

Human health risks of lead, copper and zinc in game meat

14.03.2024, Berlin

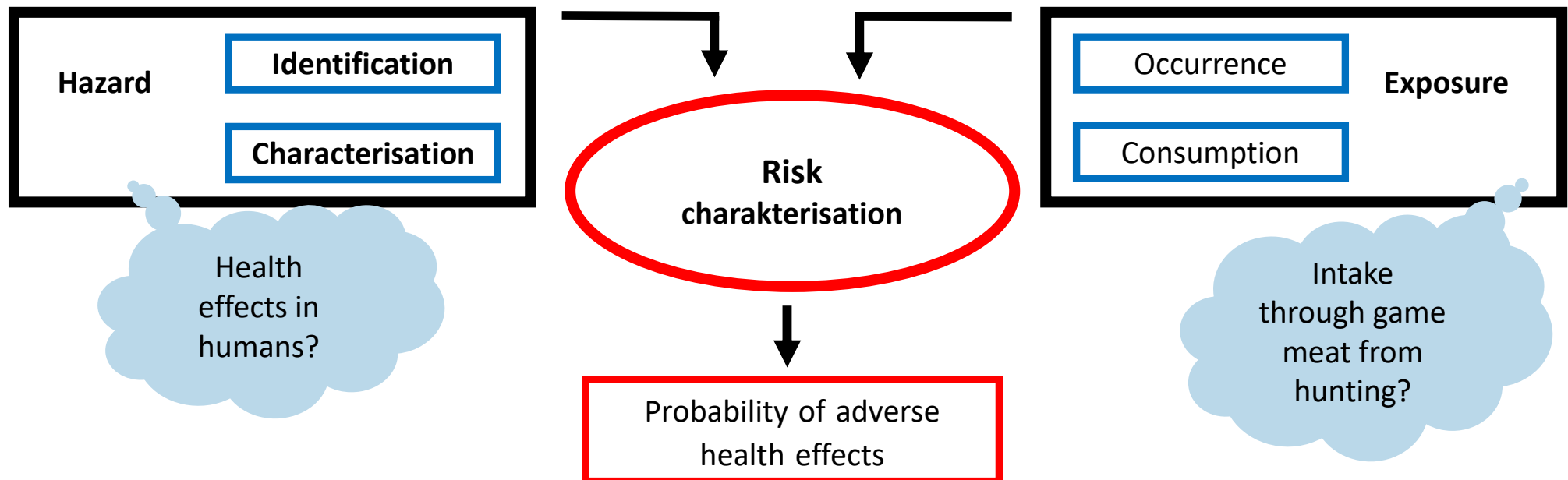
Ulrike Pabel

Human health risks of lead, copper and zinc in game meat

- Why are we concerned with the contamination of game meat from hunting with **lead**?
- Outline:
Risk assessment process



<http://www.deutschewildtierstiftung.de/de/wissen-lernen/wissen/reh/steckbrief-reh/>



Hazard identification and characterisation

1. Physiological function and needs

Copper (Cu)

- **essential trace element**
 - ✓ enzymatic function (e.g. cytochrom-c-oxidase, superoxid dismutase)
 - ✓ e.g. growth, bone stability, blood cell maturation, iron transport,...
- requirement** 1.0 – 1.5 mg / day (adults, D-A-CH 2015)

Zinc (Zn)

- **essential trace element**
 - ✓ enzymatic function (e.g. RNA-polymerase, glutathione peroxidase, alkohol dehydrogenase)
 - ✓ e.g. growth, wound healing, immune defense ...
- requirement** 7.0 – 16.0 mg / day (adults, D-A-CH 2019)

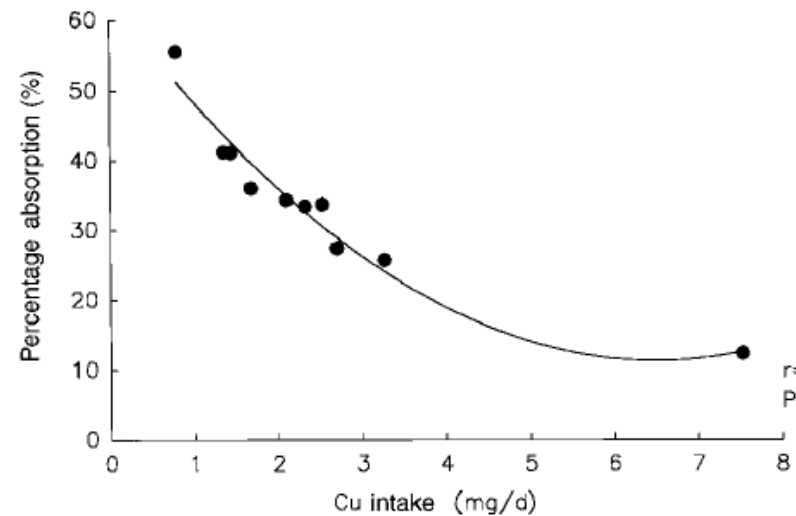
Lead (Pb)

- **non essential for humans, i. e.:**
 - ✓ no physiological needs, no physiological function, no health benefit
 - ✓ no deficiency syndrome known

2. Toxicokinetics and bioavailability

Copper and zinc

- ✓ Absorption in the gastrointestinal tract
- ✓ Relative absorption decreases with increasing uptake
- ✓ Physiological regulation of copper and zinc status through the control of absorption and excretion results in **homeostasis** over a broad range of intake



Fromme, BfR-Symposium „Alle(s) Wild?“, 18./19.03.2013

3. Toxicity, copper and zinc

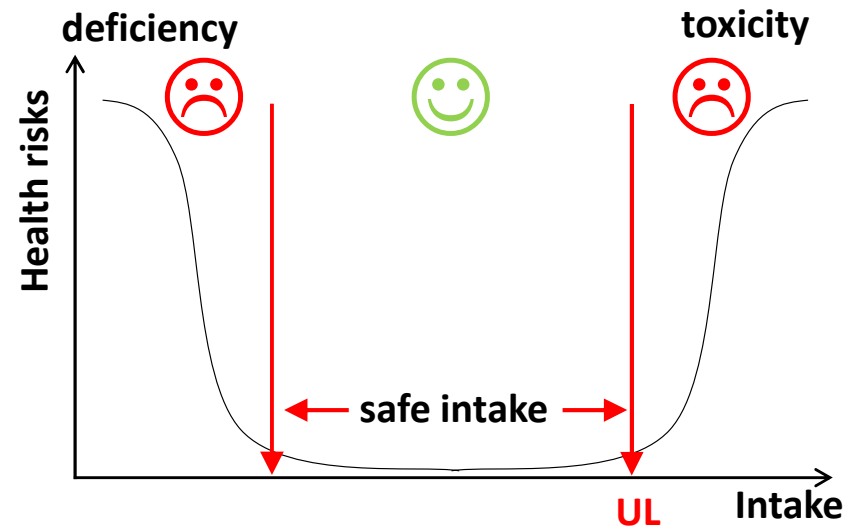
Copper (Cu)

- tolerable upper limit (UL):
5 mg / day, adults
1-4 mg / day, children ≥ 1 year,
(depending on body weight)
- chronic oversupply leads to gastrointestinal disturbances and liver effects (NOAEL 10 mg/day)

NOAEL: No Observed Adverse Effect Level

Zinc (Zn)

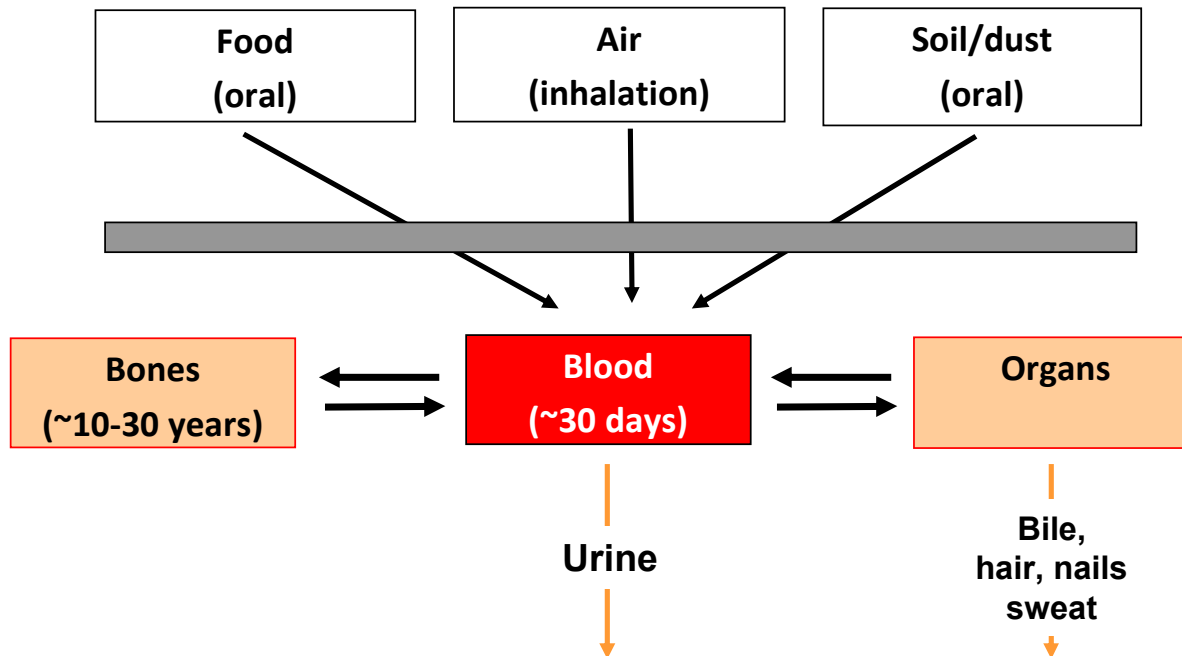
- UL:
25 mg / day, adults
7-22 mg / day, children ≥ 1 year,
(depending on body weight)
- chronic oversupply affects copper status in serum and organs as well as iron storage
- For both elements no evidence for carcinogenicity or reproductive toxicity in humans



SCF 2003,
https://ec.europa.eu/food/fs/sc/scf/out176_en.pdf
EFSA 2015,
http://www.efsa.europa.eu/sites/default/files/scientific_output/files/main_documents/4253.pdf

2. Toxicokinetics and bioavailability

Lead



Fromme, BfR-Symposium „Alle(s) Wild?“, 18./19.03.2013

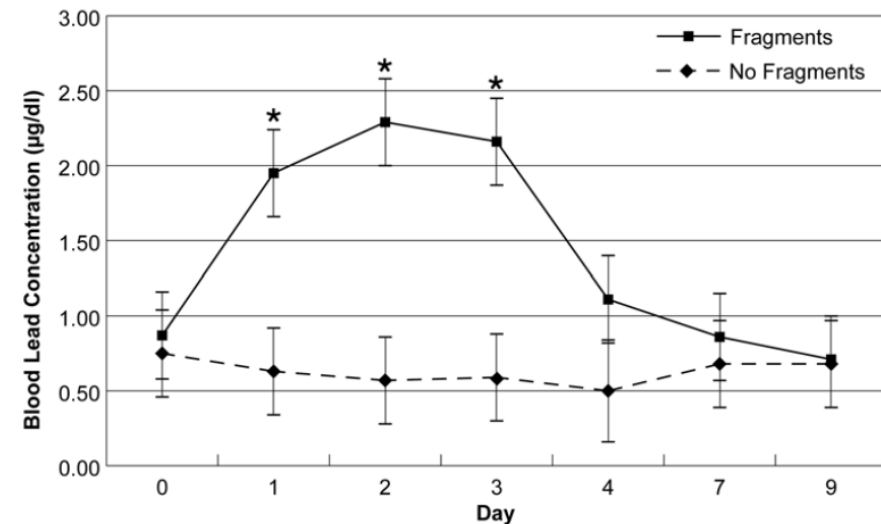
- Absorption in the gastrointestinal tract, children > adults
- Transport in blood (erythrocytes) to organs (liver, kidney)
- Accumulation in bones (half life 10-30 years)
- **Slow excretion** with urine and faeces

➤ **Chronic intake** of comparable small amounts of lead is responsible for adverse effects resulting from intake of lead with food

Bioavailability of lead from fragments of ammunition

- Intestinal absorption is possible
- Absorption is highly dependent on size of particles
- Higher absorption in children compared to adults
- Evidence from epidemiological studies for higher internal lead exposure in people eating higher amounts of hunted game meat (Tsuji et al., 2008, Iqbal et al., 2003, Bjerzegard et al., 2004, Dewailly et al., 2001)
- Concentration of lead in game meat ready-to-eat depends on the way of preparation

See also the following presentation by Kirsten Schulz on bioavailability!



- 2 x 4 pigs, 70-82 days old
- Meat with and without visible fragments
- No information on dose available!

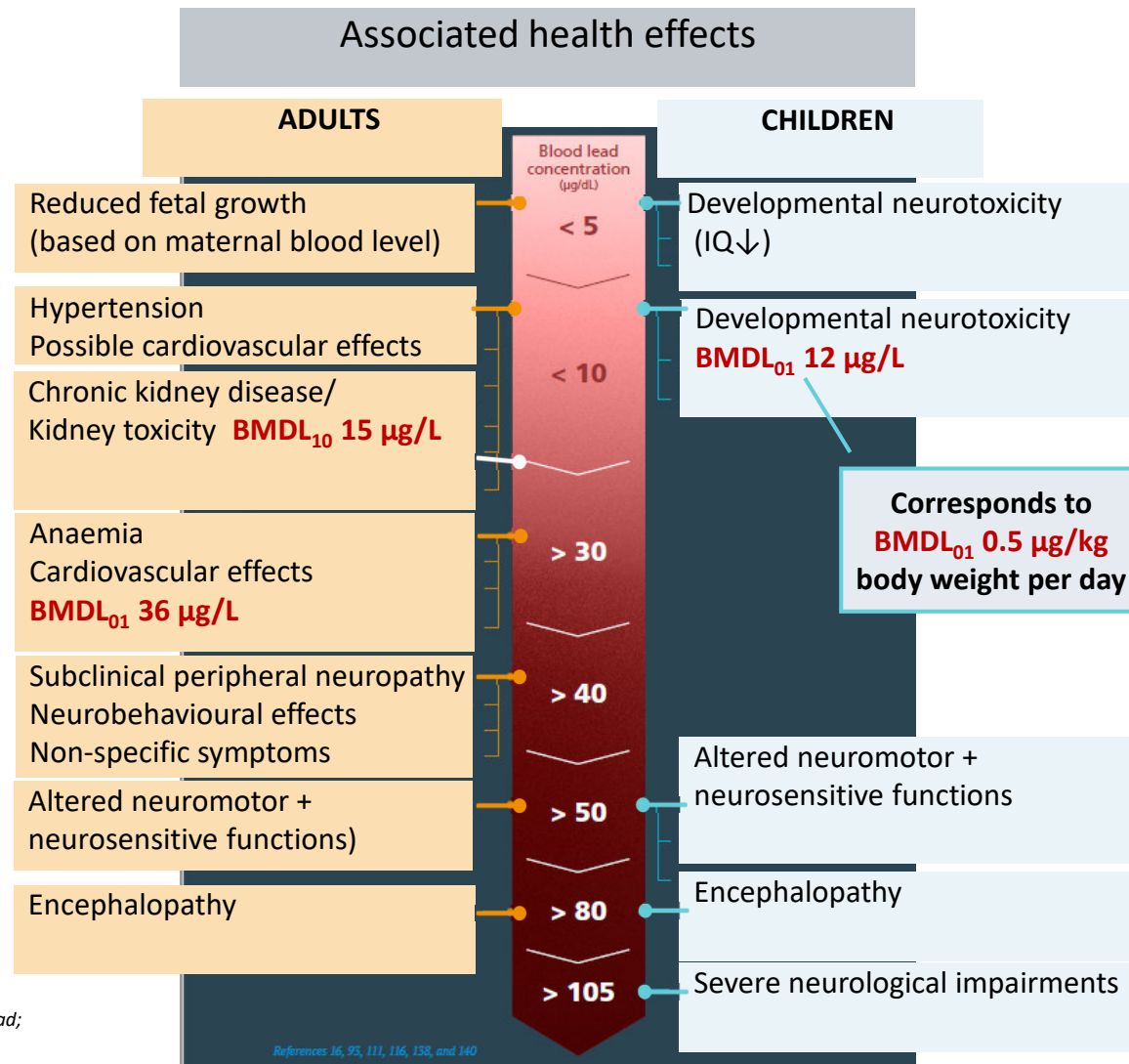
Fromme, BfR-Symposium „Alle(s) Wild?“, 18./19.03.2013

Hunt et al., PLOS ONE 2009

3. Toxicity

Lead

- No intake level without potential for adverse health effects (no „threshold“)
- Higher sensitivity of the developing nervous system of young and unborn children (pregnant women)



EFSA 2010, Scientific opinion on lead in food, <https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2010.1570>

Graphic modified from WHO, 2021, Guideline for the clinical management of exposure to lead; <https://iris.who.int/bitstream/handle/10665/347360/9789240037045-eng.pdf>

References 16, 93, 111, 116, 138, and 140

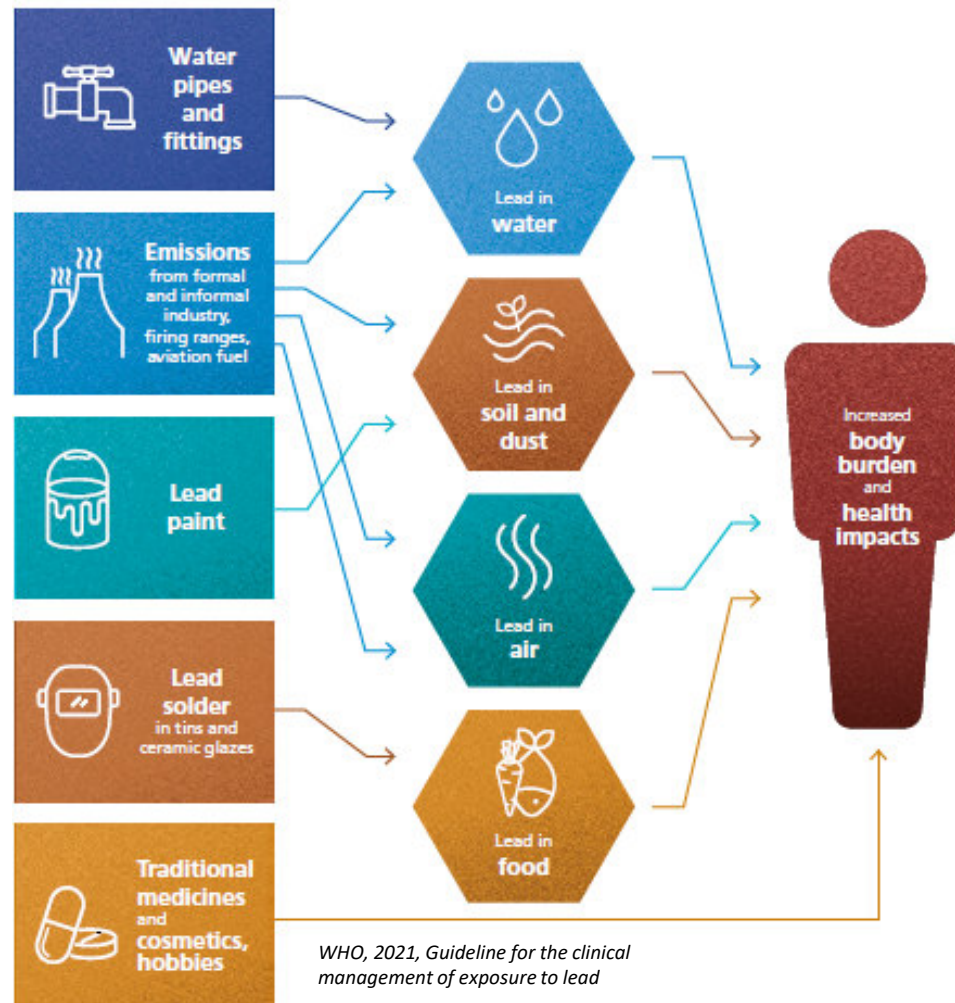
Briefly ...

Element	Physiological requirement	Health-based guidance value	Carcinogenicity (IARC)
Copper	yes	yes	--- No classification apart from copper 8-hydroxyquinoline (Group 3)
Zinc	yes	yes	--- (no classification)
Lead	no	No intake without potential adverse health effect	Group 2A (probably carcinogenic for humans)

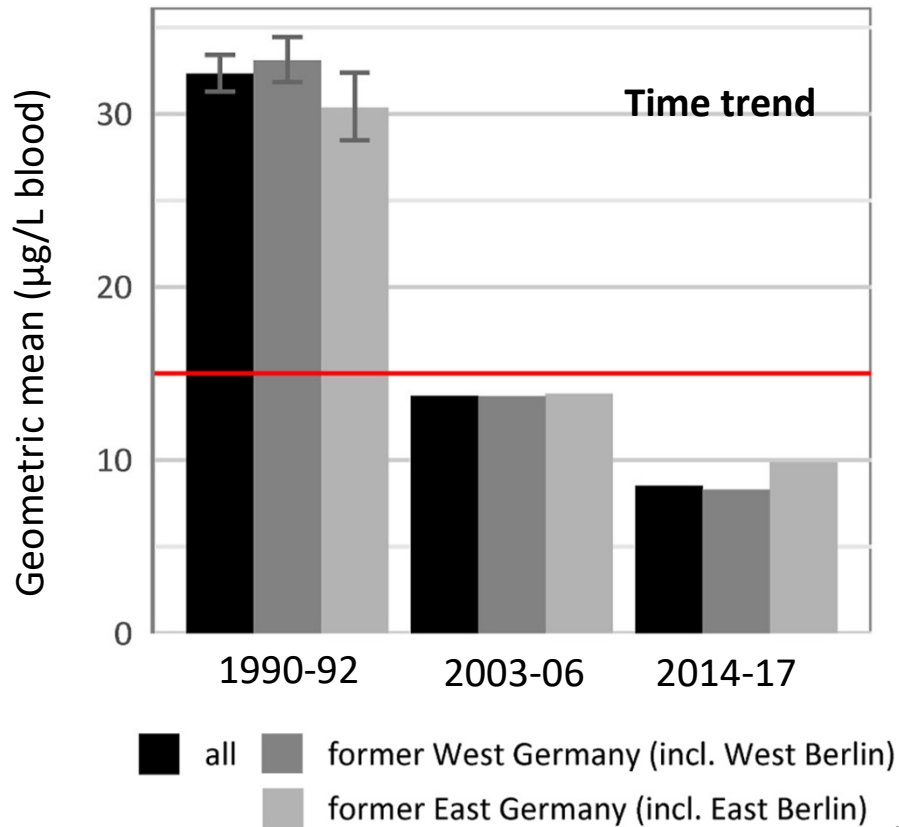
- Health risks from intake of **zinc and copper** through consumption of game meat
 - **unlikely to occur** in consumers
 - **due to their comparable low hazard potential**
- What is crucial for consumer health is the level of chronic lead intake from **all sources**, which can also **include game shot with lead-containing ammunition**

Exposure

Lead, principal sources



Lead in blood in children / adolescents in Germany



Lead in blood in children and adolescents in Germany, GerES V (2014-17)

n	< LOQ	P 50	P90	P95	P98	Max
720	0	9.4	19.8*	19.9*	24*	129*

*above BMDL₀₁ of 12 µg Lead/ L blood

Vogel et al., 2021 <https://doi.org/10.1016/j.ijheh.2021.113822>

Estimation of lead intake with food, data from the BfR-MEAL study

(Mahlzeiten für die Expositionsschätzung und Anytik von Lebensmitteln)

- Occurrence data from food purchased in Germany 2016-19



BfR
MEAL Studie
Was im Essen steckt



- **Adults:**

mean exposure between 0.07 (LB) and 0.08 (UB) $\mu\text{g} / \text{kg}$ body weight per day

high exposure (P95) between 0,16 (LB) and 0,17 (UB) $\mu\text{g} / \text{kg}$ body weight per day

(Kolbaum 2021, DOI: 10.1080/19440049.2019.1668967)

- **Children:** higher exposure compared to adults, highest results for children < 1 year to 3 years

- EFSA 2012 (exposure to lead from food in EU member states)

Adults: 0.42-0,63 $\mu\text{g} / \text{kg}$ body weight per day (LB-UB)

Children: 0.73-1.54 $\mu\text{g} / \text{kg}$ body weight per day (LB-UB)

Toxicological reference values for comparison:

[$\mu\text{g} / \text{kg}$ bw per day]

BMDL₁₀ kidney toxicity: 0.63

BMDL₀₁ cardiovascular effects: 1.5

BMDL₀₁ developmental neurotoxicity: 0.5

LB: Lower bound

UB: Upper bound

Occurrence of lead in game meat

➤ Sources of lead in edible parts of game meat

- ✓ Intake of food and soil („environmental“)
- ✓ lead and non-lead ammunition



Species	Bullet	Number	>LOQ %	Mean	Median	P95	P97	Max
Roe deer (<i>Capreolus capreolus</i>)	lead	2235	49	5.0	0.011	0.58	1.71	4728
	non-lead	1527	31	0.3	0.003	0.05	0.08	190
Wild boar (<i>Sus scrofa</i>)	lead	1542	51	5.4	0.025	1.45	5.81	1582
	non-lead	1020	34	0.9	0.002	0.06	0.12	352

Data from the research project „Safety of game meat obtained through hunting“ (LEMISI), Gerofke et al., 2018, <https://doi.org/10.1371/journal.pone.0200792>

Consumption of game meat in Germany

- Game meat is rarely consumed in comparable small amounts



Consumers

total: 11 %
 male: 13 %
 female: 8 %

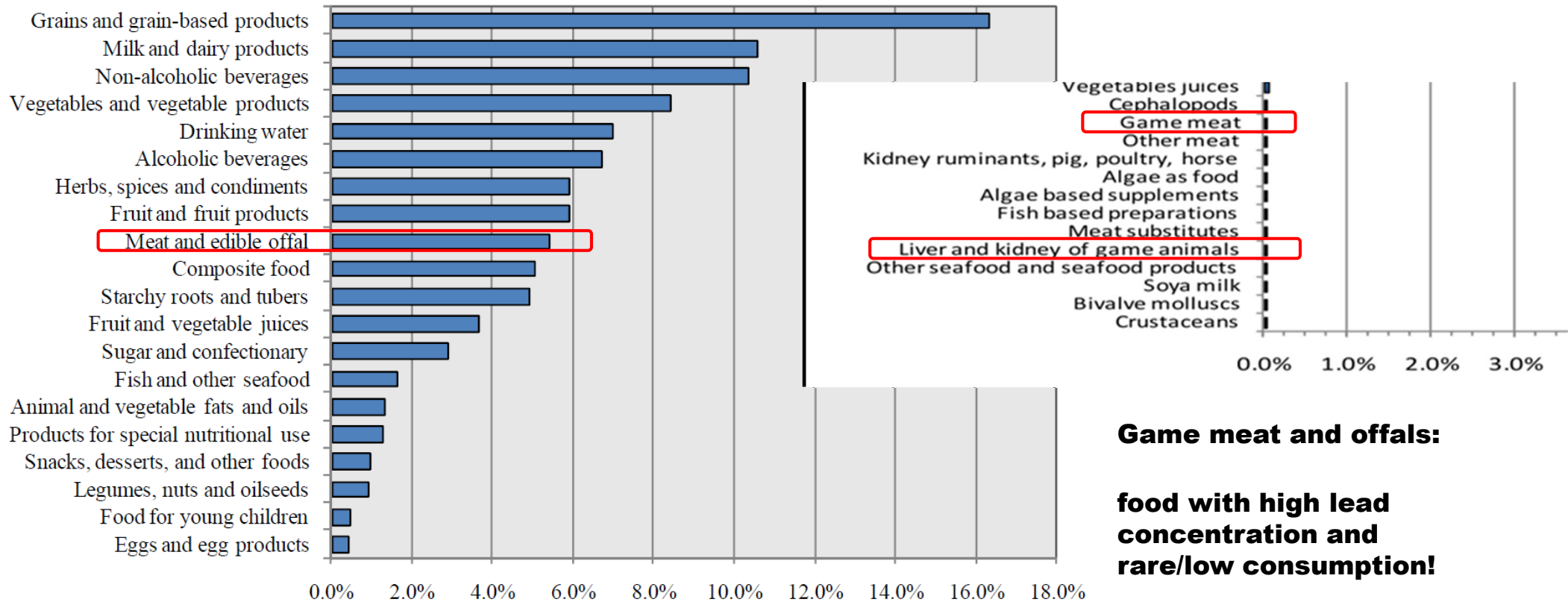
(NVS II, 20 000 adults)

Consumption frequency, 200 g game meat per meal

consumer group	female	male
average consumers (mean value of consumption from NVSII*)	1 meal per year	2 meals per year
high consumers (95 th percentile of consumption from NVSII)	5 meals per year	10 meals per year
“extreme consumers” (estimation and survey in hunters’ households [2]; [21])	up to 91 meals	

*NVSII = Nationale Verzehrsstudie II; national consumption survey II
 Gerofke et al., 2018, <https://doi.org/10.1371/journal.pone.0200792>

Lead, relative contribution of food categories to exposure in Europe



Game meat and offals:

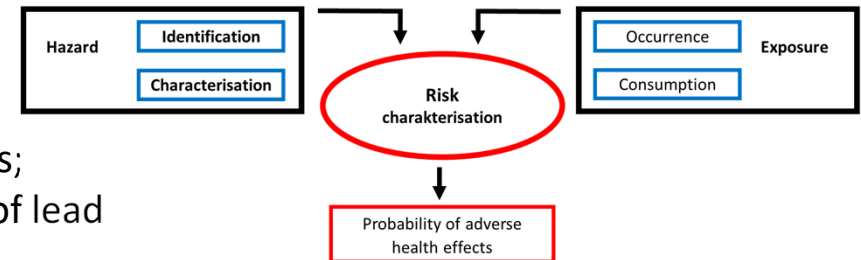
food with high lead concentration and rare/low consumption!

EFSA 2012, <https://efsa.onlinelibrary.wiley.com/doi/epdf/10.2903/j.efsa.2012.2831>

Risk characterisation and summary

Risk characterisation and summary

- Health risks from intake of **zinc** and **copper** through consumption of game meat
 - unlikely to occur in consumers, among others due to their comparable low hazard potential



- Lead: no intake level without potential for adverse health effects; higher sensitivity of young and unborn children to toxic effects of lead
- Exposure for some age groups (children) in the range of toxicological reference values (BMDL) or above; lower exposure for adults and adolescents
- Any additional intake of lead should be avoided (ALARA principle „As low as reasonably achievable“)
- Due to the low consumption of game meat: no or marginal additional health risks from intake of lead for most consumer groups expected
- Particular attention should be paid on
 - consumer groups with extremely high consumption (hunter’s households)
 - and children due to their higher absorption and sensitivity

Thank you for your attention!

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