Tidsskriftet Tidsskrift for Den norske legeforening

Lead from ammunition harmful to public health

PERSPECTIVES

JON M. ARNEMO

Jon M. Arnemo, doctor of veterinary science, veterinarian and professor at the University of Inland Norway
The author has completed the ICMJE form and declares no conflicts of interest.

MARIA AVERINA

Maria Averina PhD, specialist in medical biochemistry and departmental senior consultant in the Department of Laboratory Medicine, University Hospital of North Norway, Tromsø and associate professor at the Department of Clinical Medicine, UiT The Arctic University of Norway
The author has completed the ICMJE form and declares no conflicts of interest.

ANNE-LISE BJØRKE-MONSEN

Anne-Lise Bjørke-Monsen PhD, paediatrician and specialist in medical biochemistry at Innlandet Hospital, Førde Hospital Trust, and Haukeland University Hospital
The author has completed the ICMJE form and declares no conflicts of interest.

BJØRN J. BOLANN

bjorn.bolann@uib.no
Bjørn J. Bolann, specialist in medical biochemistry and professor emeritus at the University of Bergen
The author has completed the ICMJE form and declares no conflicts of interest.

JAN BROX

Jan Brox, specialist in medical biochemistry, professor emeritus and senior consultant at the Department of Laboratory Medicine, University Hospital of North Norway, Tromsø
The author has completed the ICMJE form and declares no conflicts of interest.

MERETE ÅSE EGGESBØ

Merete Åse Eggesbø PhD, doctor and professor emerita at the Faculty of Veterinary Medicine, Norwegian University of Life Sciences (NMBU)
The author has completed the ICMJE form and declares the following conflicts of interest: she has received lecture fees and royalties from GOLD Academy, had travel and hotel expenses covered for participation at the World of Microbiome Conference, a seminar with Monica Lind, a workshop in Tromsø by Young CAS fellow Veronika K. Pettersen, and a symposium for Philip Grandjean. Until 2023, she was a board member of ISCHE (International Society of Children's Health and the Environment).

INGRID HOKSTAD

Ingrid Hokstad PhD, specialty registrar in medical biochemistry at Innlandet Hospital.
The author has completed the ICMJE form and declares no conflicts of interest.

SANDRA HUBER

Sandra Huber PhD, special adviser in the Department of Laboratory Medicine, University Hospital of North Norway, Tromsø
The author has completed the ICMJE form and declares no conflicts of interest.

All ingestion of lead, regardless of the amount, is harmful to health. It is therefore paradoxical that the use of lead-based ammunition is still allowed.

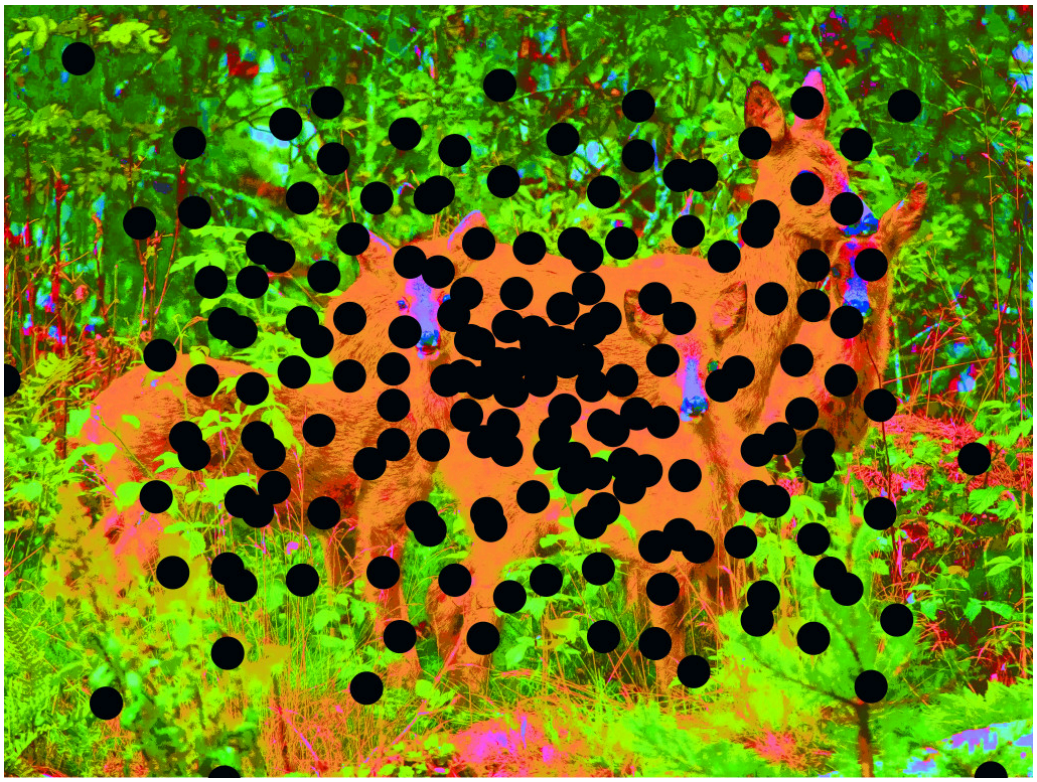

Illustration: Journal of the Norwegian Medical Association

Lead exposure is ranked as the worst chemical threat to humanity (1). The presence of lead in the environment is now 1000 times higher than the natural background levels before we started extracting and using lead (2). There is no 'safe' level of lead digestion or blood lead concentration. Acute lead poisoning can be fatal, but chronic, low-level lead exposure is also associated with health problems, such as reduced cognitive development, ADHD and autism in children, as well as increased risk of aggression, substance use and criminal behaviour, cancer and cardiovascular disease in adults (2–5).

Lead concentrations from 0.06 to 0.17 µmol/L (12–36 µg/L) have been associated with reduced IQ in children, as well as increased systolic blood pressure and chronic kidney damage in adults (3). Children absorb lead much more efficiently than adults. Lead is absorbed orally, via inhalation or through intact skin, and most of it is stored in the bones. Lead is gradually released from bone tissue with a half-life of 10–30 years. In blood, the half-life is 4–5 weeks (3).

Blood concentrations in the Norwegian population

Skogheim et al. (6) reported a 75th percentile for blood lead levels in whole blood of 0.06 µmol/L (12 µg/L) in 1034 Norwegian children. This means that approximately 25 % of the children had a lead concentration associated with a reduction in IQ. A total of 13 % of pregnant women in the Norwegian Mother and Child Cohort Study (MoBa) had a blood lead concentration associated with neurotoxic effects on the fetus (7). A multi-centre study of blood donors in Norway found that 18 % had lead concentrations that could be harmful in blood transfusions to infants (8).

«Lead-based ammunition constitutes the largest unregulated source of lead in the environment in Norway»

Lead exposure from ammunition

Lead-based ammunition constitutes the largest unregulated source of lead in the environment in Norway (9). Both those using the ammunition and the surrounding environment are exposed, as lead dust settles on clothes and equipment. A study from the United States showed a correlation between lead exposure in children and the number of guns in their household (10). In Norway, there are more than 1.3 million registered civilian firearms (11), and nearly 500,000 Norwegians have one or more guns in their home.

Shooting and handling ammunition increases blood lead concentrations. Laidlaw et al. (12) reviewed 36 published articles with data on blood lead concentrations in shooters, and found that several had very high levels. Lead levels were associated with lead in aerosols when firing shots, the number of shots fired and the calibre of the weapon. We are aware of one study on blood lead concentrations in biathletes (13), which showed that the median blood lead concentration was more than twice as high in biathletes as in a comparable group of cross-country skiers.

Shooting is one of the most popular recreational sports in Norway, and lead-based ammunition is primarily used. On standard shooting ranges, the bullets are caught by a mound of earth or sand located behind the targets. In biathlon, metal targets, known as self-indicating targets, are mostly used. Upon impact with the metal, the bullet is pulverised, and lead fragments and dust fall to the ground. This lead will eventually disperse into the environment, thereby exposing all users of the facility. The primer in most types of ammunition is lead-based, and the gunpowder gas released upon firing also contains lead.

Norway has approximately 3000 active or decommissioned shooting ranges (14, 15). All are heavily contaminated with lead from ammunition and pose a health risk to humans, animals and the environment (14, 16, 17). In some cases, the concentration of lead is so high that the soil is classified as hazardous waste, i.e. > 2500 mg Pb/kg of dry matter (17–19). Thousands of tonnes of lead are present at active and decommissioned shooting ranges (14). In the summer of 2024, a cattle herd was exposed to lead at a biathlon range, where piles of pure lead were found under the targets (20). Three calves were found dead, while two others showed signs of acute lead poisoning. The sick calves had blood lead concentrations of 4.79 and 6.07 µmol/L (993 and 1257 µg/L), respectively. One calf died and the other was euthanised.

Bullets with lead cores are also commonly used for hunting large game such as moose and deer (21). The bullets fragment upon impact, depositing lead in the animal (22). Fragments larger than 0.1–0.2 mm are visible on X-rays and can be found at least 45 cm from the wound channel. Synchrotron X-ray can detect fragments smaller than 0.01 mm. These fragments are the size of a red blood

cell and can circulate in the bloodstream to all parts of the body in animals that survive for some time after being shot. There can also be up to 50 million lead nanoparticles per gram of muscle tissue located near the wound channel. Nanoparticles can pass through intact cell membranes, including the blood-brain barrier (23).

> ***«Consuming meat from wild game shot with lead-based ammunition is associated with increased blood lead concentration, both in children and adults»***

Meat from wild game shot with lead-based ammunition can therefore contain significant amounts of lead. Two studies found that the average lead content in minced moose meat sold in Norwegian supermarkets was 18 and 56 times higher, respectively, than the maximum permitted limit for lead in livestock meat, which is 0.1 mg/kg (23). However, this legislation does not apply to wild game meat. Several studies have shown that consuming meat from wild game shot with lead-based ammunition is associated with increased blood lead concentration, both in children and adults (23, 24).

When hunting with shotguns, cartridges containing 200–500 round pellets of lead or other metals are used. Although lead shot is now banned for most types of hunting in Norway (25), enforcement is practically non-existent and compliance is unknown. Lead shot breaks into fragments and deposits lead around the wound channel. If ingested with food, lead shot can become lodged in the appendix and release lead over time. This is commonly observed in people who regularly eat meat from wild fowl killed using lead shot (23).

> ***«Lead from ammunition poses a threat to health in both humans and animals»***

Diagnostics

All exposure to lead is harmful to health, but clinical signs of low-dose lead exposure can be nonspecific or absent. Absorbed lead is stored in bone tissue, and the concentration in the blood therefore only reflects current or recent exposure (26). Consequently, any suspicion or information regarding potential lead exposure should trigger efforts to identify the source and reduce further exposure.

Light at the end of the tunnel?

It is well-documented that lead from ammunition poses a threat to health in both humans and animals (27). However, there are lead-free alternatives for most types of weapons. Based on a risk assessment by the European Chemicals

Agency (28), the EU is currently considering potential restrictions or a ban on the use of lead-based ammunition. A decision is expected in 2025.

It is not possible to have a zero-tolerance approach to lead exposure, but one source can easily be eliminated. We therefore hope that the EU will ban lead-based ammunition. Furthermore, lead and lead dust at and around shooting ranges must be controlled to prevent exposure to humans and animals in the area.

REFERENCES

1. Marti D, Hanrahan D, Sanchez-Triana E et al. Structured expert judgement approach of the health impact of various chemicals and classes of chemicals. PLoS One 2024; 19. doi: 10.1371/journal.pone.0298504. [PubMed][CrossRef]

2. Lanphear B, Navas-Acien A, Bellinger DC. Lead Poisoning. N Engl J Med 2024; 391: 1621–31. [PubMed][CrossRef]

3. EFSA Panel on Contaminants in the Food Chain (CONTAM).. Scientific opinion on lead in food. EFSA J 2010; 8. doi: 10.2903/j.efsa.2010.1570. [CrossRef]

4. Farmer JG, Specht A, Punshon T et al. Lead exposure across the life course and age at death. Sci Total Environ 2024; 927. doi: 10.1016/j.scitotenv.2024.171975. [PubMed][CrossRef]

5. Grosse SD, Matte TD, Schwartz J et al. Economic gains resulting from the reduction in children's exposure to lead in the United States. Environ Health Perspect 2002; 110: 563–9. [PubMed][CrossRef]

6. Skogheim TS, Weyde KVF, Engel SM et al. Metal and essential element concentrations during pregnancy and associations with autism spectrum disorder and attention-deficit/hyperactivity disorder in children. Environ Int 2021; 152. doi: 10.1016/j.envint.2021.106468. [PubMed][CrossRef]

7. Caspersen IH, Thomsen C, Haug LS et al. Patterns and dietary determinants of essential and toxic elements in blood measured in mid-pregnancy: The Norwegian Environmental Biobank. Sci Total Environ 2019; 671: 299–308. [PubMed][CrossRef]

8. Averina M, Hervig T, Huber S et al. Environmental pollutants in blood donors: The multicentre Norwegian donor study. Transfus Med 2020; 30: 201–9. [PubMed][CrossRef]

9. Miljøstatus. Bly og blyforbindelser. Miljødirektoratet. https://miljostatus.miljodirektoratet.no/tema/miljogifter/prioriterte-miljogifter/bly-og-blyforbindelser/ Accessed 8.1.2025.

10. Hoover C, Fossa AJ, Ranney ML et al. Firearm-related lead exposure and child lead levels in the United States, 2012-2018. J Pediatr 2024; 269. doi: 10.1016/j.jpeds.2024.113975. [PubMed][CrossRef]

11. Foss AB, Stokke O. Nå er det over 1,3 millioner private skytevåpen i Norge. To distrikter troner klart øverst på våpenstatistikken. Aftenposten 8.2.2017. https://www.aftenposten.no/norge/i/44MnG/naa-er-det-over-13-millioner-private-skytevaapen-i-norge-to-distrikter-troner-klart-oeverst-paa-vaapenstatistikken Accessed 8.1.2025.

12. Laidlaw MAS, Filippelli G, Mielke H et al. Lead exposure at firing ranges-a review. Environ Health 2017; 16: 34. [PubMed][CrossRef]

13. Turmel J, Bougault V, Couture J et al. A preliminary study on assessment of lead exposure in competitive biathletes: and its effects on respiratory health. Mov Sport Sci 2022; 116: 39–47. [CrossRef]

14. Forsvarsbygg. Kunnskapsstatus og kunnskapsbehov knytt til grunnforureining ved skytebaner. M-348. https://www.miljodirektoratet.no/publikasjoner/2015/april-2015/kunnskapsstatus-og-kunnskapsbehov-knytt-til-grunnforureining-ved-skytebaner/ Accessed 8.1.2025.

15. Asplan Viak. Nasjonal kartlegging av nedlagte sivile skytebaner. M-2130. https://www.miljodirektoratet.no/publikasjoner/2023/juni-2023/nasjonal-kartlegging-av-nedlagte-sivile-skytebaner/ Accessed 8.1.2025.

16. Forsvarets forskningsinstitutt. Veileder for undersøkelse, risikovurdering, opprydning og avhending av skytebaner og øvingsfelt. FFI-rapport 2010/00116. https://www.ffi.no/publikasjoner/arkiv/veileder-for-undersokelse-risikovurdering-opprydning-og-avhending-av-skytebaner-og-ovingsfelt Accessed 8.1.2025.

17. Søraas KS. Vurdering av bly- og antimon forurensninger fra skiskytterarenaen på Fossum i Bærum kommune. Kconsult. https://www.kconsult.no/Papers_and_Presentations/Blyundersokelse,%20Fossum%20skiskytterarena%206.%20desember%202015.pdf Accessed 8.1.2025.

18. Statens forurensingstilsyn. Veileder. Helsebaserte tilstandsklasser for forurenset grunn. TA 2553. https://www.miljodirektoratet.no/globalassets/publikasjoner/klifsft/publikasjoner/2553/ta2553.pdf Accessed 8.1.2025.

19. Miljødirektoratet. Grunnforurensing. 2024. https://grunnforurensning.miljodirektoratet.no/ Accessed 8.1.2025.

20. Næsheim A, Undseth R. Fant flere døde og syke kalver. Østlendingen 28.8.2024. https://www.ostlendingen.no/fant-flere-dode-og-syke-kalver/s/5-69-1758055 Accessed 8.1.2025.

21. Arnemo JM, Andersen O, Stokke S et al. Norske jegere forgifter økosystemet. Nor Vet-Tidsskr 2019; 131: 94–8.

22. Stokke S, Brainerd S, Arnemo JM. Metal deposition of copper and lead bullets in moose harvested in Fennoscandia. Wildl Soc Bull 2017; 41: 98–106.

[CrossRef]

23. Arnemo JM, Fuchs B, Sonne C et al. Hunting with Lead Ammunition: A One Health Perspective. I: Tryland M, red. Arctic One Health. Challenges for Northern Animals and People. Cham: Springer Nature, 2022: 439–68.

24. Meltzer HM, Dahl H, Brantsæter AL et al. Consumption of lead-shot cervid meat and blood lead concentrations in a group of adult Norwegians. Environ Res 2013; 127: 29–39. [PubMed][CrossRef]

25. Regjeringen. Reach/XVII/blyhagl i og ved våtmark. https://www.regjeringen.no/no/sub/eos-notatbasen/notatene/2019/nov/reachxviiblyhagl/id2678122/ Accessed 6.3.2025.

26. Nasjonal brukerhåndbok i medisinsk biokjemi. Bly. https://www.brukerhandboken.no/index.php?action=showtopic&book=biokjemi&topic=751e4fa658ac85e3a3a0 Accessed 8.1.2025.

27. Arnemo JM, Andersen O, Stokke S et al. Health and environmental risks from lead-based ammunition: science versus socio-politics. EcoHealth 2016; 13: 618–22. [PubMed][CrossRef]

28. European Chemicals Agency (ECHA). A review of the available information on lead in shot used in terrestrial environments, in ammunition and in fishing tackle. Helsinki: ECHA, 2018. https://echa.europa.eu/documents/10162/13641/lead_ammunition_investigation_report_en.pdf/efdc0ae4-c7be-ee71-48a3-bb8abe20374a Accessed 8.1.2025.

Publisert: 24 March 2025. Tidsskr Nor Legeforen. DOI: 10.4045/tidsskr.25.0042
Received 20.1.2025, first revision submitted 3.2.2025, accepted 6.2.2025.