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

Slide set 1 of 3 belonging to the handbook

Module 1
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 1

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9. Final considerations
Introduction

• Why estimate the burden of foodborne diseases?
• Challenges
• Purpose of the module 1
• Scope of the module 1
• Target audience
Why estimate the burden of foodborne diseases?

• It was estimated that unsafe foods led to 600 million cases of foodborne illness, 420,000 deaths, and the loss of 33 million years of healthy life globally.
• Considerable burden, particularly in low- and middle-income countries (LMIC).
• Ranking of public health impact.
• Identifying needs and data gaps and support efficient resource allocation.
• Support development of risk-based food safety systems and (inter)national standards.
• Support stakeholder engagement.
Challenges

• Over 250 foodborne diseases, caused by bacteria, viruses and parasites, and chemicals
• Underreporting
• Chronic diseases are difficult to attribute to a specific exposure
• Food hazards may have complex effects, including multiple health endpoints and long-term sequelae
• Foodborne pathogens may also cause disease through other pathways, such as contaminated water, contact with animals, or environmental routes
Purpose of module 1

• Guidance for anyone planning to assess the burden of foodborne diseases, particularly at national level.

• Complete picture of:
  • the requirements
  • enabling factors
  • challenges and opportunities
  • the steps in the process

• Based on the methodology defined by FERG

• Aims to foster harmonization of methodologies for estimating foodborne disease burden across countries.
Scope of module 1

This module focuses on the initial steps involved in estimating the burden of foodborne diseases caused by food hazards:

- planning
- definition of context
- data collection
Target audience

- National governments
- Academic institutions
- Others involved in conducting a study of burden of foodborne disease at national or other level (i.e. regional, subnational)
- Food business operators as potential data providers
- Consumer organizations as potential partners to establish priorities
Burden of foodborne disease studies

- The concept of disability-adjusted life years (DALYs)
- Goal and objectives
- Main elements and steps of a burden of foodborne disease study
- Requirements of a burden of foodborne disease study
The concept of disability-adjusted life years (DALYs) (1)

- Health gap metric, measuring the healthy life-years lost due to diseases or risk.
- Calculated by adding the number of years of life lost (YLL) due to premature mortality and the number of years lived with disability (YLD), adjusted for severity:
  \[ \text{DALY} = \text{YLL} + \text{YLD} \]

- YLL is the product of the number of deaths (M) and average remaining life expectancy (RLE) at the time of death:
  \[ \text{YLL} = M \times \text{RLE} \]

- YLD is the product of the number of incident cases (N), average duration until remission or death (D), and the disability weight (DW), which reflects the reduction in health-related quality of life on a scale from 0 (no impact on full health) to 1 (death):
  \[ \text{YLD} = N \times D \times DW \]
The concept of disability-adjusted life years (DALYs) (2)

\[ \text{DALY} = \text{YLD} + \text{YLL} \]

YLD: Years lived with disability, illness or injury
YLL: Years of life lost

Goal and objectives

- **Goal**: to rank and prioritize foodborne diseases based on their overall public health impact in the population.

- **Objectives**: (can be fulfilled in stages, typically in the order indicated)
  - To estimate the burden of disease caused by identified foodborne hazards, in terms of incidence, mortality and DALYs by age and sex
  - Develop a framework for routine updating of estimates and evaluation of trends
  - Provide a baseline against which food safety interventions can be evaluated

- **Estimates of burden of foodborne diseases can be used to**:
  - Set food safety priorities
  - Allocate resources to national foodborne disease risk management efforts and food safety systems
Main elements and steps of a burden of foodborne disease study

1. Planning
   - Develop workplan
   - Conduct situation analysis
   - Define context
   - Ensure capacity
   - Select hazards

2. Data preparation
   - Address data gaps and biases
   - Collect data
   - Select health outcomes

3. Calculations
   - Identify data requirements and sources
   - Estimate incidence and mortality
   - Estimate foodborne DALYs
   - Estimate DALYs

4. Attributions
   - Interpret and contextualize estimates

5. Interpretation

6. Dissemination
   - Communicate results and transfer knowledge
Requirements of a burden of foodborne disease study: incidence data

• Surveillance data for some pathogens or data on the syndromes frequently associated with these pathogens (e.g., diarrhoea)
• The data should be geographical, age and gender representative of the population in the country
Requirements of a burden of foodborne disease study: chemical hazards

- Surveillance data for chemicals in food: Ideally the data should be generated for food as consumed (e.g. Total Diet Studies)
- National food consumption data ideally based on individual food consumption survey by age and gender representative of the population in the country
- The slope of the dose-response curve for considered hazard and disease due to the foodborne hazard
Other requirements of a burden of foodborne disease study

- National and regional demographic
- Disability Weight (DW) for the selected disease or health outcome e.g. DW for various severity steps
- Capacity to analyse surveillance data, apply methods to adjust for data gaps and biases, and calculate DALYs
- Possibility to engage key actors with clinical and contextual knowledge and experts in selected diseases and data
Planning a burden of disease study

- Develop a workplan
- Conduct a situation analysis
- Ensure capacity
- Define context
- Select hazards for estimation
- Identify disease endpoints caused by selected hazards
Develop a workplan

Draw up a project plan, containing:

• the objectives of the study
• a protocol
• the personnel needed to implement the study
• tasks, activity leaders and participants funding sources
• a timeline
• main milestones
• how progress will be monitored and reported
Conduct a situation analysis (1)

Objectives
• to help define the context of the national burden of foodborne disease study;
• to facilitate knowledge translation of burden estimates into policy
• to identify and engage with key actors in food safety during the initial information-gathering process, and alert them to the study at its outset promoting collaboration

Expected outcomes
• a document positioning estimates of foodborne disease burden as input to the national policy-making process
• strengthening of stakeholder collaboration and sharing of data
Identify stakeholders in food and food safety (global, regional, national)

Map their role and influence, and investigate the dynamics among stakeholders:

• How do the interests of different stakeholders converge, overlap or conflict?
• What is the history of interaction among stakeholders (e.g. previous cooperation, relationships and potential conflicts)?
• How might a shift in policy or political context modify these dynamics?

Identify potential barriers to collaboration and data sharing and address these

• A stakeholder–issue interrelationship diagram may be useful

An overview and analysis of the political context of food and food safety, at the global, regional, and national levels, may also facilitate the planning and implementation of a burden of foodborne disease study
Range of skills needed

- epidemiology
- data management
- statistics
- modelling
- food science
- public health
- foodborne disease

Ensure capacity

- If the required skills and knowledge are not present in the core team, a network of experts who can provide ad hoc input can be useful.

- In addition to the requisite staff, an appropriate structure and routes for coordination and collaboration with key partners (e.g. data providers, data collectors and disease experts) need to be in place.
Define context

Define

- The study population, and possible subpopulations
- The levels of analysis
- The period of the study

These choices will determine the data requirements and data sources, as well as methodological considerations throughout the study.
Select hazards for estimation

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Questions to guide selection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Public health relevance</td>
<td>Is there evidence of cases of illness occurring in the population? Are there data from national public health surveillance, regional studies or ad hoc research studies?</td>
</tr>
<tr>
<td>Occurrence of foodborne outbreaks</td>
<td>Have outbreaks of illness caused by the pathogen been identified in the population? Have these outbreaks been investigated, and linked to specific foods?</td>
</tr>
<tr>
<td>Food contamination evidence, including food safety events</td>
<td>Is there evidence of foods or animals being contaminated with the hazard in the country? Are data available from national or regional monitoring programmes, ad hoc studies, or food import control programmes? Has there been any trade issue or concern?</td>
</tr>
<tr>
<td>Food consumption habits</td>
<td>Are specific food consumption patterns associated with common hazards?</td>
</tr>
<tr>
<td>Evidence from other countries</td>
<td>Has the hazard been identified as of public health concern in other countries? Is it a food safety problem in neighbouring countries?</td>
</tr>
<tr>
<td>Research, published studies or reports</td>
<td>Are there national or international studies or reports flagging the hazard as a food safety issue at national, regional or global level?</td>
</tr>
</tbody>
</table>
Identify disease endpoints caused by selected hazards

• Some food hazards are causing diseases with potentially multiple health endpoints e.g. arsenic causes bladder, lung and nonmelanoma skin cancer in humans but also increases risk of mortality from cardiovascular and respiratory diseases.
• The burden should be estimated for each health endpoint individually
• The Disability Weight* should be available for the considered endpoint or should be derived by medical expert.

4 Data preparation

• Identifying data requirements and sources
  • Demographic data
  • Incidence data
  • Exposure data
  • Dose/response data

• Selecting health outcomes
  • Disease model data
  • Disability weights
  • Duration of disease
  • Mortality data

• Collecting data

• Addressing data gaps and biases
Identifying data requirements and sources

• Where possible, data should be stratified by age and sex, as well as other categories defined under context
• The reference year(s) should follow the period defined under the context of the study
• Limitations and data gaps should be documented so that challenges can be overcome, assumptions made, and uncertainties measured
## Identifying data requirements and sources

### Demographic data (1)

<table>
<thead>
<tr>
<th>Data requirement</th>
<th>Importance</th>
<th>Data source</th>
<th>Quality assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total population, stratified by age and sex</td>
<td>Required for all diseases</td>
<td>Population census. Demographic surveys (e.g. Demographic and Health Surveys (USAID); WHO World Health Survey; INDEPTH Health and Demographic Surveillance System; National Living Standards Survey; National Household Budget Survey; National Health Survey; standard life tables.</td>
<td>Sample size, sampling area and time period</td>
</tr>
<tr>
<td>Total number of pregnancies or proportion of pregnant women</td>
<td>Required for some diseases</td>
<td>WHO global health estimates. Global Burden of Disease Study.</td>
<td></td>
</tr>
<tr>
<td>Total number or proportion of live births, stillbirths and abortions</td>
<td>Required for some diseases</td>
<td>WHO global health estimates. Global Burden of Disease Study.</td>
<td></td>
</tr>
<tr>
<td>Local life expectancy table, stratified by sex.</td>
<td>Required for all diseases</td>
<td>WHO global health estimates. Global Burden of Disease Study.</td>
<td></td>
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</tbody>
</table>
Identifying data requirements and sources
Demographic data (2)

- The use of a standard life table is preferred
- Reflects ideal life expectancy

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<th>Age</th>
<th>SEYLL*</th>
<th>Age</th>
<th>SEYLL*</th>
<th>Age</th>
<th>SEYLL*</th>
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<td>69</td>
<td>24.08</td>
<td>83</td>
<td>12.11</td>
<td>97</td>
<td>4.18</td>
</tr>
</tbody>
</table>

Reproduced from ref. 18
*SEYLL: standard expected years of life lost
Identifying data requirements and sources

Incidence data (1)

Incidence is the number of new cases of a particular disease or its sequelae in the year of interest. Data may be available from:

• public health surveillance systems if the infection is notifiable
• foodborne outbreak surveillance
• ad hoc studies or research projects
Correcting for:

- **Underdiagnosis**: cases in the community that did not seek medical care
- **Under-reporting**: cases for which medical advice was sought, but that were not correctly diagnosed, classified, or notified to the surveillance authority.

Figure: The foodborne diseases surveillance pyramid
For some foodborne diseases, it may be useful or even necessary to use syndrome-specific data (e.g. diarrhoea) in estimating the burden.

Table: Types of data, data sources, and quality assessment indicators for syndrome-specific data needed for a national burden of foodborne disease study

<table>
<thead>
<tr>
<th>Data requirement</th>
<th>Importance</th>
<th>Data source</th>
<th>Quality assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incidence of syndrome (e.g. diarrhoea or acute gastroenteritis), stratified by age and sex</td>
<td>Required for burden estimation of enteric diseases when hazard-specific data are not available</td>
<td>National Health Registries. Public health surveillance systems. National health management information systems. Scientific literature. International Data Banks.</td>
<td>Covered population and time period</td>
</tr>
<tr>
<td>Mortality of syndrome, stratified by age and sex</td>
<td></td>
<td>National Health Registries. Cause of Death Registries. Medical and hospital registers. Scientific literature. International Data Banks (e.g. Demographic and Health Surveys (21) and WHO mortality data (22)).</td>
<td></td>
</tr>
</tbody>
</table>
Identifying data requirements and sources

Exposure data for chemical hazards (1)

- In the absence of incidence data, the number of cases can be extrapolated from the dietary exposure of a population to the hazard causing the disease.
- Dietary exposure is the result of level of food consumption multiplied by food contamination.
- For chronic diseases, food consumption and food contamination should be averaged on a long period of time.
Identifying data requirements and sources

Exposure data for chemical hazards (2)

• Ideally food consumption data should be based on individual survey by age and gender representative of the population in the country
• Food consumption data can be extrapolated from household survey as « adult equivalent » or from per capita data for a whole country
• Ideally food contamination data should be based on hazard concentration in food as eaten (Total Diet Study)
• Food contamination data can be extrapolated from food monitoring of raw commodities
Identifying data requirements and sources
Dose-response data for chemical hazards

- Slope factors, or cancer potency factors, for incidence of each arsenic-related cancer

<table>
<thead>
<tr>
<th>Cancer type</th>
<th>Slope factor (increased population risk per ug iAs/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
</tr>
<tr>
<td>Bladder *</td>
<td>0.0000127</td>
</tr>
<tr>
<td>Lung *</td>
<td>0.0000137</td>
</tr>
<tr>
<td>Skin ^</td>
<td>0.000015</td>
</tr>
</tbody>
</table>

* slope factor derived by using data adapted from Morales et al (2000)
^ slope factor was adapted from the United States EPA IRIS database (2001)
Selecting health outcomes
Disability weights (1)

- DW represents severity of each health outcome
- The value of the DW is between 0 and 1, where 0 represents full health, and 1 represents death
- An obvious choice is the most recent set of DWs developed for the WHO global health estimates or GBD study
Selecting health outcomes
Disability weights (2)

Figure: Sample disability weights for different diseases

When Disability Weight is missing, proxy health states should be selected for example by a medical expert.
Selecting health outcomes
Duration of disease

• Duration is defined as the average observed duration of a health outcome until remission or death, and can vary from a few days to lifelong.
• Data: from scientific literature or health registries.
• Meta-analysis can be used to integrate data from different sources.
• When duration is lifelong, it is recommended to use the life expectancy in the country to calculate the duration of disease, i.e. from onset until expected time of death.
Selecting health outcomes

Mortality data

• Hazard-associated mortality may be available from national health registries, medical records or hospital registers.

• However, cause of death is often limited to the syndrome (e.g. diarrhoea), and the causative agent (e.g. Campylobacter) may not be registered. In those cases, as for incidence, mortality associated with a foodborne pathogen often needs to be estimated.
Addressing gaps and biases

- Examples of data gaps or biases commonly encountered in burden of foodborne disease studies, their causes and possible solutions

<table>
<thead>
<tr>
<th>Data gap or bias</th>
<th>Causes of the data gap</th>
<th>Possible solutions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases of disease not reported to public health surveillance</td>
<td>Disease not notifiable in the country. Laboratory surveillance absent in the country.</td>
<td>Apply a disease envelope approach to estimate incidence.</td>
</tr>
<tr>
<td>Cases reported, but with a degree of underdiagnosis and under-reporting.</td>
<td>Failure in any of the steps between onset of illness and reporting to public health surveillance system.</td>
<td>Reconstruction of surveillance pyramid to correct for under-reporting.</td>
</tr>
<tr>
<td>Lack of associated mortality data.</td>
<td>Lack of cause of death data in national health statistics. Deaths not linked with infection by pathogen. Lack of data on outcome of cases identified by surveillance.</td>
<td>Use of data from epidemiological studies (scientific literature). Apply a disease envelope approach to estimate mortality.</td>
</tr>
<tr>
<td>Lack of data on health outcomes and sequelae of infections</td>
<td>Occurrence of the health outcome not registered in national health statistics, or not linked with infection by pathogen.</td>
<td>Use of data from epidemiological studies (scientific literature) or other clinical data sources.</td>
</tr>
<tr>
<td>Disability weight for specific health outcomes not available</td>
<td>Health state has not been included in the GBD survey.</td>
<td>Use a proxy disability weight that is associated with similar health effects. Choose a disability weight from one of the alternative sets.</td>
</tr>
</tbody>
</table>
9 Final Considerations
Final considerations (1)

• Burden of foodborne disease estimates are essential to inform food safety policy and help establish priorities for interventions to reduce the burden.

• National studies are critical to:
  • fill data gaps identified in global and regional efforts
  • focus efforts on the national context
  • deliver estimates that are as accurate as possible and build on local data

• They can flag needs and data gaps, and promote cooperation and communication among stakeholders.
Countries are encouraged to start estimating National Foodborne BoD to the extent that expertise and resources allow:

- this could mean starting at a basic level, and working towards improvement and expansion

Identified data gaps and needs may promote further development of surveillance programmes and encourage further investments.

Study execution should be done by a team of technical and scientific staff:

- early inclusion of stakeholders and decision-makers will support knowledge translation and science-based policies

In the longer term, information on burden of foodborne disease should be a fundamental component of a systematic approach to food safety. Such an approach can improve both public health and trade.
Thank you

Multisectoral Actions in Food Systems
Department of Nutrition and Food Safety
Email: fbd-burden@who.int

Further learning
Steps 1-4: Current
Steps 5-6: Module 2
Steps 7-9: Module 3

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