LIFE16 ENV/ES/000437

Life ALCHEMIA

Health risk assessment – why, how and to whom?

Maria Leier

maria.leier@ut.ee

UNIVERSITY OF TARTU

03.03.2020

Topics

- Legislation and principles
- Overview of doses received from drinking water in Estonia
- Methodology for assessing the health risks
- Combining international and Estonian data – practical output
- Implementation

Topics

- Legislation and principles
- Overview of doses received from drinking water in Estonia

WHY?

- Methodology for assessing the health risks
- Combining international and Estonian data – practical output

HOW?

- Implementation

TO WHOM?

Council directive 2013/51/EURATOM

laying down requirements for the protection of the health of the general public with regard to radioactive substances in water intended for human consumption

- Parametric value for annual indicative dose is **0.10 mSv.**
- Article 4 states that Member States *„shall take all measures necessary to establish an appropriate monitoring programme … to ensure that in the event of non-compliance with the parametric values … it shall be assessed whether that poses a risk to human health which requires action and remedial action shall be taken, where necessary, to improve the quality of water to a level which complies with requirements for the protection of human health from a radiation protection point of view.“*

Council directive 2013/59/EURATOM

laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation

- Article 5: General principles of radiation protection:
  - Justification – *„Decisions introducing or altering an exposure pathway for existing and emergency exposure situations shall be justified in the sense that <u>they should do more good than harm</u>.“*
  - Optimisation – *„Radiation protection of individuals subject to public or occupational exposure shall be optimised with the aim of keeping the magnitude of individual doses, the likelihood of exposure and the number of individuals exposed <u>as low as reasonably achievable taking into account the current state of technical knowledge and economic and societal factors</u>.„*
  - Dose limitation – *„In planned exposure situations, the sum of doses to an individual shall not exceed the dose limits laid down for occupational exposure or public exposure. Dose limits shall not apply to medical exposures.“*

UNIVERSITY OF TARTU

Council directive 2013/59/EURATOM

laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation

- Article 5: General principles of radiation protection:
  - Justification – *„Decisions introducing or altering an exposure pathway for existing and emergency exposure situations shall be justified in the sense that they should do more good than harm.“*
  - Optimisation – *„Radiation protection of individuals subject to public or occupational exposure shall be optimised with the aim of keeping the magnitude of individual doses, the likelihood of exposure and the number of individuals exposed as low as reasonably achievable taking into account the current state of technical knowledge and economic and societal factors.“*
  - Dose limitation – *„In planned exposure situations, the sum of doses to an individual shall not exceed the dose limits laid down for occupational exposure or public exposure. Dose limits shall not apply to medical exposures.“*

UNIVERSITY OF TARTU

Annual doses from drinking water

- Study of 2017 shows that radiological analyses were done in ~ 50% of the water works that has regular consumers

446 waterworks, ~ 83% of regular consumers (937 864 people)

- From that, in 36 water treatment plants, the annual effective dose was exceeded with an average value of 0.253 mSv

112 846 people

County	Effective dose calculated (WTP, %)	Effective dose calculated (consumers)	Exceeding the ID (WTP, %)*	Exceeding the ID (consumers)	Average effective dose (mSv/y)
Harjumaa	58.6	193 443	23.6	69 928	0.238
Ida-Virumaa	57.3	95 449	23.3	22 457	0.189
Lääne-Virumaa	32.9	96 722	20.0	20 461	0.377
Sum:		**385 614**		**112 846**	
Average:					**0.253**

Health risks

- Radiation protection – to prevent deterministic effects and to reduce the possibility of stochastic effects until it is acceptable to the wider public.
- Quantifying the possibility of occurrence of stochastic effects

→ Dose limits, parametric values

→ International Commission on Radiological Protection (ICRP)

↓

Nominal risk coefficiets – sex-averaged and age-at-exposure-averaged lifetime risk estimates for a representative population

Nominal risk coefficients

Detriment-adjusted nominal risk coefficients ($10^{-2}Sv^{-1}$) for stochastic effects after exposure to radiation at low dose rate[1]

Exposed population	Cancer	Heritable effects	Sum
Whole	5.5	0.2	5.7
Adult	4.1	0.1	4.2

$5.5 * 10^{-2}\ Sv^{-1}$ = 0.055 cancer cases per Sv = 0.000055 cancer cases per mSv = 0.0000055 cancer cases per 0.1 mSv, the parametric value for indicative dose.

One can now calculate probabilistic cases in the population – but how to compare?

[1] ICRP, 2007. 2007 Recommendations of the International Commission on Radiological Protection (Users Edition). ICRP Publication 103 (Users Edition). Ann. ICRP 37 (2-4)

Combining International and Estonian data

- In order to consider the loss to the society, four different scenarios are quantified:

S1: Acceptable loss to the society in case of Cm-V consumers (233 000 people, 0.10 mSv)
S2: Loss to the society due to exceedance of parametric value (112 846 people, 0.235 mSv)
S3: Acceptable loss to the society (112 846, 0.10 mSv)
S4: Preventable loss to the society (112 846 people, S2-S3)

Scenarios	Cancer cases
S1	1.28
S2	1.57
S3	0.62
S4	**0.95***
*hereinafter, the value is rounded to 1.	

When the exceeding population would receive acceptable dose, we could prevent one cancer case.

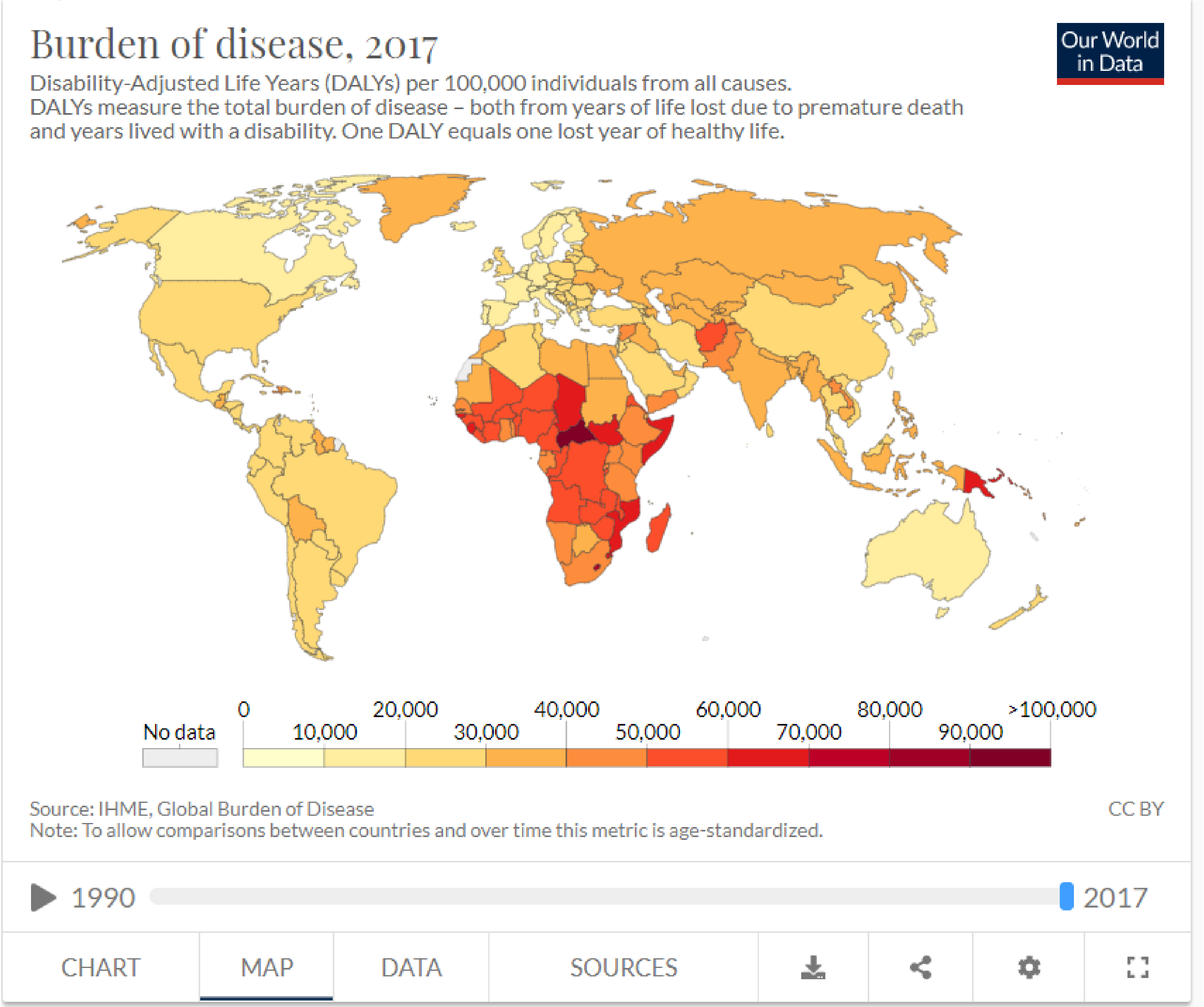
Loss to the society and monetary value

- The Global Burden of Disease study by WHO
- Burden of Disease is developed to describe death and loss of health due to diseases, injury and risk factors for all regions of the world.
- Developed in 90s by Harvard School of Public Health, the World Bank and the World Health Organization.

Disability Adjusted Life Year

- Is estimated by adding together:
  - The number of years of life a person loses as a consequence of dying early because of the disease – **YLL = Years of Life Lost**
  - The number of years a person lives with a disability caused by the disease – **YLD = Years of Life lived with a Disability**

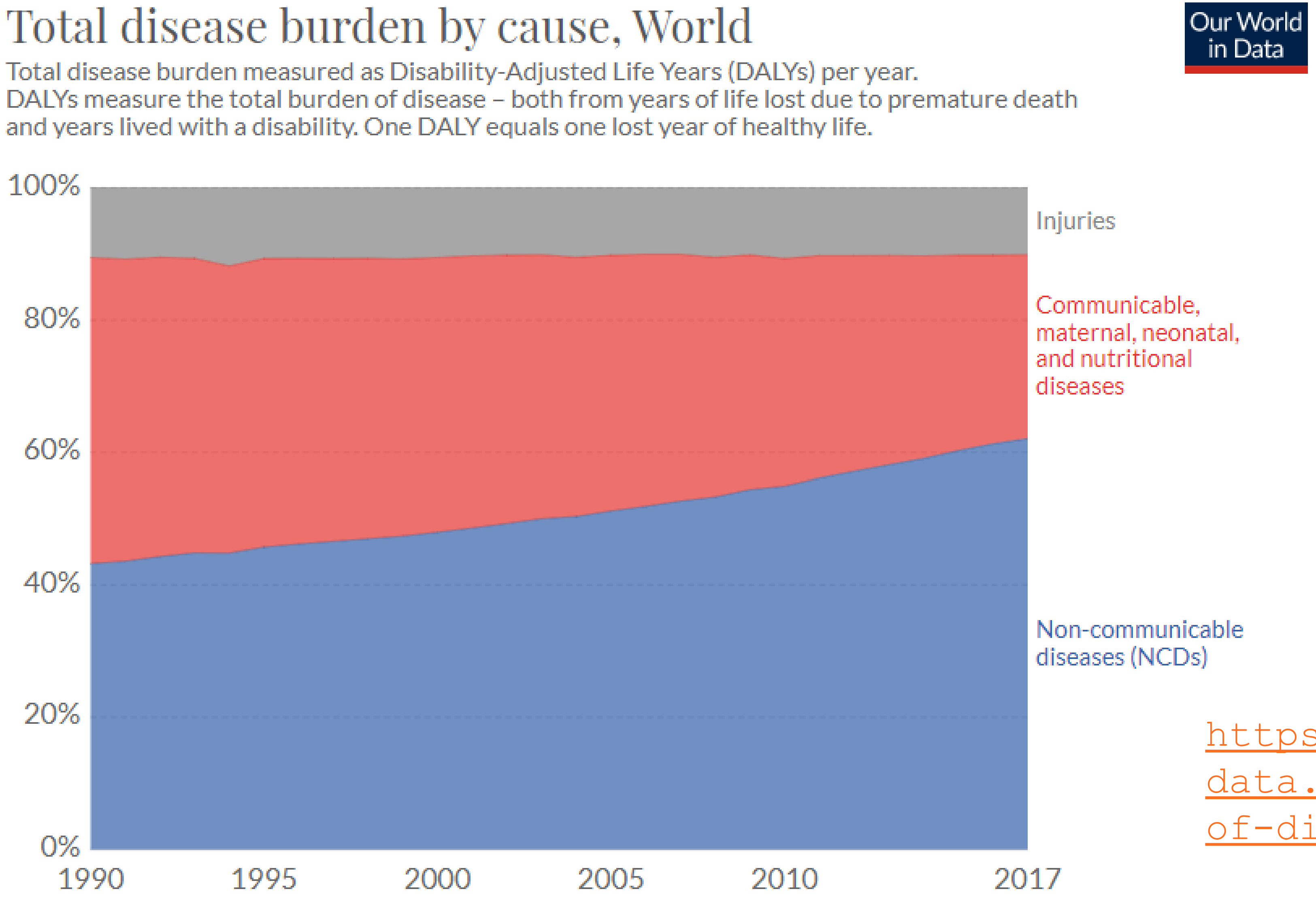
- Adding YLL and YLD together gives a single figure estimate of disease burden – **Disability Adjusted Life Year = DALY**



https://ourworldindata.org/burden-of-disease

Total disease burden by cause, World

Total disease burden measured as Disability-Adjusted Life Years (DALYs) per year.
DALYs measure the total burden of disease – both from years of life lost due to premature death and years lived with a disability. One DALY equals one lost year of healthy life.



https://ourworldindata.org/burden-of-disease

Source: IHME, Global Burden of Disease

Combining data

What we already know?

- Parametric value from legislation – 0.10 mSv/y
- Annual doses received from drinking water – 112 846 people, 0.253 mSv
- Nominal risk coefficients
- When the exceeding population would receive acceptable dose, we could prevent one cancer case.

Quantification

YLL – Years of Life Lost

- Average years of life lost in 2015 for both sexes was 15.6 years.[1]
- Cancer caused 208.2 DALY-s worldwide in 2015, of which 96% came from YLLs and 4% came from YLDs. [2]
- This ratio is used in our work. If YLL is 15.6 (96%), then 4% is 0.65 (YLD).
- Burden of disease from cancer 15.6 + 0.65 = 16.25 ≈ **16 years.**

This means: 16 years is lost for one case of cancer compared to life lived with full health.

[1] Centers for Disease Control and Prevention, National Center for Health Statistics, 1975-2015
[2] *JAMA Oncol.* 2017;3(4):524-548. doi:10.1001/jamaoncol.2016.5688

Value of statistical life (VSL)

This does not express value of a human life, but rather a risk value i.e. value of safety per se.

This means willingness to pay for safety i.e. How a small reduction in the risk of dying or being injured in an accident/occurence is valued.

IMPACT study (Internalisation Measures of Policy for External Cost of Transport):

Value of safety per se in Estonia for fatality is 1 163 000€[3] and with 2018 values this is **1 531 449€.**

[3] Korzhenevych, et al. Update of the Handbook on External Costs of Transport. Final Report 2014

VSL Estonia

VSL for Estonia is **1 531 449€** and according to Statistics Estonia, life expectancy at birth is 77.78 years[4].

What is the value of statistical life year?

1 531 449€ / 77.78 y = 19 689.5 €/y ≈ **20 000 €/y**

The willingness to pay for safety for one human life.

[4] Statistika andmebaas. RV045: Oodatav eluiga sünnimomendil ja elada jäänud aastad soo ja vanuse järgi.

VSL and DALY

Value of one statistical life year is 20 000 €/y and DALY in case on cancer is 16 years.

The loss to the society therefore is 16 y*20 000€/y = **320 000 €.**

When the exceeding population would receive acceptable dose, we could prevent **one cancer case.**

Acceptable cost for achieving parametric value

Our selection:

Annual doses received from drinking water – 112 846 people, 0.253 mSv

- In order to achieve parametric value, one must lower the effective dose 0.253 – 0.1 = **0.153 mSv.**
- The loss to the society for one case is 16 y*20 000€/y = **320 000 €.**

Interim calculation for one person: 320 000€/112 846 people = 2.84 €/person and in order to present this in €/mSv:

2.84€/0.153 mSv*y^{-1} = 18.56 €/mSv ≈ **19 €/mSv.**

Acceptable cost for achieveing parametric value

In order to achieve the parametric value for indicative dose received from drinking water for 1 consumer the acceptable cost is 19 €/mSv.

BUT assessments should be made for the representative population, therefore it should be calculated as follows:

$$AC = x * 19\ €/mSv * y$$

where

x preventable indicative dose i.e difference between parametric value and calculated effective dose (mSv/y)

y number of consumers in the water treatment plant

Practical output

When knowing the acceptable cost for a representative group of consumers, one must take into consideration the economical costs for achieving acceptable drinking water quality parameters.

This includes:

- Assessements for improving the existing technology, implementing a new technology or finding entirely different alternatives (e.g changing the water source)

Implementation

WTP operator is responsible for providing drinking water to the consumers which conforms the legislation.

Regulators and decision makers are resposible for providing know-how and support in order to provide the population quality drinking water.

COLLABORATION

but how?

Implementation (2)

Right now, WTP operators must analyse water for radiological parameters at least once in 10 years.

- Better interpretation of the results
- Possible ways for futher actions
- Impossible to provide universal solution for all water treatment plants – initiative from the operators.

UNIVERSITY OF TARTU
1632

- **Acknowledgements**
- Financial support of LIFE ALCHEMIA project (LIFE16 ENV/ES/000437) is greatly acknowledged.
- The presentation reflects only the views of the authors. The European Commission/Agency is not responsible for any use that may be made of the information it contains.

Maria Leier

maria.leier@ut.ee