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Coalition Clean Baltic

EESTI VEEÜHING
ESTONIAN WATER ASSOCIATION

RIVER UNIVERSITY

Studies of the health risks related to the fluoride content in the drinking water in Estonia

Haaliste river, credit, Ilmar Roosmaa, www.Soomaa.com

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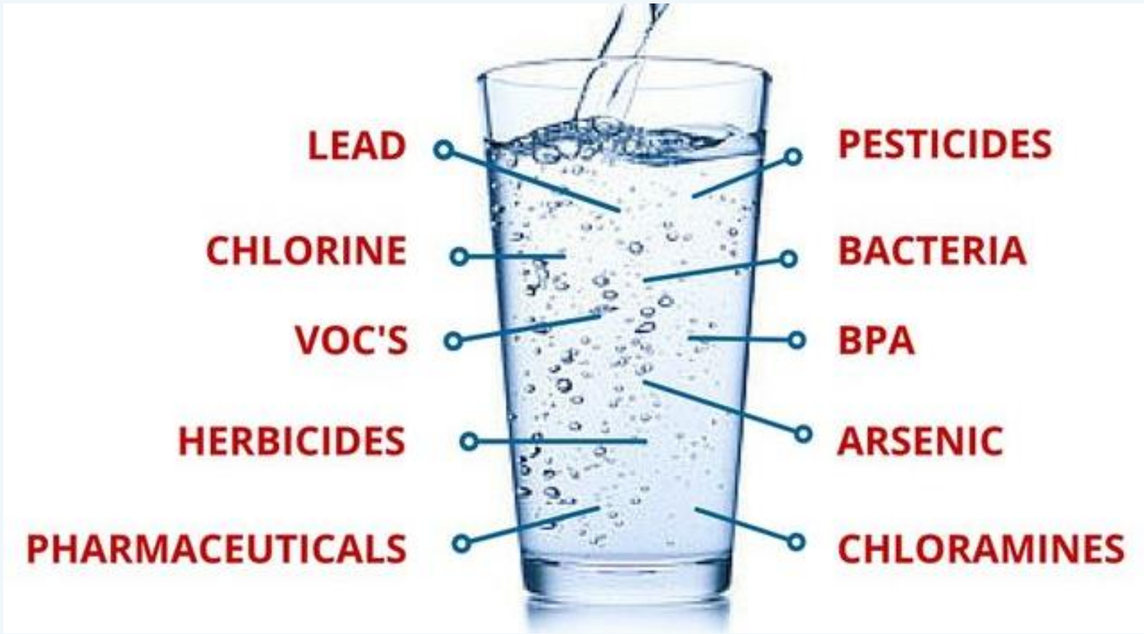
Health risks from drinking water

Drinking water = H_2O ?

Daily consumption (long-term exposure)
~1-1,2 l
Depending on:
age, physical activity, climate etc



To prevent negative (health) effects limit (guideline) values are set.

Long-term effects are often underestimated/overlooked

Fluoride –
a friend or a foe?

Fluoride in drinking water

- Fluoride as health determinant
  - Deficiency – caries
  - Excess – dental and skeletal fluorosis
- Sources of fluoride
  - Drinking water (70-90%)
  - Food, fluoridated dental products
- WHO health-based limit in drinking water – 1.5 mg/l

  highest desirable limit 1.0 mg/l (fluoridation)
- High levels of fluoride in drinking water – limiting factor in water supply

Adverse health effects of fluoride

- Dental fluorosis or “mottled teeth”

- Skeletal fluorosis

Adverse health effects of fluoride

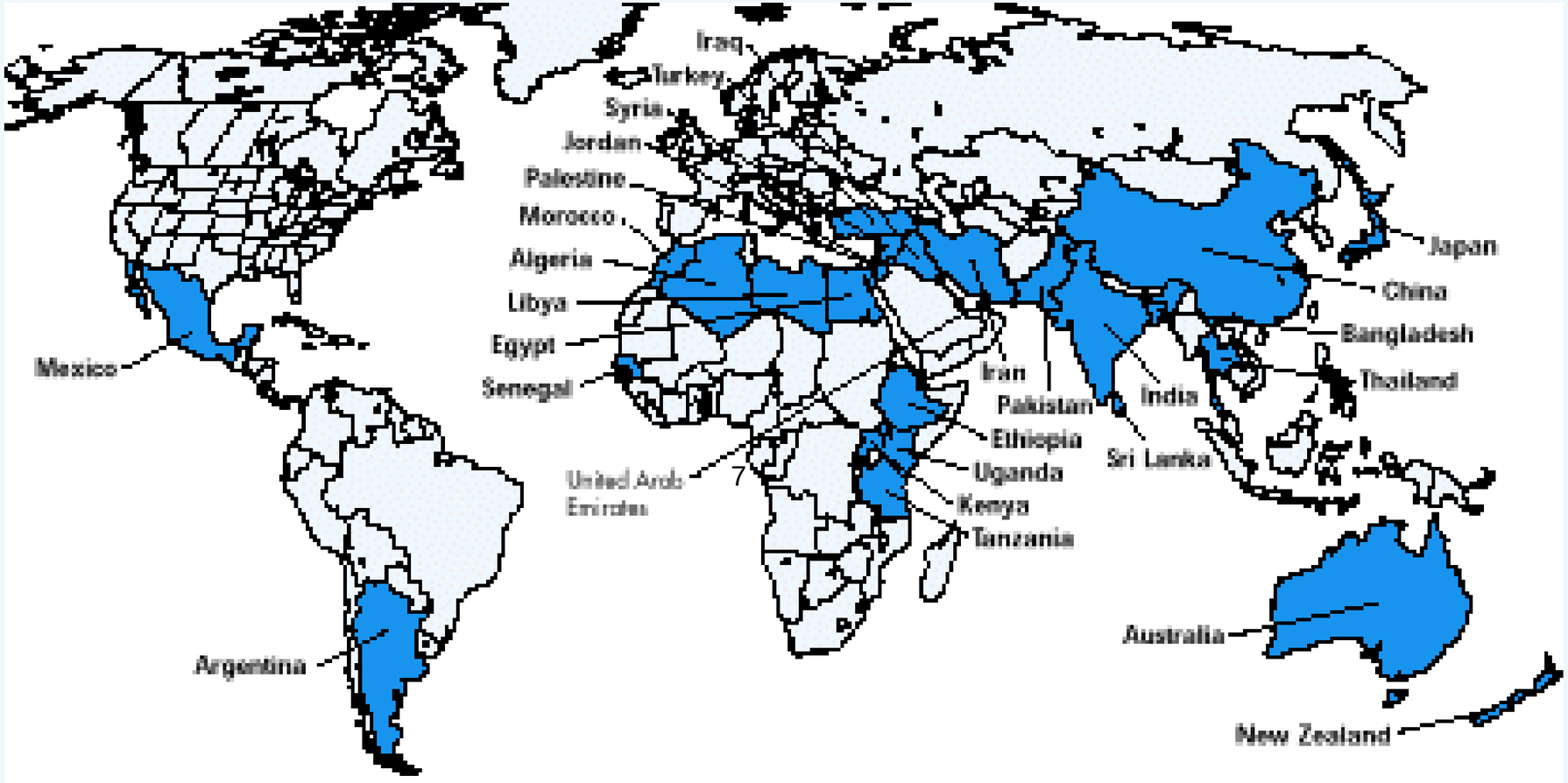
- Other health effects

Endpoint	Author	LOAEL ppm
Pineal gland	Luke 2001	<1,0
Neurotoxicity	Varner 1998	1,0
Thyroid	Bachinskii 1985	2,3
	Galletti 1958	1,0
Osteosarcoma	Cohn 1992	1,0
Bone fracture, children	Alarcon-Herrera 2001	1,0
Hip fracture, elderly	Li and others 1990-2001	1,0-1,5
Reproduction	Freni 1994	3,0

WHO limit 1,5 mg/l !

Fluorosis worldwide

Countries with endemic fluorosis due to excess fluoride in drinking water



25 endemic areas in the world (Asia, Africa, Middle-East)
Some areas in Estonia (Kuik, 1964, Saava et al. 1973)

Methodology: Health risk assessment (HRA)

RA concept used in scientific research to protect population from long-term adverse health effects from environmental risk factors

- Hazard identification
- Dose-response assessment
- Exposure assessment
- Risk characterization

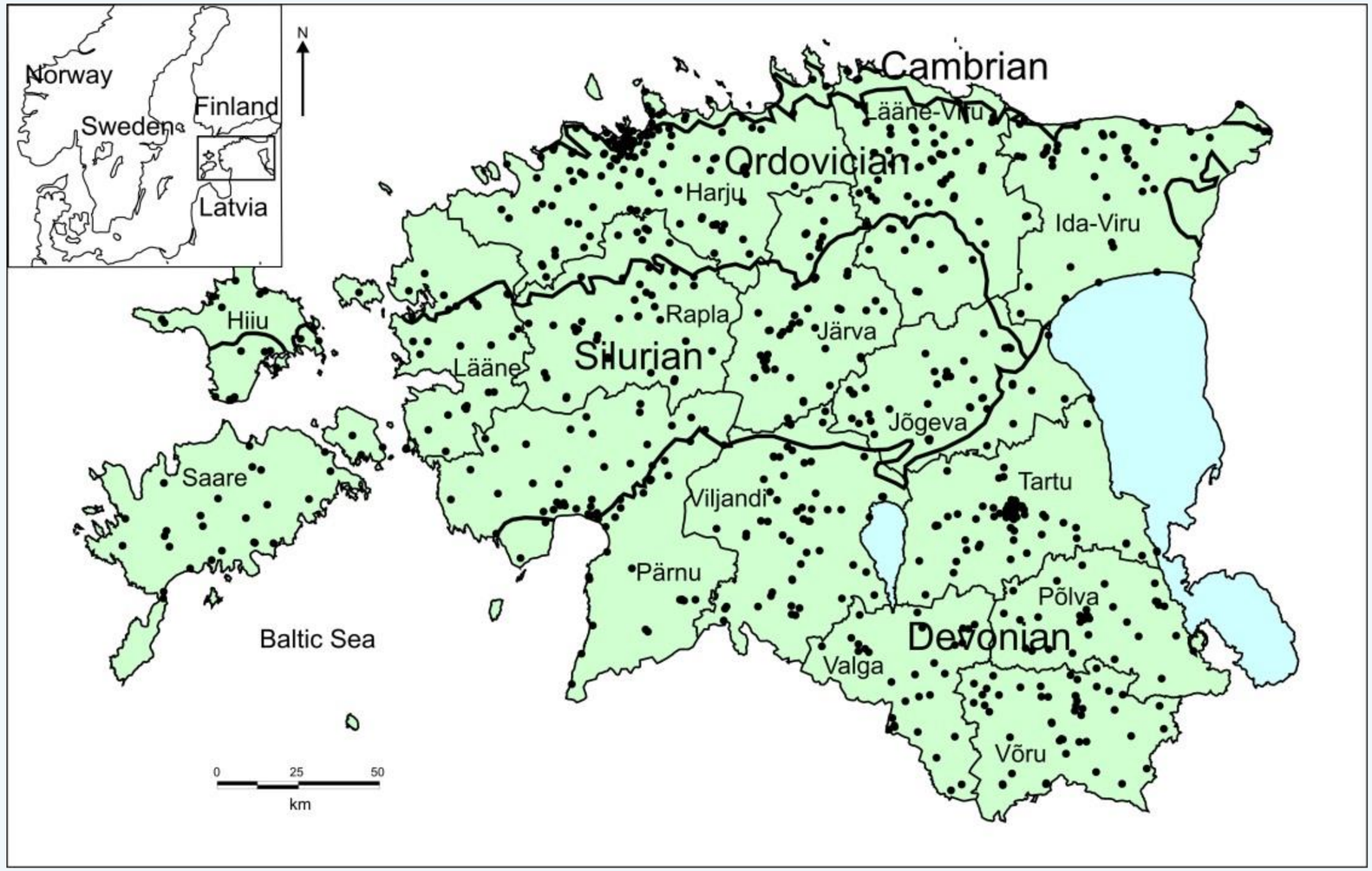
HRA combines evidence from several (and different types of) studies

All 4 steps should be covered to provide completed health risk assessment

HRA of drinking water fluoride in Estonia

HRA steps	***Research***
1. Hazard identification	Does agent cause adverse health effects? Distribution in the environment, persistence of chemical in the environment and bioaccumulation in the body. Exposure routes. *Fluoride occurrence in groundwater. Fluoride levels in tap water, regional differences in Estonia.*
2. Dose-response assessment	What is the relationship between dose and response? Quantifies hazard on population and individual level. Toxicological & epidemiological studies. *Fluorosis prevalence in relation to drinking water fluoride level among 12-year-old schoolchildren.*
3. Exposure assessment	How much of the agent are people exposed to a certain period of time? How many people are exposed?[9] Type and level of exposure. Frequency and duration of exposure *Exposure of Estonian population to different levels of fluoride in drinking water.*
4. Risk estimation	What is the estimated probability or incidence of adverse health effects? How robust is the evidence? How certain is the evaluation? *Dental fluorosis risk at different fluoride levels in drinking water in Estonia by counties.*
Risk management → Risk communication	

Study area



Population – 1.34 million

Total area – 45,227 km^2

15 counties

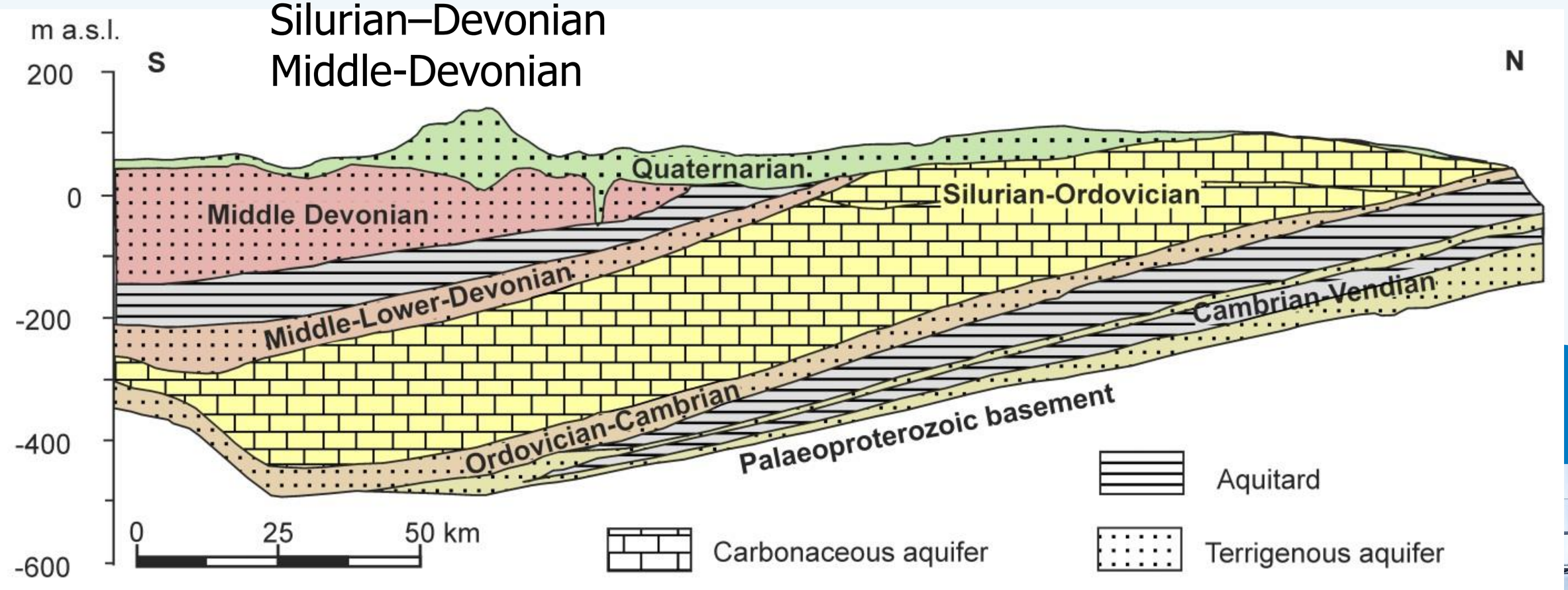
1233 public water supplies (PWS)

Study area

Public water supply is based mainly on **groundwater**

5 aquifers:
- Cambrian–Vendian
- Ordovician–Cambrian
- Silurian–Ordovician
- Silurian–Devonian
- Middle-Devonian

Surface water is used in capital Tallinn and town Narva.



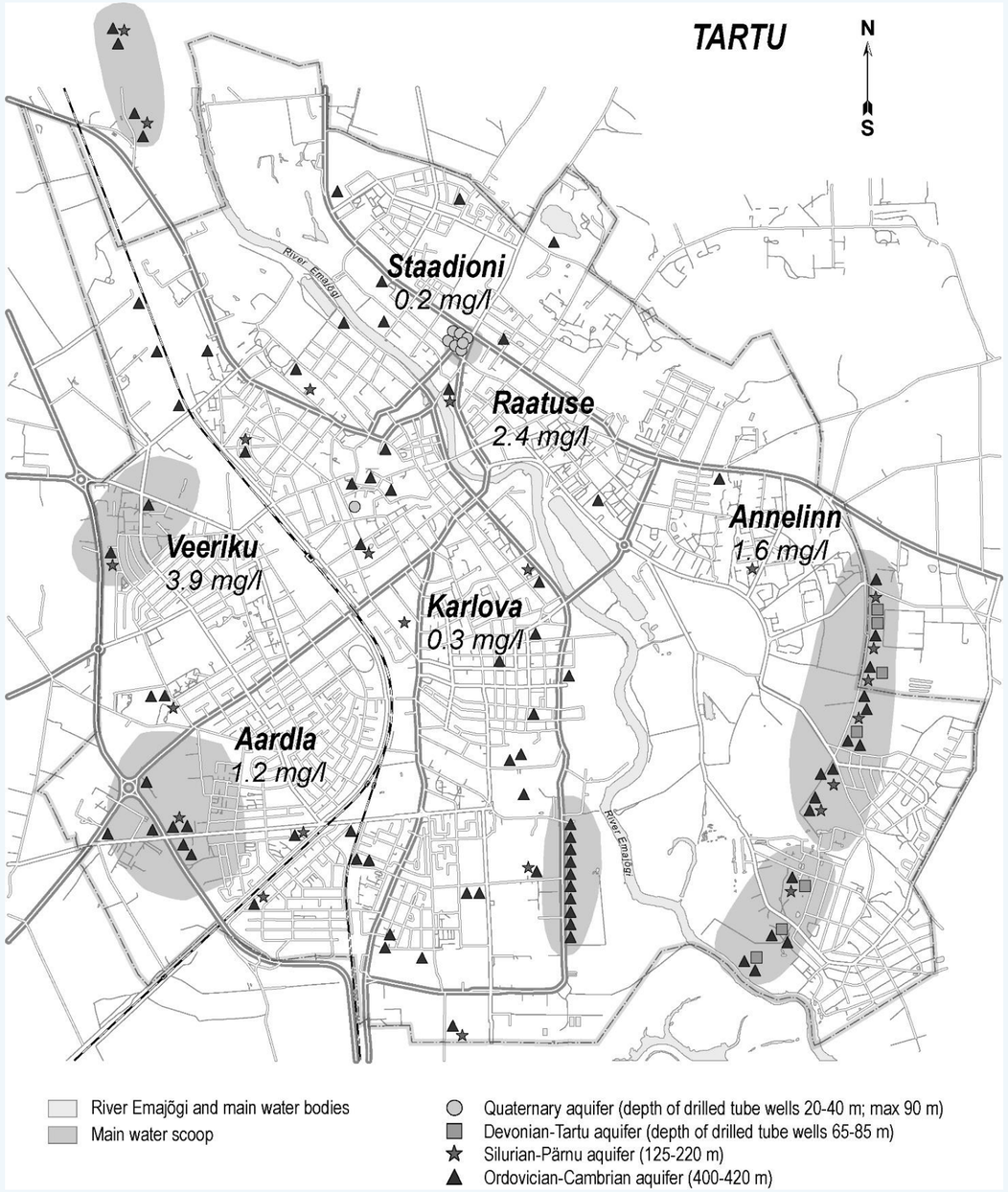
Material and methods

Step 1. Hazard identification

- Fluoride study in Estonia in 2004 (follow-up studies 2008, 2020)
  - Tap water sampling in all public water supplies (PWS) serving ≥ 100 inhabitants
  - 735 samples, 47 towns, 471 rural settlements
  - SPADNS colorimetric method (APHA 1998, WHO 2004)
  - Regional analysis: Mapinfo Professional GIS
  - Distribution of water samples into 3 categories:
    - High-fluoride drinking water (>1,50 mg/l)
    - Medium-fluoride (0,51-1,50 mg/l)
    - Low-fluoride (< 0,51 mg/l)

Material and methods

Step 2. Dose-response assessment



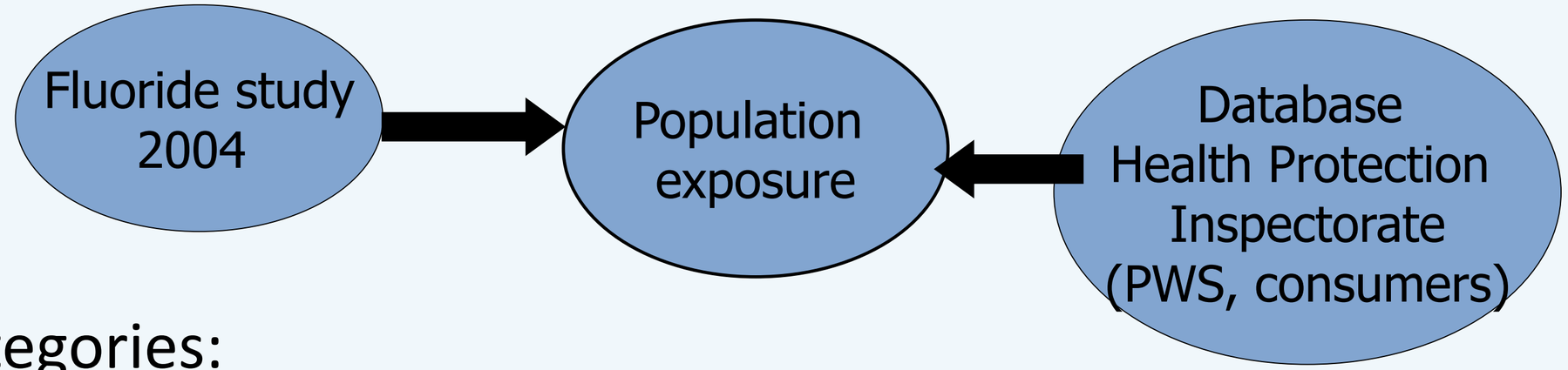
Retrospective case study in Tartu

- Dental fluorosis prevalence in relation to drinking water fluoride
- 12-year-old schoolchildren (WHO, 1997)
- Fluorosis diagnosis: Dean's index
- 6 districts: fluoride in drinking water 0.2-3.9 mg/l
- Only children reporting a continuous residence in selected districts were included in the study
- Sample size 368

Material and methods

Step 3. Exposure assessment

Data linking



Exposure categories:

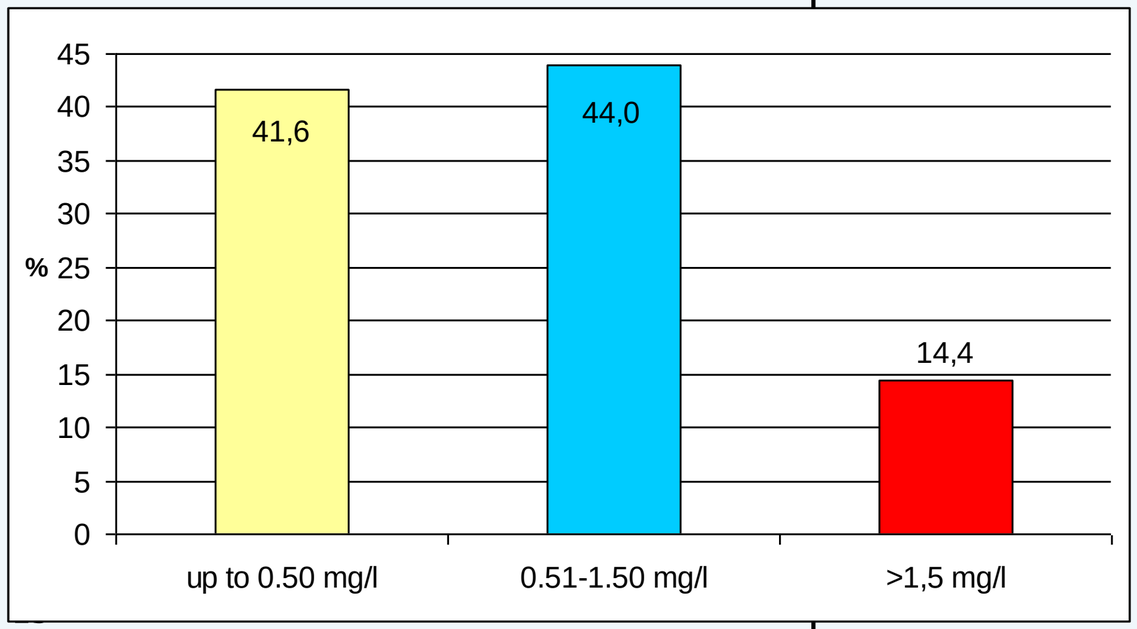
- Exposure to <u>low-fluoride</u> drinking water (up to 0.50 mg/l) – *insufficient to prevent caries.*
- Exposure to <u>optimal fluoride</u> drinking water (0.51–1.50 mg/l) – *medium level*
- <u>Excessive exposure</u> (over 1.50 mg/l) – *possible toxic effects*

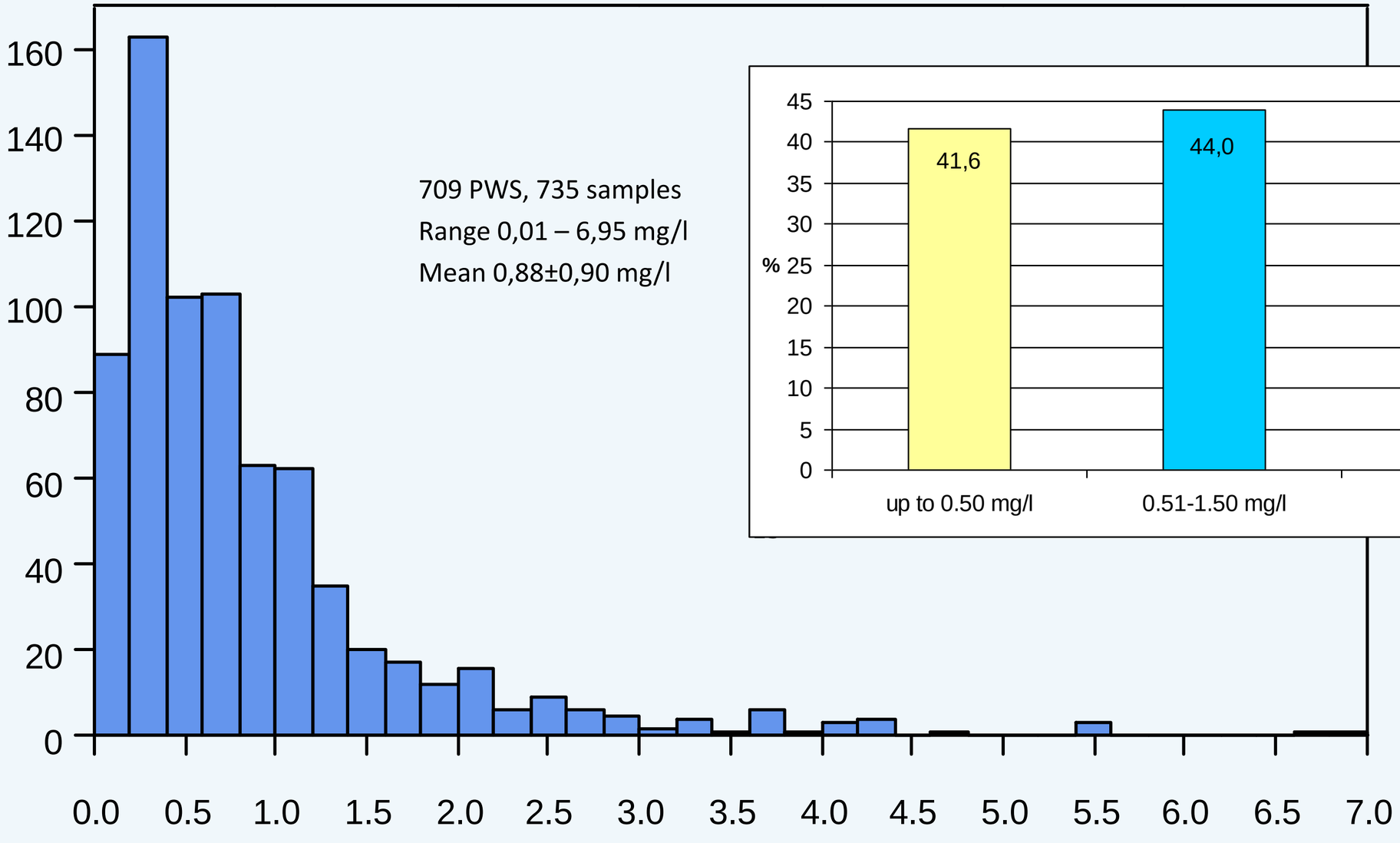
4-point exposure intensity scale:

1,5-2,0 mg/l	2,1-3,0 mg/l	3,1-4,0 mg/l	over 4,0 mg/l

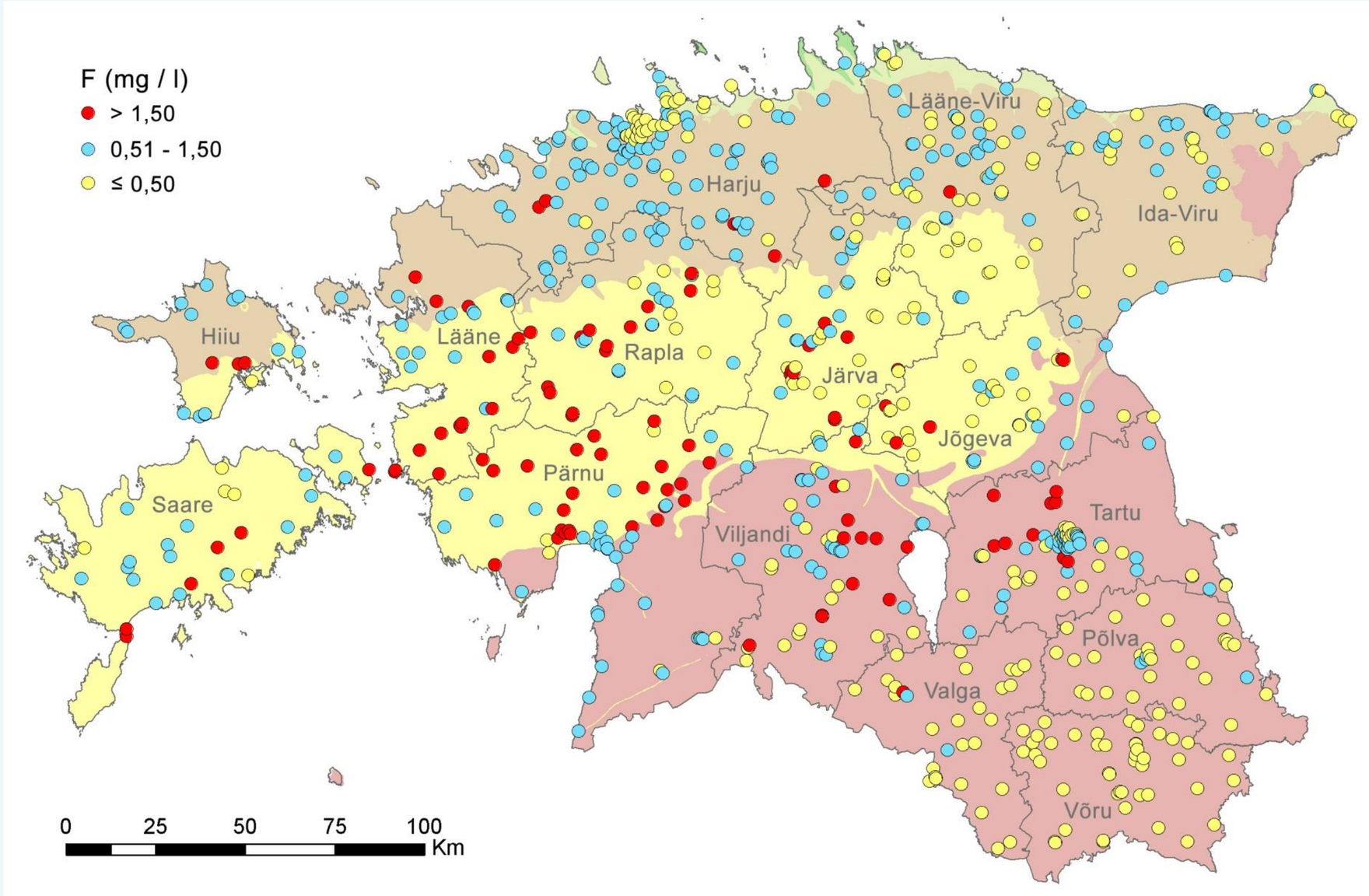
Results: fluoride concentration in drinking water

709 PWS, 735 samples
Range 0,01 – 6,95 mg/l
Mean 0,88±0,90 mg/l



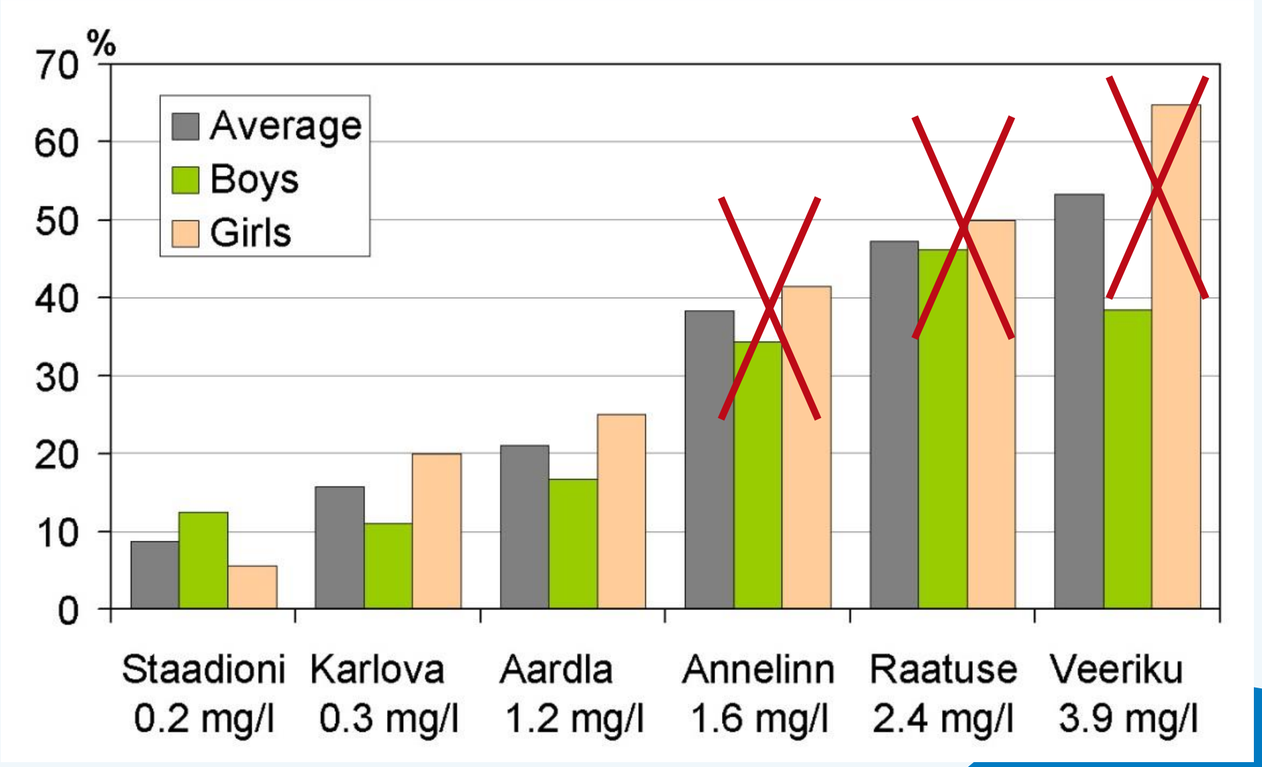


Regional distribution of fluoride concentration in public water supplies in Estonia

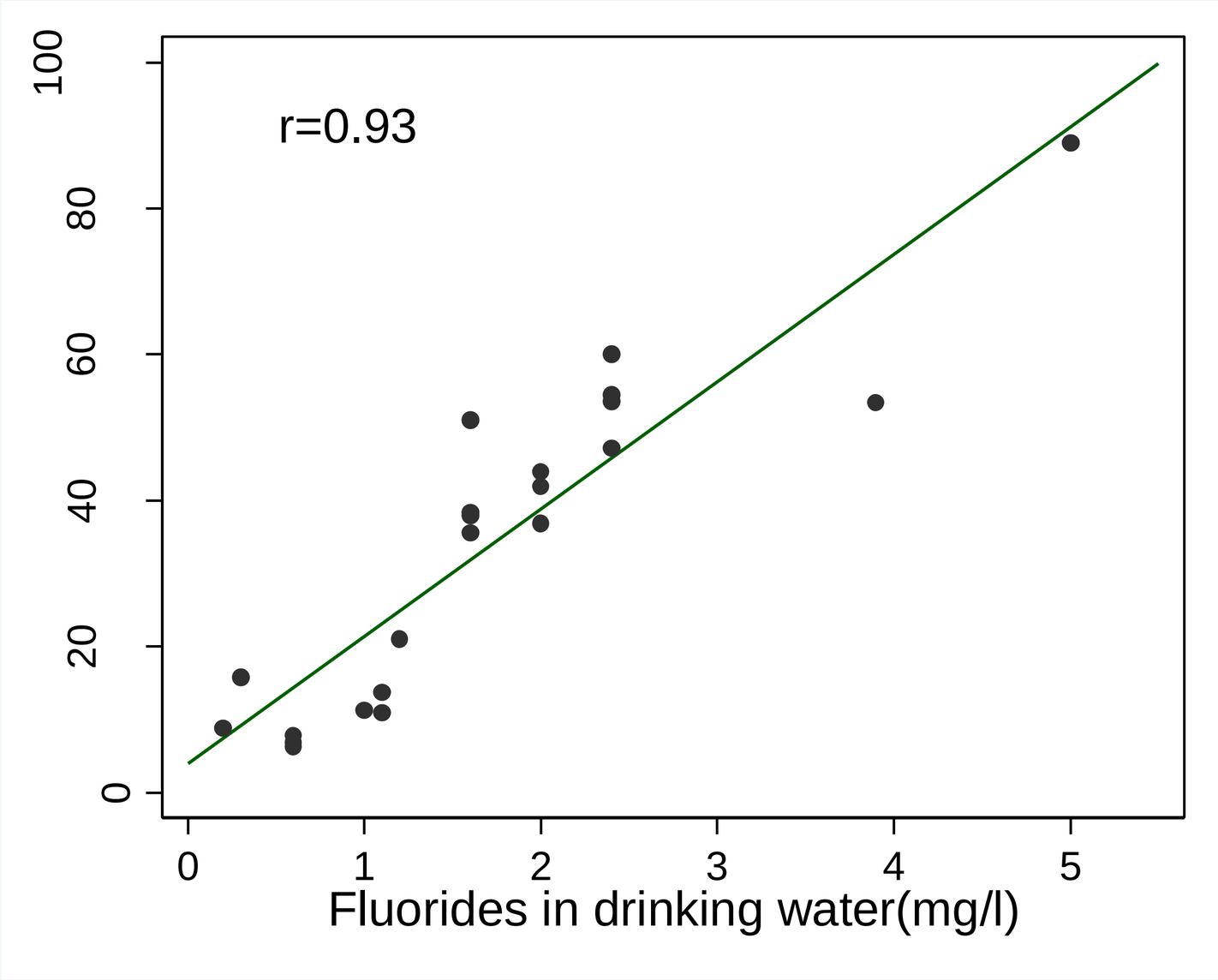


Dose-response assessment of dental fluorosis in relation to drinking water fluoride

District	No of water samples	Fluoride content in water (mg/l)	
		mean	range
Staadioni	25	0.18	0.10 – 0.30
Karlova	20	0.29	0.10 – 0.70
Aardla	28	1.19	0.80 – 1.50
Annelinn	35	1.59	1.30 – 1.90
Raatuse	24	2.41	1.85 – 3.20
Veeriku	8	3.89	3.35 – 4.40
Total	140	1.34	0.10 – 4.40



Correlation between dental fluorosis and fluoride concentration in drinking water



Pooled data

Prevalence of dental fluorosis in relation to drinking water fluoride concentration

Pooled data

Fluoride concentration (exposure group)	No. of children	Children with fluorosis (cases)	Healthy children (controls)	Fluorosis prevalence %
< 1.0 mg/l	1024	69	955	6.7
1.0 – 1.5 mg/l	984	120	864	12.2
1.5 – 2 mg/l	386	147	239	38.1
2 – 3 mg/l	167	75	92	44.9
3 – 4 mg/l	30	16	14	53.3
> 4 mg/l	36	32	4	88.9

Risk of dental fluorosis attributable to drinking water fluoride

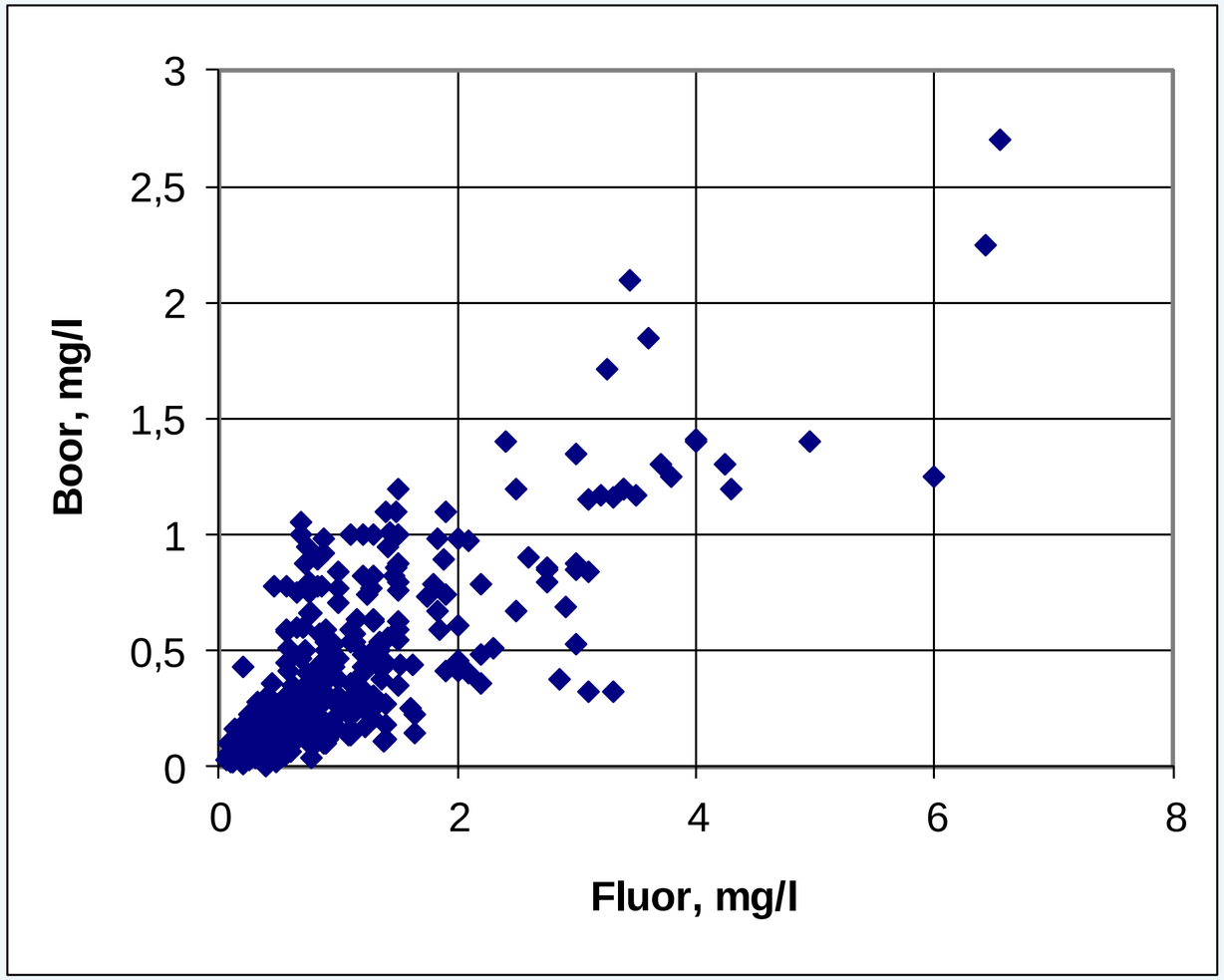
Exposure intensity, mg/l	Prevalence of dental fluorosis, %	OR	95% CI
Normal 1.00 – 1.50	12.2 (120/984)	1.0	
Small 1.51 – 2.00	38.1 (147/386)	4.4	3.3 – 5.9
Medium 2.10 – 3.00	44.9 (75/167)	5.9	4.1 – 8.4
High 3.10 – 4.00	53.3 (16/30)	8.2	3.9 – 17.3
Very high > 4.00	88.9 (32/36)	57.6	20.0 – 165.7

Estimation of dental fluorosis risk, by county

County	No. of population at dental fluorosis risk				
	Total	Risk category (OR, 95% CI)			
		4.4 3.3–5.9	5.9 4.1–8.4	8.2 3.9–17.3	57.6 20.0–165.7
Harju	3978	3978	0	0	0
Hiiu	1228	1228	0	0	0
Jõgeva	1571	580	691	300	0
Järva	5026	4696	200	130	0
Lääne	4110	190	1540	1640	740
Lääne-Viru	225	225	0	0	0
Pärnu	8562	1919	1266	4117	1260
Rapla	5354	2890	2158	306	0
Saare	2140	1030	400	260	450
Tartu	5222	3472	1400	350	0
Valga	1500	1500	0	0	0
Viljandi	3655	1313	2342	0	0
Total	42,571	23,021	9997	7103	2450

Future research: correlation between

fluoride and boron concentration levels in drinking water in Estonia



Health effects of boron in drinking water:
Reproductive system /spermatogenesis

Summary

- There is a high variability of naturally occurring fluoride content in drinking water sources in Estonia (up to 7 mg/l). F is naturally occuring mainly in the Silurian-Ordovician deposits
- Concentration of fluoride in tap water varies between regions (counties) and depends on used aquifer (well depth)
- Population exposed to excessive levels of fluoride live mainly in western and central Estonia and on islands (4,1% of study population)
- The strong relationship between drinking water fluoride and dental fluorosis prevalence among 12-year old schoolchildren in Estonia was determined.

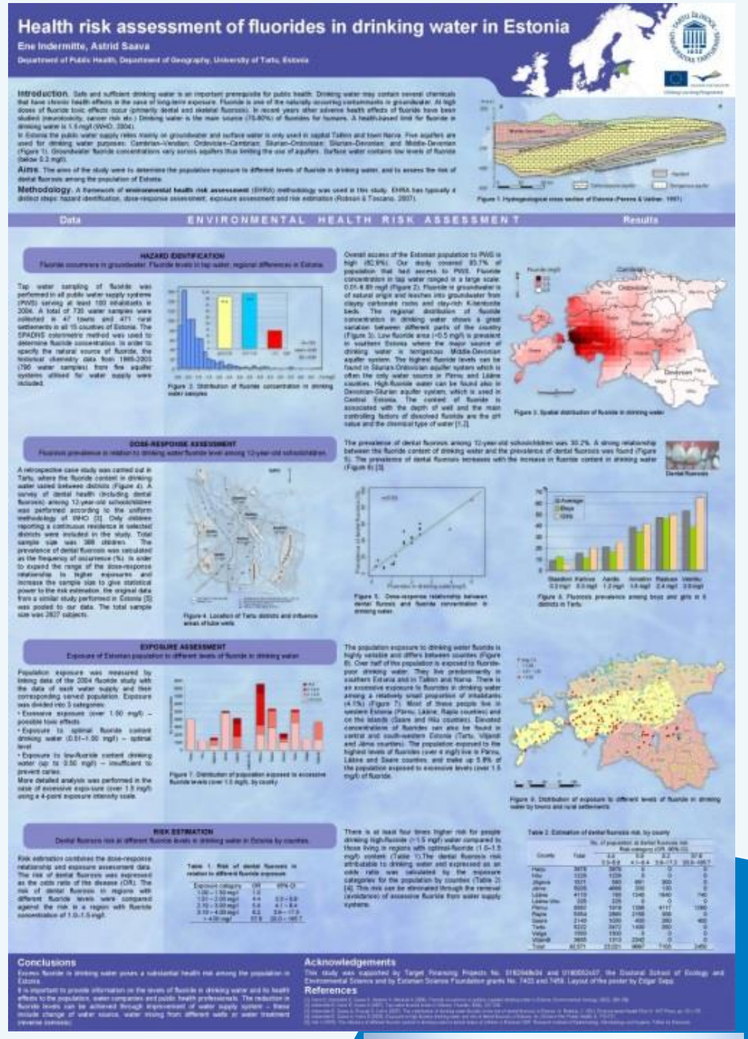
Summary

- There is at least 4.4 times higher risk of dental fluorosis for people living in areas with high-fluoride drinking water (over 1.5 mg/l)
- Other health effects from excessive fluoride exposure should be considered in future studies
- Exposure to excessive fluoride in drinking water has decreased by half since 2004 due to implementation of fluoride reduction action plans.

Application of HRA in other environmental health poblems in Estonia

- Health risks from naturally occuring compounds in drinking water: boron, arsenic, etc
- Health risks from water purification: chlorination by-products (trihalometanes) in drinking water supply system in town Narva.

- Health risks from air pollution in major towns in Estonia.
- Health risks from heat waves (climate change) among the population of Estonia
- etc…



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THANK YOU

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