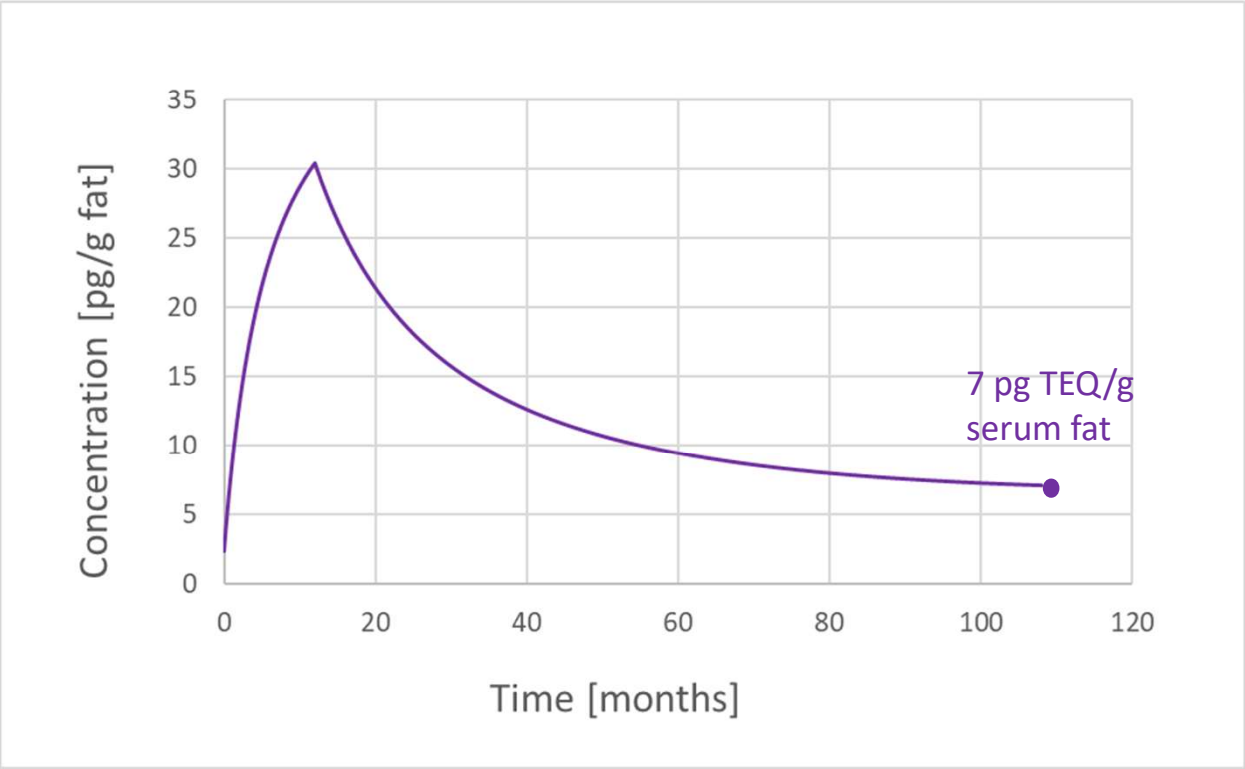
- Features
  - Toxicokinetics TK
  - Established for 2,3,7,8-TCDD
  - Oral exposure
- Included
  - Changes in body mass with age
  - Sequestration in the liver (Michaelis-Menten)
  - Breastfeeding intake



CADM model

Initial EFSA calculation

- Endpoint: TCDD/F concentration in lipids at 9 years
- Adjustment of parameters to achieve the NOAEL of 7 pg TEQ/g fat in serum (Minguez 2017)



Parameters (A0)

Breastfeeding 12 months
Milk Conc. 6 pg/g fat
Diet intake 0.5 pg/BW day
Infants 2x diet intake

Adult diet 0.25 pg/ BW day
rounded to 0.3 pg/ BW day

Adjustment for the Swiss population

Adjustment for the Swiss population

- For TCDD/F
- Daily diet (EFSA ref data 2009)
- Breastfeeding according to (FOPH 2010)

Parameters (Swiss pop.)

Breastfeeding 12 months
Milk Conc. 5 pg/g fat
Diet intake 0.6 pg/BW day
Infants 2x diet intake

Direct ingestion of soil: parameters

- Frequency of use of the area: 0-250 days/year
- Body mass

  continuous growth of body mass with age (according to CADM model)

- Vegetation cover

  weighting of the expert model:

  no source data identified

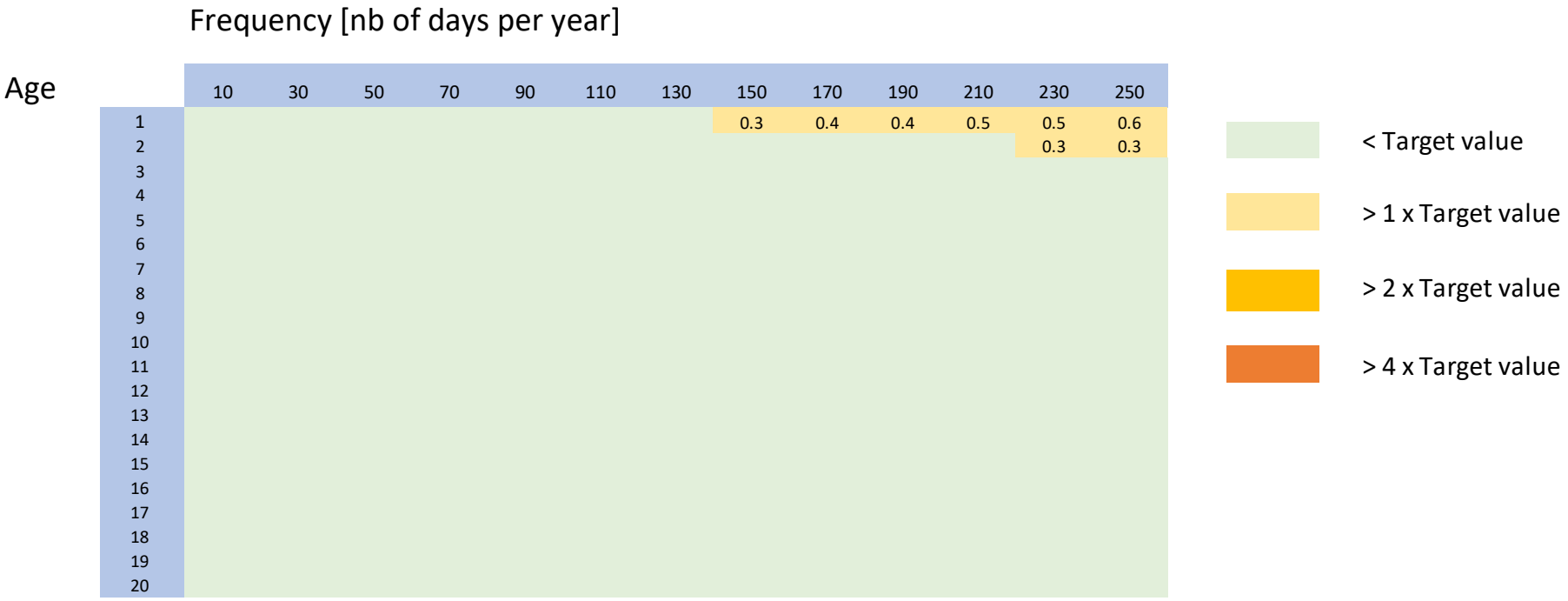
Vegetation cover (%)	Availability factor
> 90%	0.7
90 - 75%	0.85
75%	1

- Bioavailability: 75%.
- Age

  0 to 9 years, endpoint at 9 years

Direct ingestion of soil: scenarios incorporation

Soil concentration at **100** ng TEQ / kg



Direct ingestion of soil: scenarios incorporation

Soil concentration at **200** ng TEQ / kg

Frequency [nb of days per year]

Age	10	30	50	70	90	110	130	150	170	190	210	230	250
1				0.3	0.4	0.5	0.6	0.7	0.8	0.8	0.9	1.0	1.1
2						0.3	0.4	0.4	0.5	0.5	0.6	0.6	0.7
3								0.3	0.3	0.4	0.4	0.5	0.5
4										0.3	0.3	0.4	0.4
5												0.3	0.3
6													0.3
7													
8													
9													
10													
11													
12													
13													
14													
15													
16													
17													
18													
19													
20													

< Target value

> 1 x Target value

> 2 x Target value

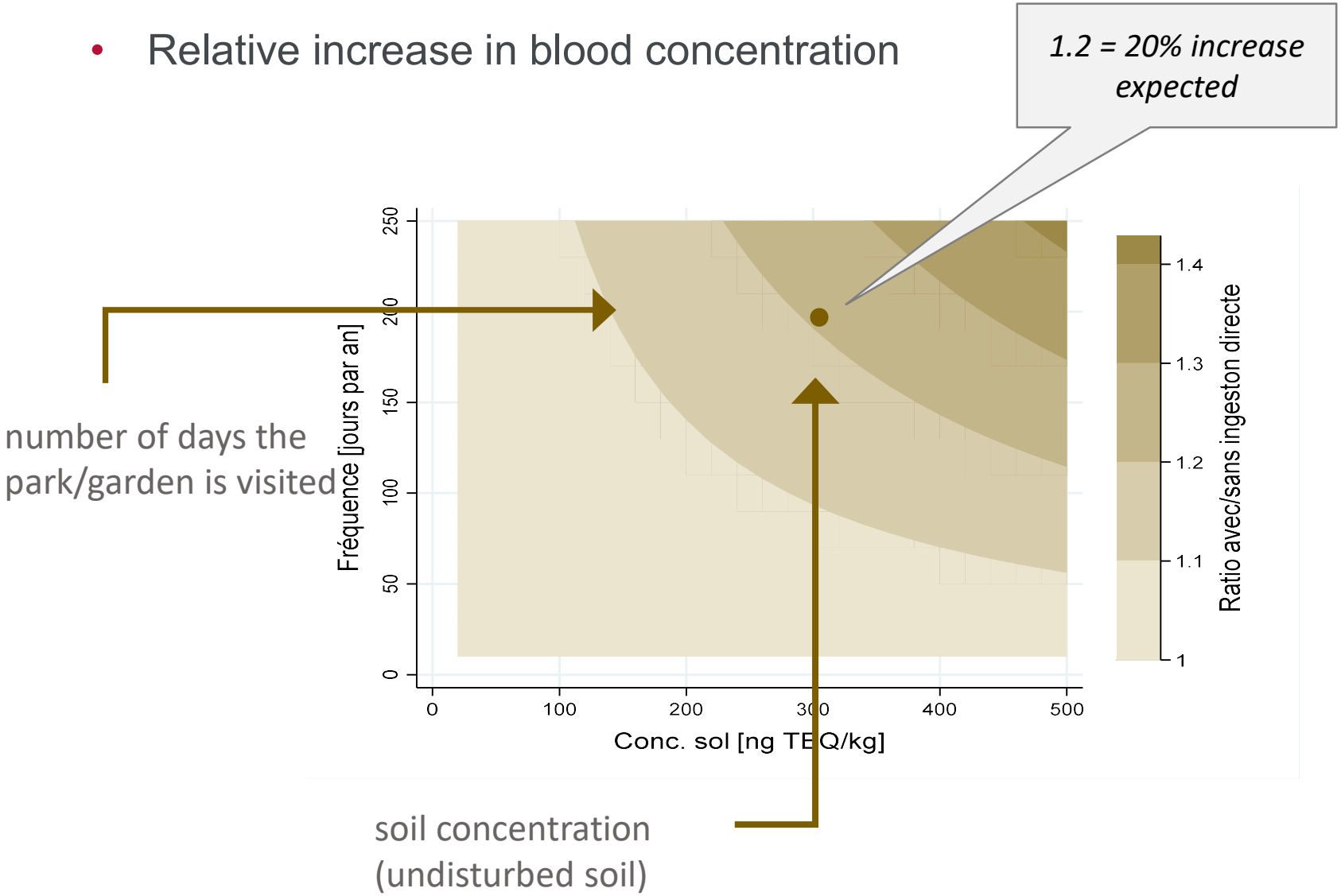
> 4 x Target value

VD1

Results

Direct ingestion of soil

- Relative increase in blood concentration



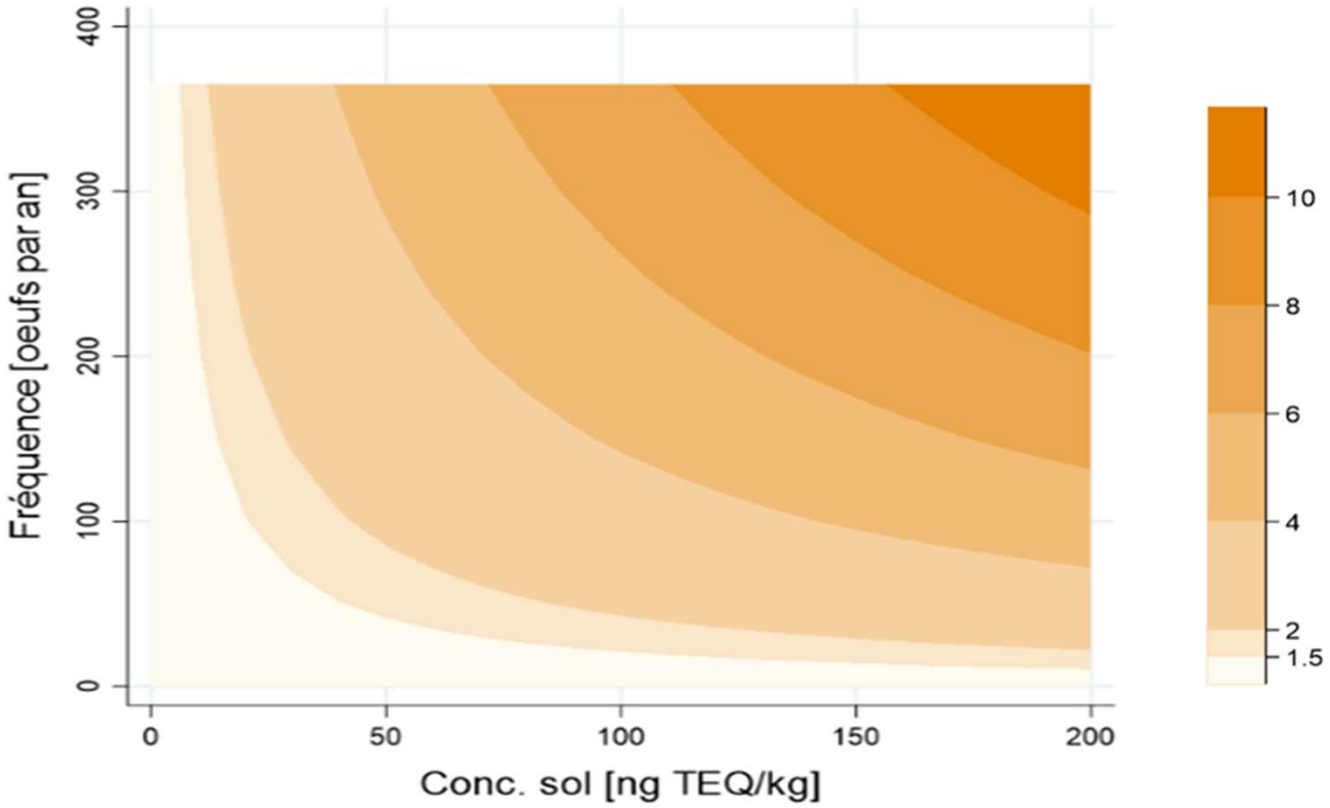
Diapositive 19

VD1 Vernez David; 21.09.2021

VD1

Results

Egg consumption



- Significant increase in blood concentration

Diapositive 20

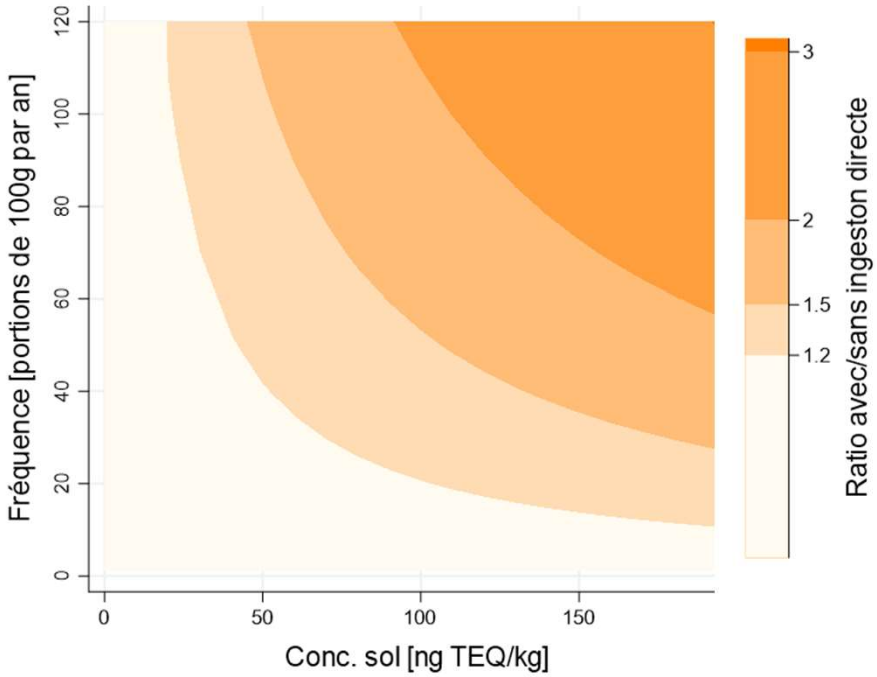
VD1 Vernez David; 21.09.2021

VD1

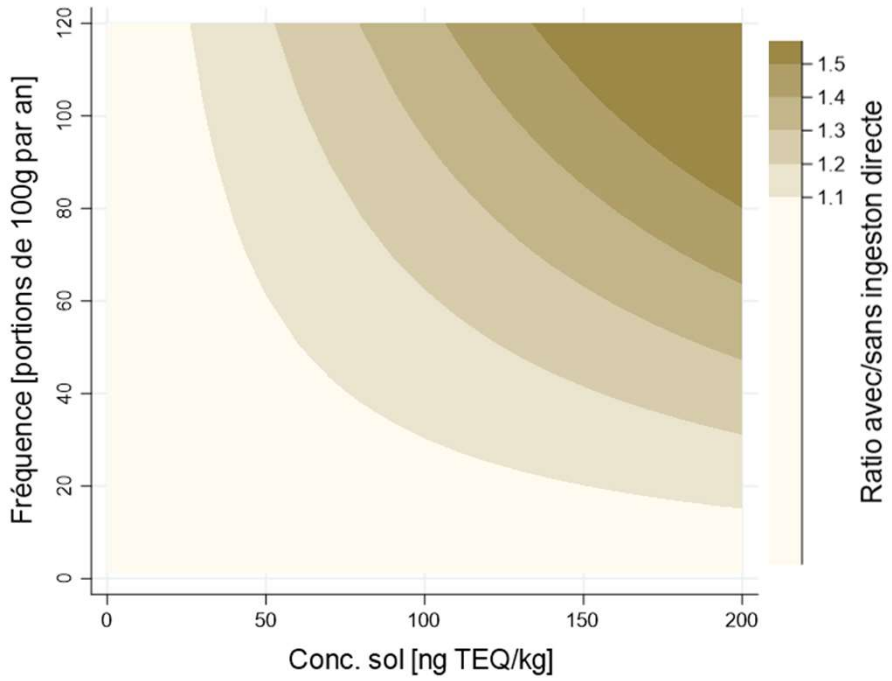
Results

Vegetable consumption

Cucurbits



Unpeeled carrots



- Moderate to significant increase in blood concentration

Diapositive 21

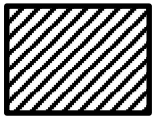
VD1 Vernez David; 21.09.2021

Appreciation

Based on relative increase in expected dose in serum

- < 20%. Low, not expected to be noticeable in the general population.
  - standard hygiene recommendations

- 20-100 %. Notable, requires preventive measures.
  - technical or organizational measures to reduce exposure



- > 100 %. Significant, should be avoided.
  - restrictive measures

Recommendations (in plain text)

		Concentration dans le sol [ng TEQ /kg]			
		20-50	50-100	100-200	>200
Détenteurs de jardins potagers	Consommer des légumes racines	Oui	Lavés et pelés uniquement		
	Consommer des cucurbitacées[1] cultivées sur ces sols	Limiter à 100g de légumes/personne/semaine		Non	
	Consommer les autres fruits et légumes (lavés)	Oui			
Utilisateurs des parcs et jardins[2]	Fréquenter les parcs et jardins	Oui			Limiter à 3 fois par semaine[3]
Détenteurs de poules	Consommer des œufs (à titre privé)	Limiter à 1 œuf/personne /semaine	Non		
	Offrir ou vendre les œufs	Non			
	Manger les poules	Non			

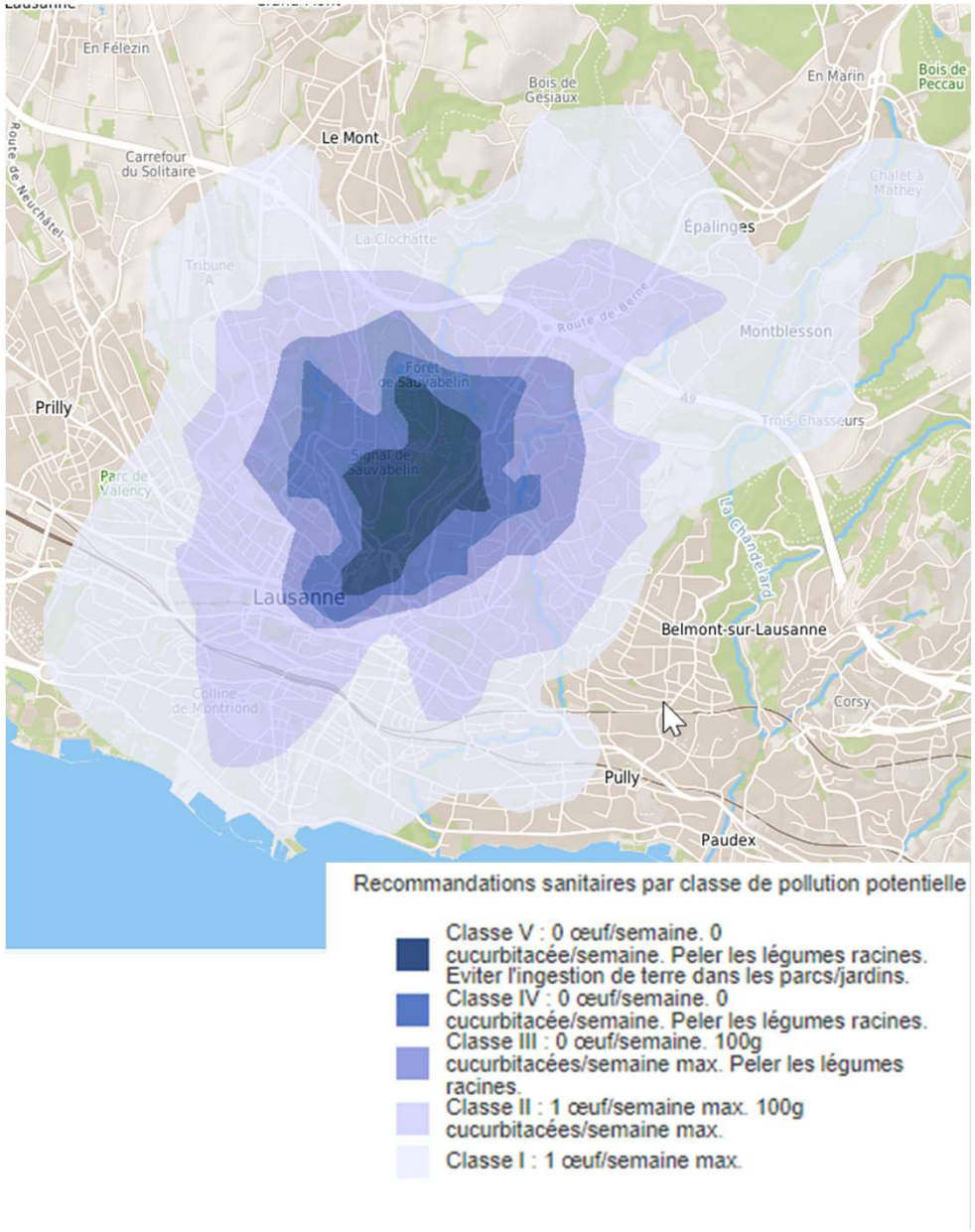
Conclusions (part 2022)

- Evaluation
  - Same studies and models as SCAHT, EFSA
  - Average (conservative) scenarios, dose accumulation with age, use pattern
- Same metric (serum concentrations) for all exposure scenarios
- Importance of the land **use pattern**
  - breeding (meat and egg consumption) is the most problematic modality
- Management of different modalities of **unbalanced** exposure (proportionate response)

Situation in 2023

Extensive mapping of the city

- Sampling to map up to 5 ng i-TEQ/kg
- Adaptation of health recommendations
- Consequences for livestock farms



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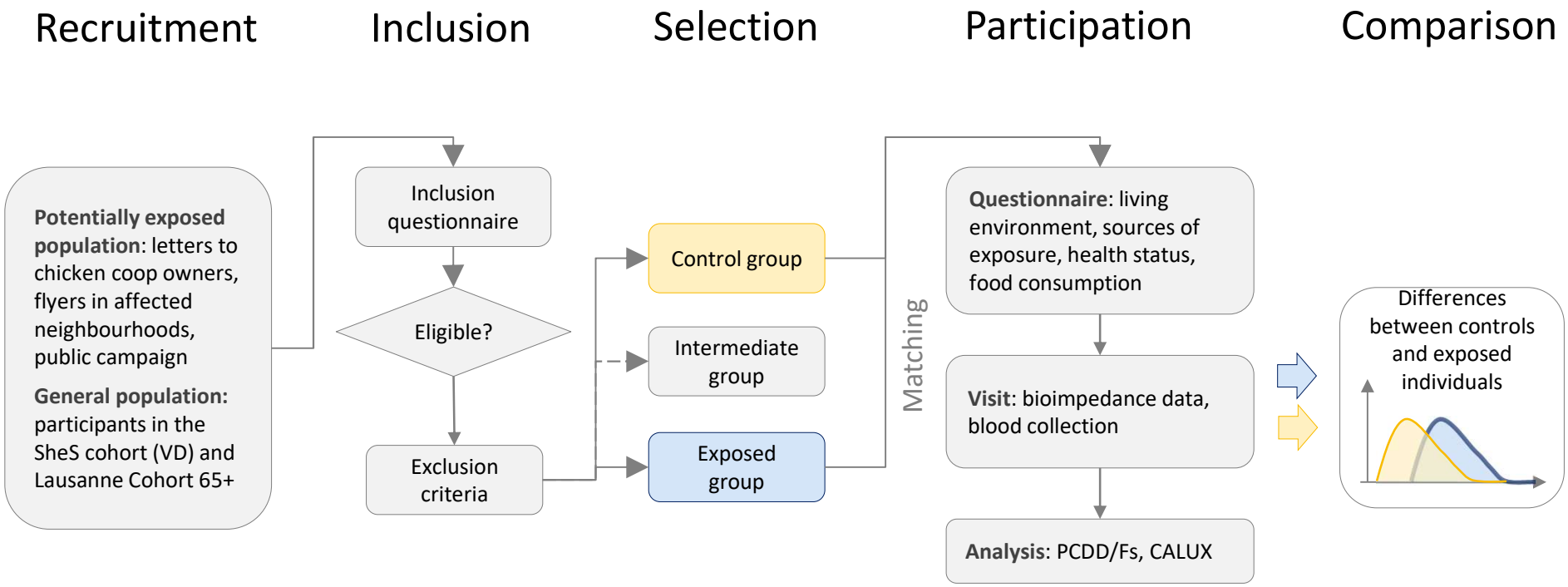
Biomonitoring study (2023-2024)



CER-VD, Project ID: 2022-02142

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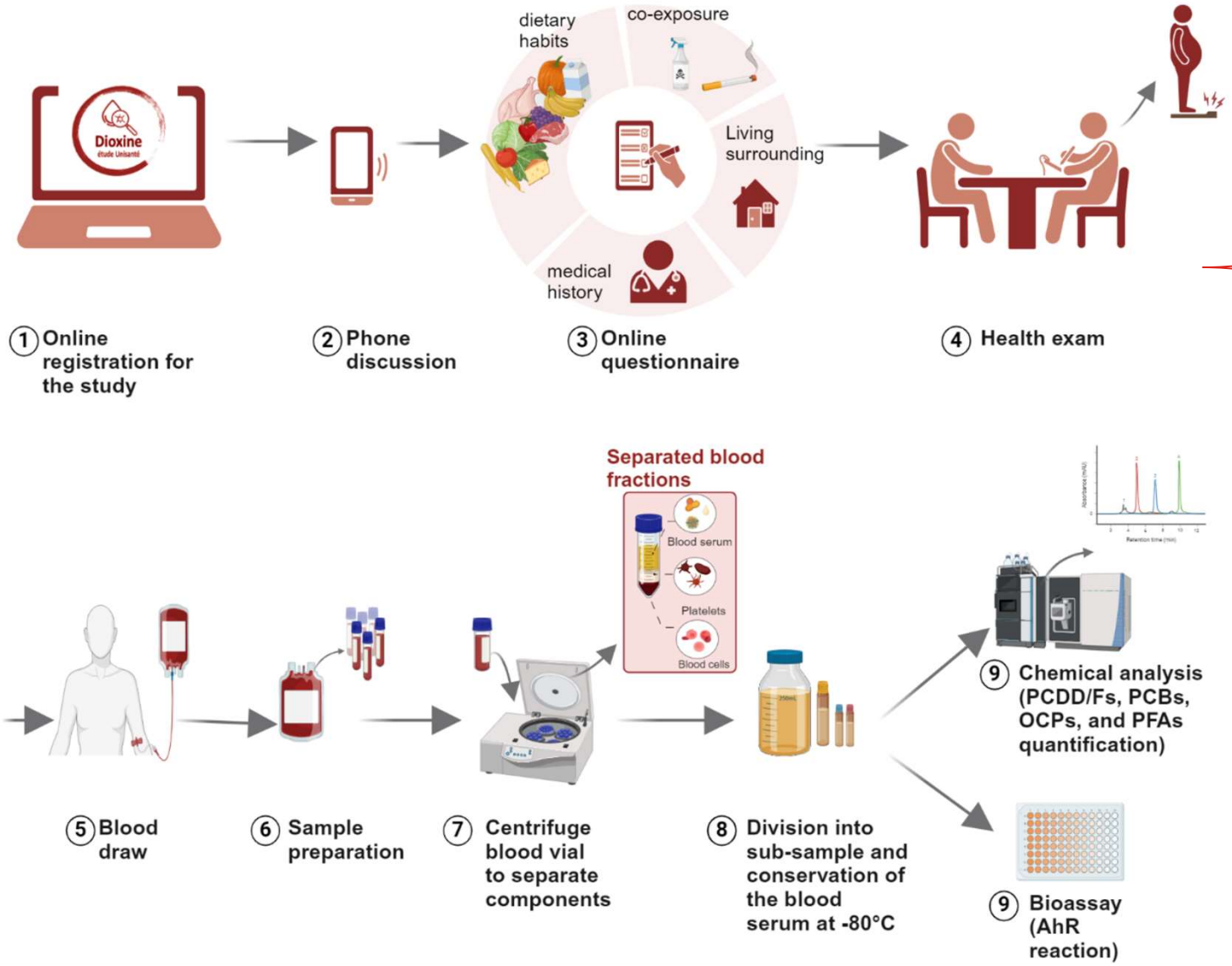
Production



Exclusion

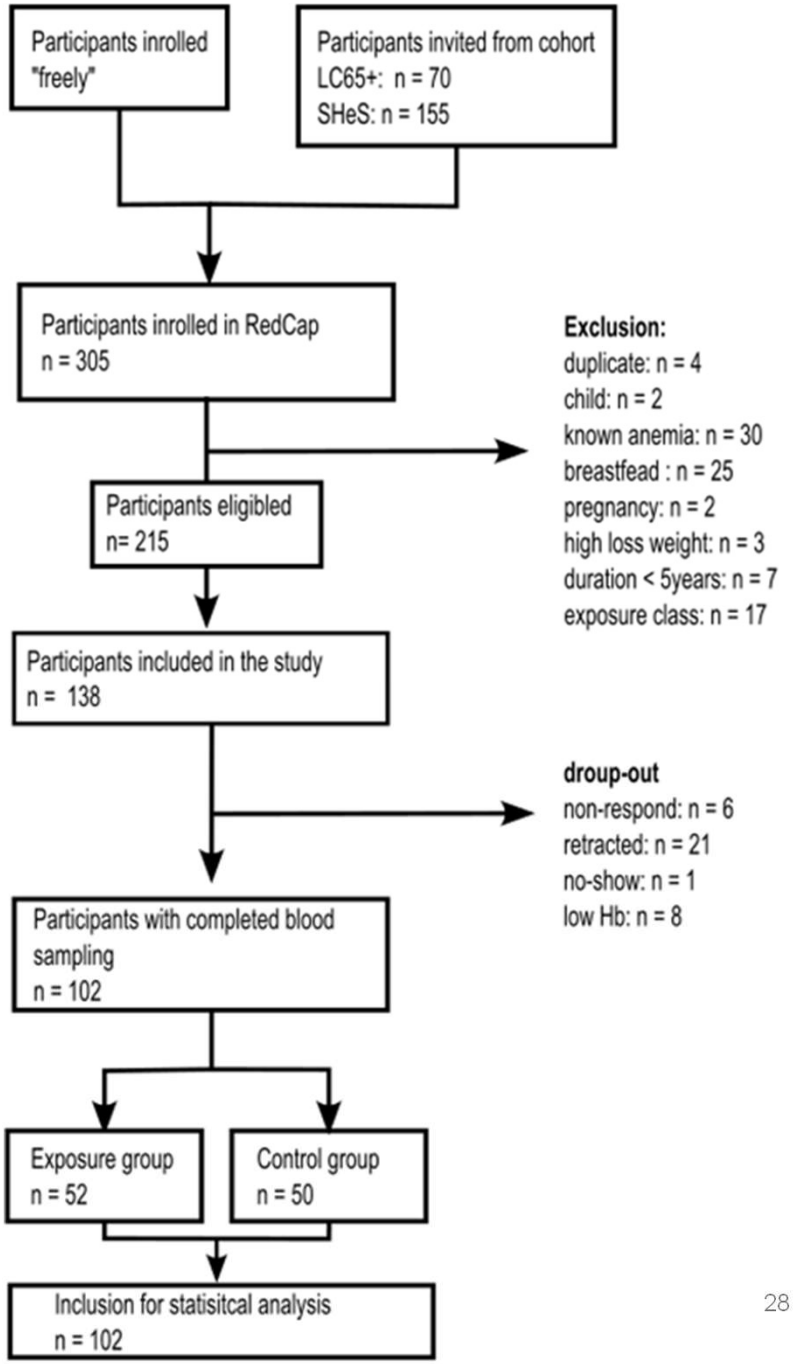
< 5 years

<12 or 13 g/dL
or
Blood donation

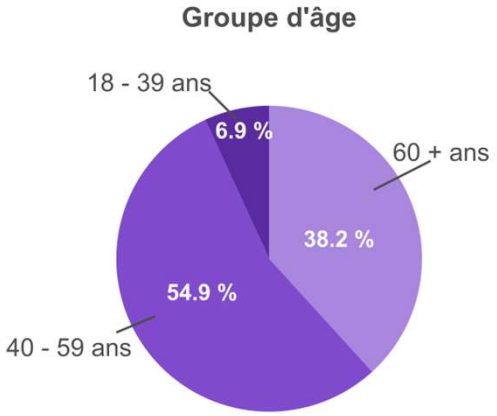
18 <BMI>35 kg/m^2
>10% weight loss

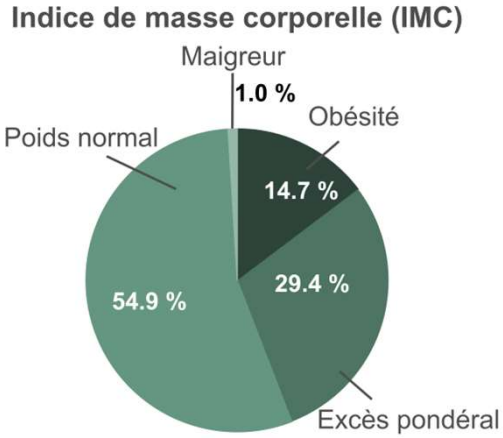
Production

- 305 volunteers in total:
  1. Inclusion of volunteers from the exposed group
  2. Matching for age and gender among controls
- 102 participants who completed their blood tests (52 exposed group)



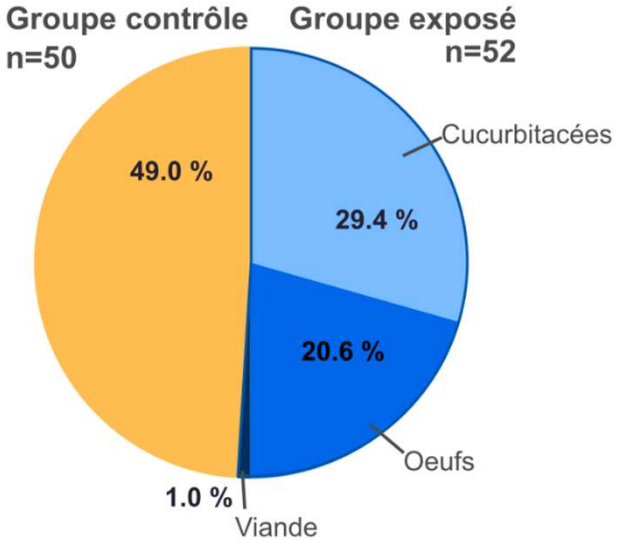
Population characteristics





	Groupe exposé N=52		Groupe contrôle N=50	
Age (années)				
Moyen	54.21		54.04	
Age (Catégorie)				
20-39	3	5.7 %	4	8 %
40-59	30	57.8 %	26	52 %
60 +	19	36.5 %	20	40 %
Sexe				
Hommes	24	46.1 %	23	46 %
Femmes	28	53.9 %	27	54 %
Indice de masse corporelle (IMC)				
Maigreur (IMC < 18.5)	0		1	2 %
Poids normal (18.5 ≤ IMC <25)	30	57.6 %	26	52 %
Excès pondéral (25 ≤ IMC < 30)	15	28.9 %	15	30 %
Obésité (IMC > 30)	7	13.5 %	8	16 %
Consommation tabac				
Jamais-fumeur	27	51.9 %	36	72 %
Fumeur actif	8	15.4 %	6	12 %
Ancien fumeur	17	32.7 %	8	16 %

Population characteristics

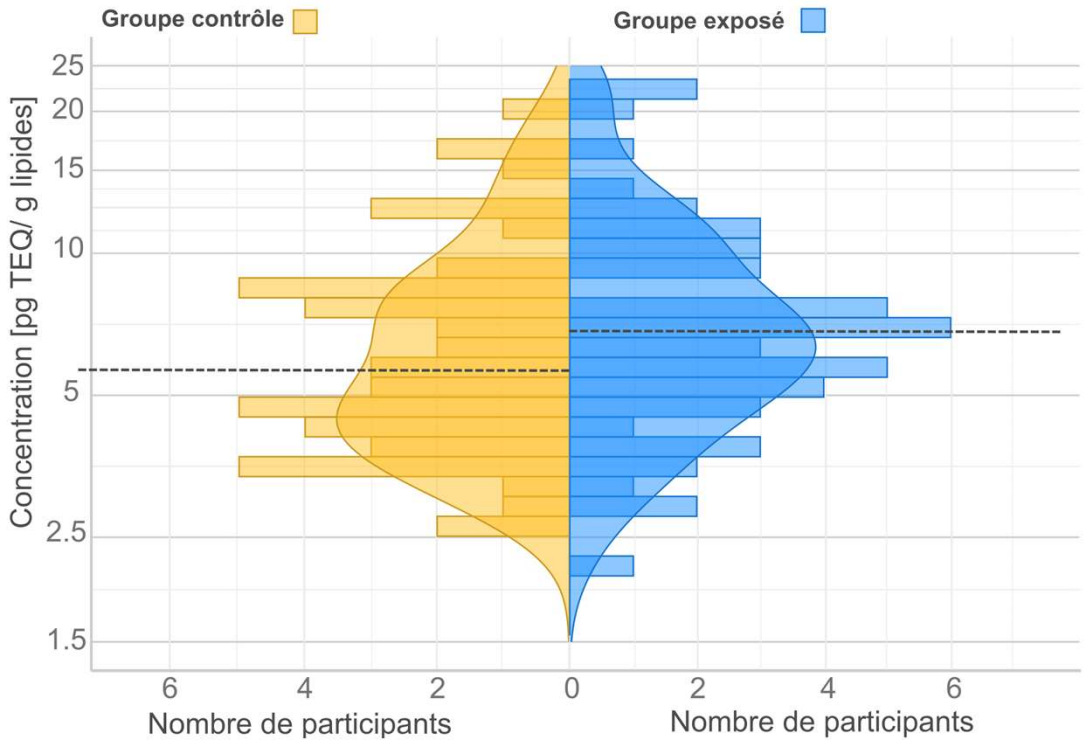


	Exposure classification	Inclusion criteria
Control group	-	No consumption of meat, eggs, or cucurbits produced in zones 1 to 5.
Exposed group	Meat (zones 1-5)	Consumption of meat produced in the contaminated area. (I.e. pork, lamb and mutton)
	Eggs (zones 1-5)	Consumption of eggs from private poultry farms located in zones 1 to 5.
	Cucurbits (zones 2-5)	Consumption of cucurbits (e.g. courgettes, pumpkins, cucumbers) produced in gardens in zones 2 to 5.

- Analyses: exposed – unexposed, consumption of eggs or cucurbits
- Marginal meat consumption

Results - Overall PCDD/F contamination

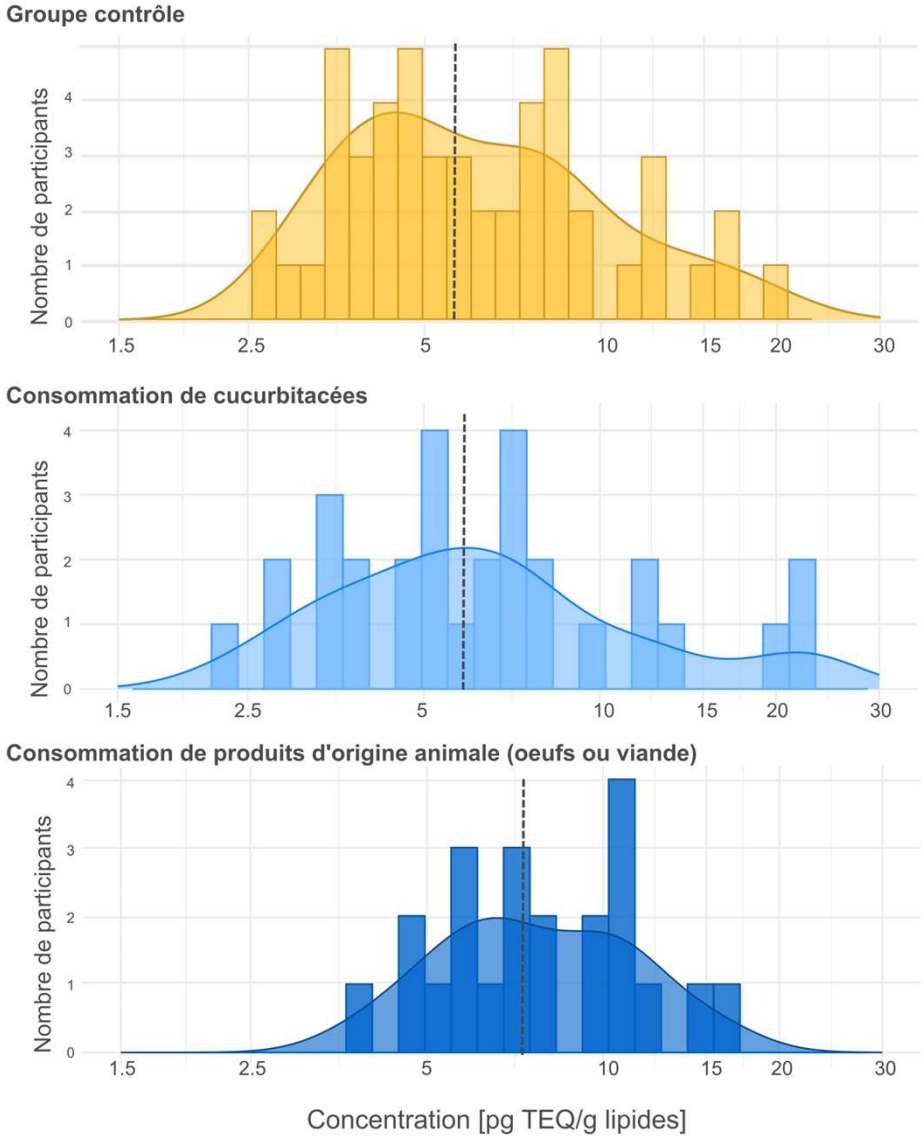
Exposed vs. unexposed



- High variability within groups (logarithmic scale)
- Slight increase in the exposed group compared to the control group
  - Median Control: 5.7 [pg TEQ/g lipids]
  - Exposed median: 6.8 [pg TEQ/g lipids]
- Not statistically significant

Results – Overall PCDD/F contamination

By exposure class



- Contribution mainly due to consumption of eggs and meat
  - Control median: 5.7 [pg TEQ/g lipids]
  - Median for cucurbits: 5.9 [pg TEQ/g lipids]
  - Median exposed to eggs and meat: 7.3 [pg TEQ/g lipids]

3. Results - Influencing variables

Variables	β Estimation	p valeur
(Intercept)	0.240	0.003 **
Age	0.010	0.000 ***
Sexe (Homme)	-0.086	0.021 *
Groupe pourcentage graisse (basse)	0.030	0.510
Groupe pourcentage graisse (haute)	0.130	0.002 **
Consommation de tabac (ancien fumeur)	0.004	0.931
Consommation de tabac (fumeur actif)	-0.035	0.503
Classe d'exposition (œufs ou viande)	0.122	0.006 **
Classe d'exposition (cucurbitacées)	0.014	0.734

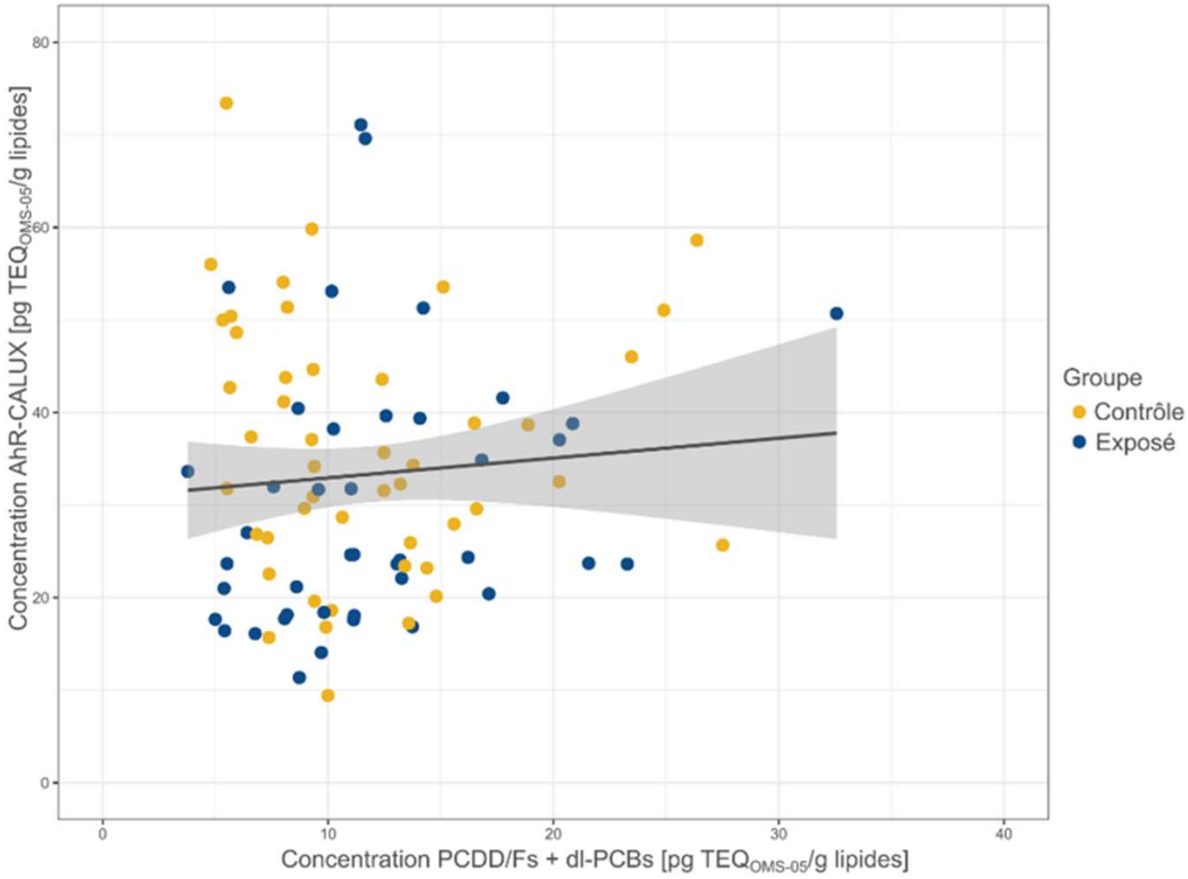
Signif. codes : *** p < 0.001 ; '**' p < 0.01 ; '*' p < 0.05

- Predictors (significant) of PCDD/F concentration in blood:
  - Age
  - Gender
  - Percentage of body fat
  - Consumption of eggs or meat

Detailed analyses - CALUX

Comparison with the CALUX rapid test

- No correlation
- Lack of specificity of the test for PCDD/Fs



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Analyses - Summary

- Median concentration Control vs. Exposure (meat, eggs or cucurbits): Slight increase (19%)

  $\Rightarrow$ This difference is not significant

- Variables influencing (significant predictors) PCDD/F concentration in blood: age, gender, % fat, consumption of eggs or meat

- Diet is the main contributor to PCDD/F contamination

Comparison with other study

	Number of participants	Age of population	Geometric mean	Median	Interval value
Lausanne study	102	21 – 89	6.5	6.3	4.5 - 8.9 (25-75%)
Germany (Fromme 2009)	48	18–65	8.87	7.74	0.79 - 19.97 (5-95%)
France (Ploteau 2016)	109	23	6.21	6.10	4.52 - 8.26 (25-75%)
France (Esteban 2021)	604	18 – 74	7.42	7.46	4.97 - 10.99 (25-75%)

Limitations- regular questions

- Only adults were included
- The influence of soil ingestion in children on PCDD/FS concentrations is unknown
- Concentrations represent current exposure only
- Relatively small number of participants

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Environmental Health Interventions
Asbestos

One of many cases...

- College built in 1972
- Contains various asbestos materials
  - false ceilings (accessible, low agglomerate)
- First diagnosis in 2005
  - positive identification
  - negative air measurements,…nothing happens
- Second diagnosis in 2014-2015
  - positive identification
  - positive air measurement, the level of fibres in the air is 5x over the tolerated dose
- End of 2015 closure of the class
  - Alert the cantonal authorities
  - Parents' and teachers' concerns

Ambiance amiantée au Conseil communal

Aigle Le législatif accepte une demande de crédit de près de 25 millions pour la réfection du bâtiment scolaire «Dents du Midi» et de la salle de gym de la Planchette. Un élu critique vertement l'exécutif pour ne pas avoir procédé à un désamiantage du collège en 2005 déjà, «alors qu'une action immédiate était requise», ce que conteste la Municipalité.

What to do?

Sanitizing and reassuring?

Close the college?

Assessing the risk?

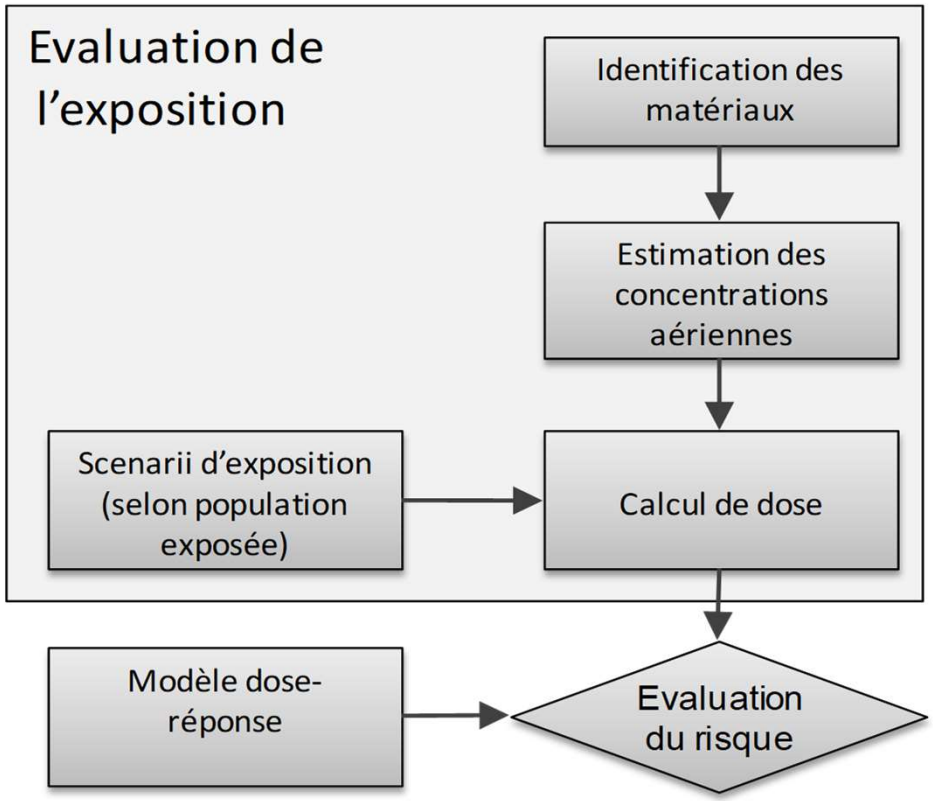
A proven communication and management problem, a health problem to be assessed...

- Factors to consider
  - Large population, presence of children
  - Long term stay in the facility
  - Amphibole asbestos fibres (1000 FAR/m^3 limit debatable)
  - Positive air measurement, the level of fibres in the air exceeds the tolerated dose in general population by a factor 5
  - Does the 5000 FAR/m^3 measurement represent background noise?

Retrospective risk assessment

Joint Working Group

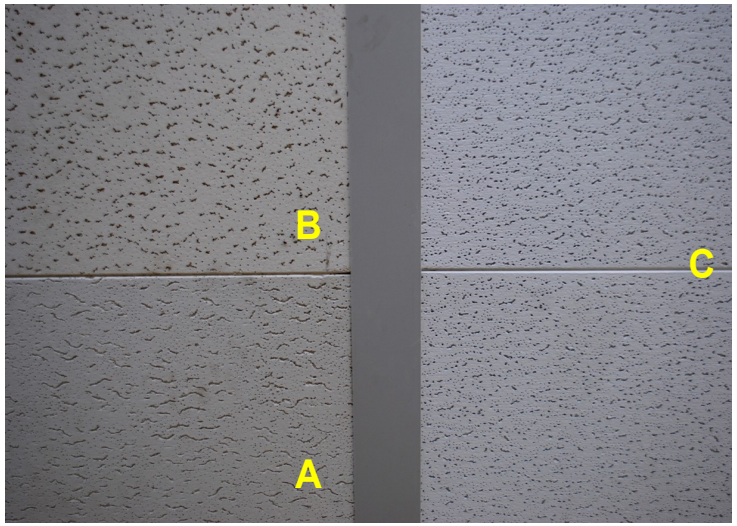
- Mandate of the Directorate of Education
- Expertise in occupational hygiene, toxicology, occupational medicine, school medicine, public health
- Parent and teacher representation
- Independent expertise



Material identification

False ceilings

- Presence of asbestos amosite (1%)
- Population of complex false ceiling panels (positive sampling on B panels)
- Less than 50% of the ceiling area



Estimated conc. Air

In situ measurements

- Use of classrooms being removed
  - Opening and closing of doors and blinds, shocks
  - Change of neon, change of plates
- Ambient measurements

Laboratory measurements

- Falling, breaking and cutting of plates
- Re-analysis of the 2015 contaminated sample

Other investigations

- Exposure database, grey literature
- Weather data
- History of the building

Exhibition scenarios

Population considered

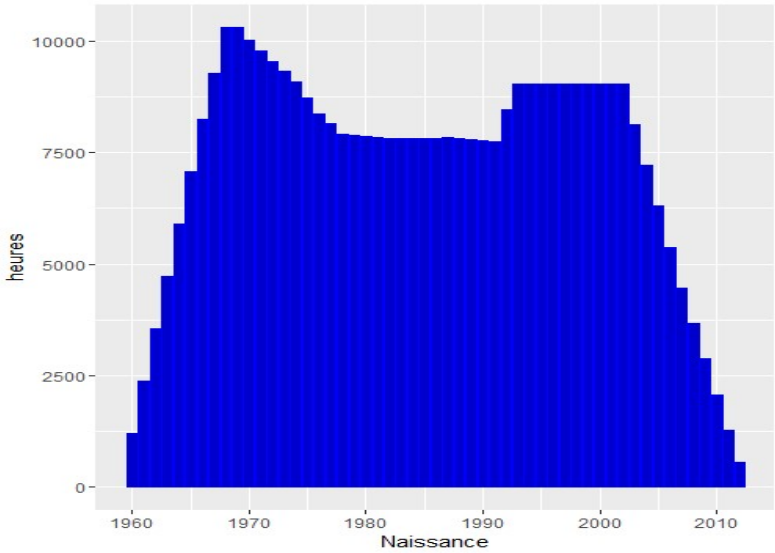
- Teachers
- Students
- Janitor

Estimation of frequencies and duration of events

- Interventions on false ceilings
- Projections of objects
- Falling plates

Data sources

- Interviews
- Teacher Questionnaire
- Teaching statistics



Maximum cumulative hours of attendance at the College according to children's birth years - without repetition (Boratto, 2013)

Dose calculations

Population	Scénario	Age début exposition [ans]	Age fin exposition [ans]	Exposition [FAR/m^3]	Commentaires
Élève	moyen	6	15	59	
	pessimiste 1	6	17	128	redoublement de 2 années, 100% en classes amiantées
	pessimiste 2	6	17	155	Scenario pessimiste 1 + incendie [1]
Enseignant	moyen	25	34	52	
	pessimiste 1	25	54	140	ancienneté et durée hebdomadaire maximale observée dans l'établissement
	pessimiste 2	25	54	170	Scenario pessimiste 1 + incendie
	pessimiste 3	25	65	170	Scenario pessimiste 2 + vie professionnelle entière (cas virtuel)
Concierge	réel [2]	30	45	200	
	pessimiste 1	20	60	320	vie professionnelle entière (cas virtuel)

Choice of a dose-response model

Regulatory value

- Does not distinguish the type of fiber or the pathology

Using the DECOS model (2010)

- Lung cancer
- Mesothelioma
- Adaptation to the situation of Aigle's college

  Mortality of the Swiss population

  Coefficient for amosite alone

Calculation of the whole-life risk

- According to the exposure scenarios

Risk calculation

Mesothelioma risk

- Very low, on average < 10^{-5}
- within "acceptable" limits in the general population

No need for follow-up

Many general recommendations