Estimating the burden of foodborne diseases: a practical handbook for countries

Module 2
Overview of all steps

1. Introduction
2. Burden of foodborne disease studies
3. Planning a burden of foodborne disease study
4. Data preparation
5. Estimating incidence, mortality and DALYs
6. Estimating foodborne DALYs (source attribution)
7. Interpreting national burden of foodborne disease results
8. Knowledge translation and risk communication
9. Final considerations
Overview of module 2

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Estimating incidence, mortality and DALYs

- Main steps of the burden of foodborne disease calculation
- Template for a disease model for the calculation of the burden of foodborne hazards
- Incidence and mortality
- Incidence of other health outcomes and sequelae
- Calculating DALYs
- Uncertainty
- Software
Main steps of the foodborne disease calculation

1. Apparent incidence
2. True incidence
3. Disease model
4. Source attribution
5. Multiplication factors
6. DALYs
7. Foodborne DALYs
Template for a disease model for the calculation of the burden of foodborne hazards
Incidence and mortality (1)

- May be collected directly from available data, if it can be assumed that there is no under-reporting or underdiagnosis in the population.
- For diseases that are known not to be fully captured by public health surveillance, the true incidence can be calculated using three approaches.
- The choice of approach will depend on the data available and the hazard in question.
Approach 1: Reconstruct the surveillance pyramid

- Preferred choice when etiology-specific incidence data are available from public health registries or other sources, and medical care-seeking behaviour, testing and diagnostic practices have been investigated in the population.

Summary

This approach starts with the number of reported cases of a pathogen (e.g. Salmonella infections) and corrects it for underdiagnosis and under-reporting by applying multiplication factors accounting for each level of the surveillance pyramid between occurrence and reporting of an illness.
Approach 2: Disease-envelope

- Useful when hazard-specific data are not available from public health surveillance or other databases
  - e.g. pathogens not notifiable; less established laboratory surveillance; absence of etiology-specific data
  - Particularly useful for foodborne BoD-related mortality.

Summary

Start with the total number of cases of a syndrome (e.g. diarrhoea) and multiply by the proportion attributable to the hazard under study (e.g. Salmonella) to obtain the incidence of hazard-associated diarrhoea.
Approach 3: Risk assessment

- Gold standard for foodborne chemicals
- Not recommended for microbiological agents (due to high data requirement and uncertainty)

Summary

This estimates exposure to a hazard via all potential transmission routes and combines this with dose–response models to predict the consequent incidence of the disease.
Incidence of other health outcomes and sequelae

• To calculate the incidence of health outcomes that may be associated with the disease but are not always present in a case of illness, the estimate of total incidence is combined with the probability of occurrence of each of these health outcomes.

• Probabilities are typically taken from scientific literature or relevant burden of disease studies.
Once all data have been collected and organized, the DALY calculation is a relatively simple step: $\text{DALY} = \text{YLL} + \text{YLD}$

**Recall**

- YLL is the product of the number of deaths (M) and the average remaining life expectancy (RLE) at the time of death: $\text{YLL} = M \times RLE$
- YLD is the product of the number of incident cases (N), the average duration until remission or death (D), and the disability weight (DW): $\text{YLD}_{\text{inc}} = N \times D \times DW$
Calculating DALYs (2)

Example
Consider a female patient who lives in a perfect state of health until she develops mild rheumatoid arthritis at age 40.

This condition has a DW of 0.58 and is thus assumed to cause a 58% reduction in health. She lives with this condition for another 20 years, after which she dies from this condition. The remaining life expectancy of a 60-year-old female is 32.65 years.

- Figure: graphical representation of the DALY calculation
- For population-based burden studies, such calculations are done for age-sex strata and then summed
Uncertainty

• Linked to the quality and representativeness of the data, and to the specifications and assumptions of the disease model used.

• Important to identify and address, to:
  • demonstrate strength of evidence
  • allow valid comparisons between studies
  • facilitate knowledge translation
  • help to identify knowledge gaps and underline the need for further data collection and research.

• When possible, sources of uncertainty in DALY calculations should be identified, quantified and analyzed, and reported in order of importance.

• Useful method: probabilistic sensitivity analysis (also called uncertainty analysis or uncertainty propagation).
A variety of software packages could be used, including:

- General software tools, such as Microsoft Excel or R
- Tools that have been specifically designed for burden of disease calculations, such as DisMod, DisModII and the DALY calculator [DALY calculator](https://www.who.int/healthinfo/bmd/bmd_calculator/en/)
Estimating foodborne DALYs: Source attribution
Estimating foodborne DALYs
Source attribution (1)

- Once the DALYs have been estimated for a particular pathogen, the proportion of the total disease burden that is due to foodborne transmission needs to be attributed
  - Some pathogens are exclusively foodborne (e.g. *Listeria monocytogenes, Taenia solium*)
  - Many foodborne pathogens also use other routes (e.g. environmental, direct contact)
- A variety of approaches exist, including epidemiological studies and studies using data from human and animal or food surveillance
- There are two primary steps to the source attribution process
Estimating foodborne DALYs
Source attribution (2)

Step 1: Estimate proportions of the BoD that can be attributed to foodborne transmission and other routes

- Often data-driven methods are not feasible (e.g. surveillance and monitoring data)
- In the absence of data, researchers often rely on opinions of foodborne disease expert panels, with modelling of uncertainty around the resulting proportions
  - e.g. the WHO GBD estimates used structured expert elicitation
- Countries with national estimates should use these to estimate the proportion of foodborne DALYs per pathogen. Countries without such estimates are encouraged to use the FERG estimates for their subregion as a proxy.
Estimating foodborne DALYs
Source attribution (3)

Step 2: Estimate the proportions of the foodborne BoD that can be attributed to specific foods and monitoring data) that are not feasible

- This step can also be performed using:
  - expert elicitation
  - data-driven methods such as microbial subtyping data analysis
  - comparative exposure assessments
  - analysis of data from outbreak investigations
  - case-control studies
Thank you

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Further learning
Steps 1-4: Module 1
Steps 5-6: Current
Steps 7-9: Module 3

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