Harmful Chemicals in Foods – health outcomes and disease burden

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Outline

• Sources of exposure
• Range of adverse health effects and severity
• Closer look at aflatoxin and dioxin
  - Sources
  - Health effects
  - Disease burden
• Challenges with chemicals and outlook
Human exposure to chemicals in food

• Humans are exposed to harmful chemicals from many sources

• Proportion of exposure from food varies from chemical to chemical
  – From 0 to 100%

• Foods can be contaminated in different ways
  – Naturally occurring
  – Anthropogenic pollution
  – Food contact material
  – Processing

• Exposure to humans may be via just one food or through many foods

Thomsen et al. (2022), https://doi.org/10.1007/s12403-022-00461-9
Exposure leading to adverse health outcomes

• Upon exposure, chemicals are absorbed, distributed, metabolised and excreted

• The chemical may induce:
  – a physiological change of no or uncertain significance, or
  – manifest as an adverse health effect

• Different sensitive populations (pregnant, children, malnourished, comorbidity etc.)

• If adverse health effect
  – Non-threshold (every dose might induce an effect)
  – Threshold (a certain level of exposure must be exceeded to induce effect)
Multitude of chemicals and adverse health effects

Chemicals may cause acute or long term health outcomes
(Examples below limited to chemicals and toxins considered by FERG)

<table>
<thead>
<tr>
<th>Chemical/Toxin</th>
<th>Health Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxin</td>
<td>Liver cancer</td>
</tr>
<tr>
<td>Dioxin</td>
<td>Male infertility</td>
</tr>
<tr>
<td>Cassava cyanide</td>
<td>Konzo (paraparesis)</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Chronic kidney disease</td>
</tr>
<tr>
<td>Inorganic arsenic</td>
<td>Lung, bladder and skin cancer</td>
</tr>
<tr>
<td>Lead</td>
<td>Intellectual disability, cardiovascular disease</td>
</tr>
<tr>
<td>Methyl mercury</td>
<td>Intellectual disability</td>
</tr>
</tbody>
</table>
A closer look: Aflatoxin B1 (AFB1)

- Major foodsource maize and tree/peanuts
- Human carcinogen (IARC group 1); causes liver cancer, genotoxic carcinogen
- Chronic infection with hepatitis B virus increase the potency of AFB1
- Liver cancer is one of the most common cancers with high mortality
- Highest incidence- and mortality rates are observed in Eastern Asia and Northern Africa


A closer look: Dioxins

- ~90% of exposure is foodborne
- Animal sourced food – accumulate in fat tissue
- One of most toxic man-made chemicals;
  - Impairment of immunesystem, developing nervous system, endocrine system
  - Reproduction: decreased semen quality leading to male infertility
  - Cancer
- Dioxin-levels in foodchain and in breast milk is closely monitored
  - Background exposure has been decreasing in past decades


# Health outcomes and severity

The range of health outcomes and their severity is illustrated by the disability weight

<table>
<thead>
<tr>
<th>Chemical/Toxin</th>
<th>Health Outcome</th>
<th>Duration and mortality</th>
<th>Range of Disability Weights for health states*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aflatoxin</td>
<td>Liver cancer</td>
<td>Chronic, fatal</td>
<td>0.288 – 0.54</td>
</tr>
<tr>
<td>Dioxin</td>
<td>Male primary infertility</td>
<td>Chronic, non fatal</td>
<td>0.008</td>
</tr>
<tr>
<td>Cassava cyanide</td>
<td>Konzon (motor impairment)</td>
<td>Chronic, fatal</td>
<td>0.01 – 0.42</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Chronic kidney disease</td>
<td>Chronic, stage 5 fatal</td>
<td>0.104 – 0.631</td>
</tr>
<tr>
<td>Inorganic arsenic</td>
<td>Lung, bladder and skin cancer</td>
<td>Chronic, fatal</td>
<td>0.288 – 0.54</td>
</tr>
<tr>
<td>Lead</td>
<td>Intellectual disability, cardiovascular disease</td>
<td>Chronic, IQ non fatal CVD fatal</td>
<td>IQ: 0.043 – 0.2 CVD: 0.019 – 0.179</td>
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<td>Methyl mercury</td>
<td>Intellectual disability</td>
<td>Chronic, non fatal</td>
<td>IQ: 0.043 – 0.2</td>
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Foodborne disease burden of chemicals
- utility of the DALY

• Foodborne DALY represents the disease burden inflicted by the given hazard

• DALY per case indicates the average loss of healthy life endured by an individual.

Globally in 2010, AFB1 induced liver cancer caused:
~ 640,000 DALY; ~ 30 DALY/case

Dioxin induced male infertility caused:
~ 200,000 DALY; ~ 1 DALY/case

Proportions of disease burden due to mortality (YLL) and morbidity (YLD)

- AFB1: DALY primarily due to high mortality and deaths occurring before life expectancy
- Dioxins: DALY only due to years lived with disability (it is assumed that male infertility is not fatal)

Challenges with chemicals and outlook

• General consensus: burden due to chemicals (not only from food) is underestimated
  – *No burden estimated does not mean that there is no burden!*

• Data gaps

• Rarely can a disease be traced back to a causative chemical
  – Multicausal health outcomes
  – Long lag time from exposure to disease onset

• Multitude of chemicals and health effects
  – Combination effects?

• With FERG and several other international projects, the coverage of chemical burden is expanding and challenges overcome.
Special thanks

WHO Foodborne Disease Burden Epidemiology Reference Group (FERG)

Chemicals and Toxins Taskforce (CTTF)

Thank you for the attention!