World Health Organization

Global Source Attribution of Foodborne Hazards

Source attribution method in the foodborne disease burden estimates

5 November 2024

WHO Foodborne Disease Burden Epidemiology Reference Group (FERG) for 2021-2025 – Source Attribution Task Force

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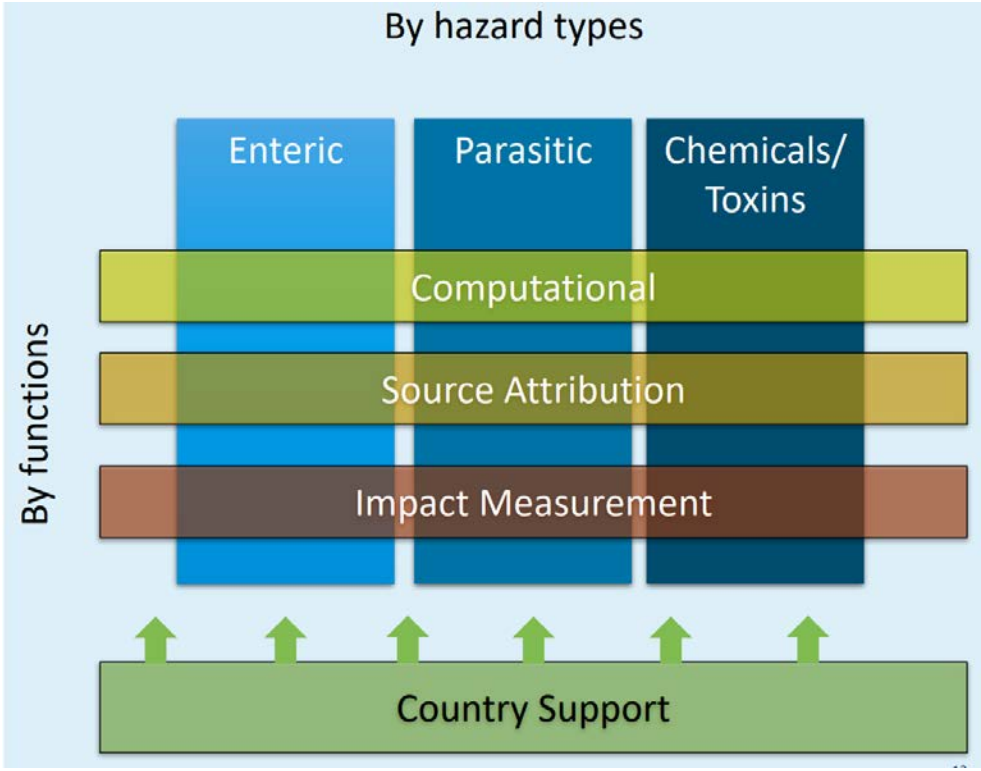
Outline

- Aims of the WHO/FERG
- What is source attribution?
- Source attribution methods
- Why Expert Elicitation?
- The process

Aims of the WHO FERG for 2021-2025

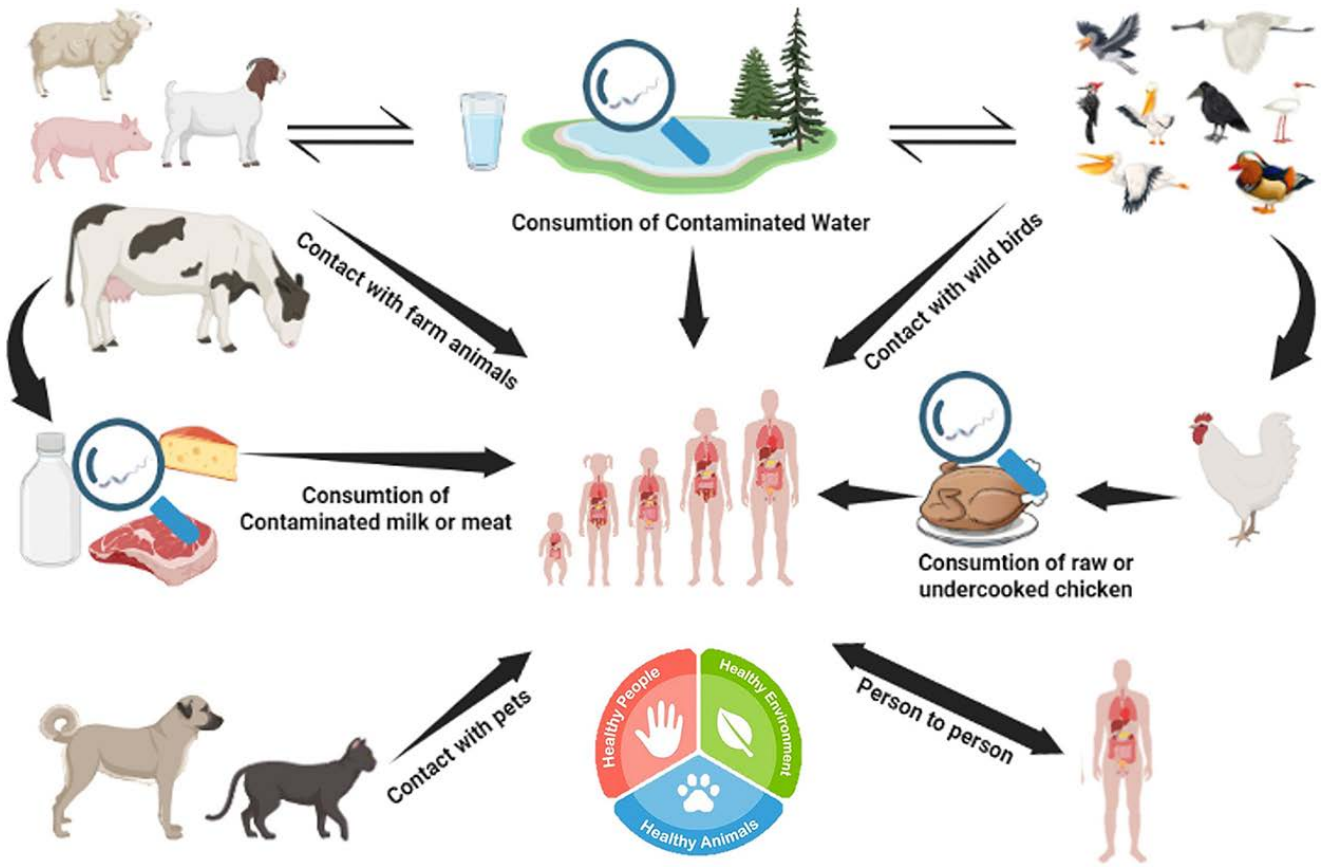
Advise WHO to:

- Estimate the global burden of foodborne diseases
- Estimate the proportion of the burden attributable to specific foods



Why is source attribution needed?

- One hazard - many exposure routes
- Delineating routes of transmission is difficult



Reservoir and transmission of Campylobacter. Source: Ali et al., 2022

https://doi.org/10.3389/fpubh.2022.1045599

What is source attribution?

The partitioning of the human disease burden of one or more foodborne illnesses to specific sources, where the term source can include reservoirs or vehicles

- Attribution to main transmission routes
- Attribution to specific foods

Source attribution methods

- Occurrence approaches
  - Subtyping approach
  - Comparative exposure assessment
- Epidemiological approaches
  - Case-control studies of sporadic infections
  - Analysis of data from outbreak investigations
- Expert elicitations
- Intervention studies

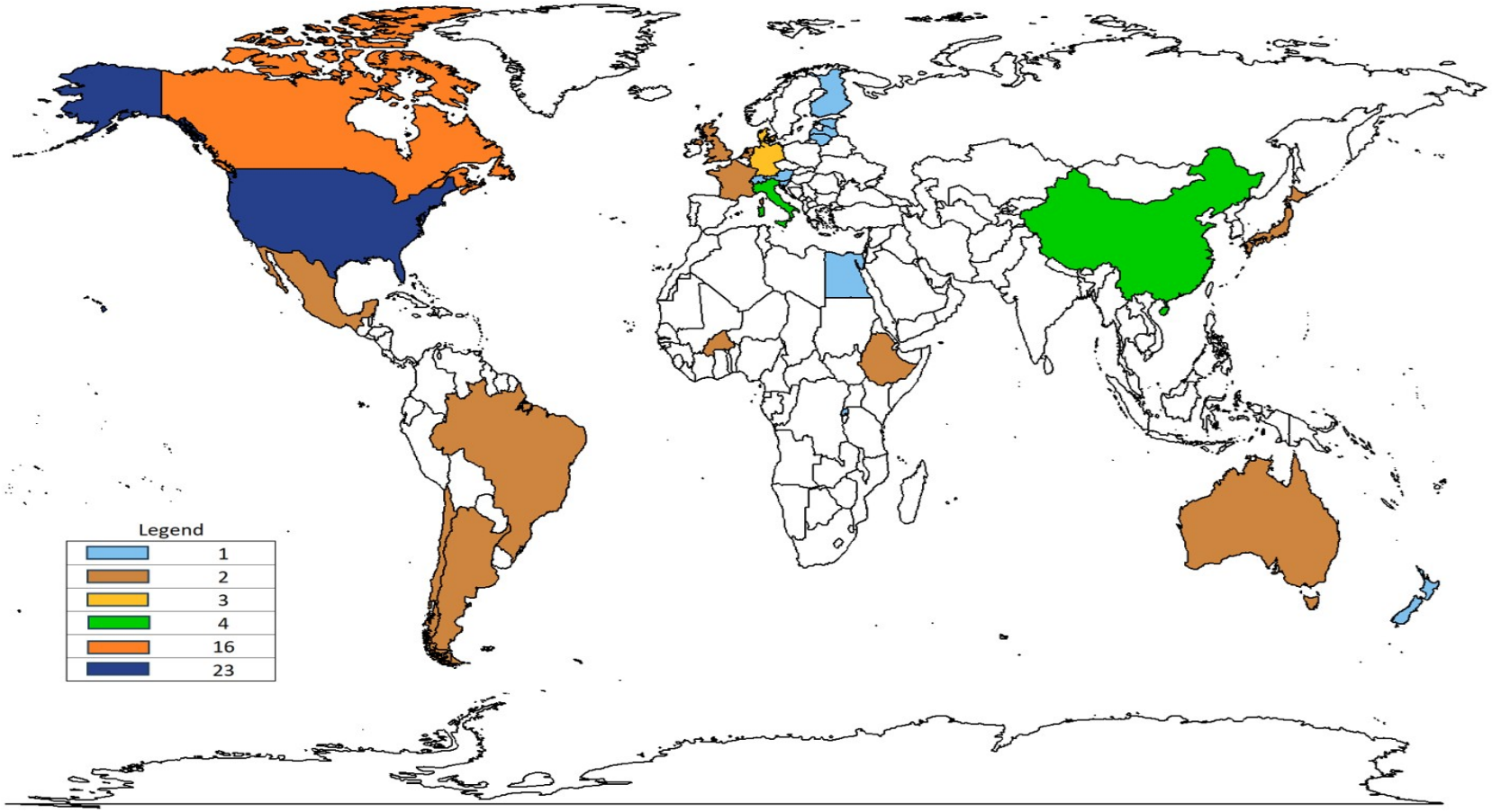
Source attribution methods

SA Method	Principles	Data requirements
Subtyping approach	**Compare subtypes** (sources and humans)	Space/time related isolates **(sources** and **humans)**
Comparative exposure assessment	Determine relative importance of transmission routes	• **Prevalence** • **Concentration** • Effect of **changes** • Exposure data

Source attribution methods

SA Method	Principles	Data requirements
Analysis of data from sporadic cases	Interviewed cases and controls; estimation of **relative role of exposures**	**Registery data**. Systematic review: sufficientc **studies published**
Analysis of data from outbreak investigations	**Outbreaks** caused by each food represent all illnesses	Date, number suspected/confirmed cases; **implicated source**
Expert elicitations	Statistical analysis of **answers of experts**	NA

Overview of source attribution studies 2010-2023



Source: Davydova et al., in preparation

Applicability of source attribution methods

- Attribution to main transmission pathways
  - Data-driven methods not useful
  - Lack of occurrence data
  - Unable to cover all potential routes - Soil, water, direct contact with animals, human contact, …

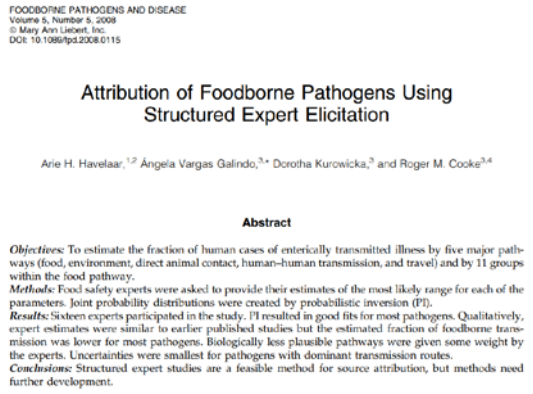
- Attribution to specific foods
  - Lack of representative and comparable data in many regions, for several hazards

Selection of methods – global source attribution

SA Method	Attribution step(s)	Coverage
Expert elicitations	• **Main transmission routes** • **Specific foods**	• All regions • All hazards
Analysis of data from outbreak investigations	• Specific foods	• Regions, countries with data • Foodborne pathogens

Expert elicitation for source attribution

- Structured approach to including judgment in modeling
- Long history of use in many fields, including source attribution of foodborne hazards



FOODBORNE PATHOGENS AND DISEASE
Volume 5, Number 5, 2008
© Mary Ann Liebert, Inc.
DOI: 10.1089/fpd.2008.0115

Attribution of Foodborne Pathogens Using Structured Expert Elicitation

Arie H. Havelaar,[1,2] Ángela Vargas Galindo,[3,*] Dorotha Kurowicka,[3] and Roger M. Cooke[3,4]

Abstract

Objectives: To estimate the fraction of human cases of enterically transmitted illness by five major pathways (food, environment, direct animal contact, human–human transmission, and travel) and by 11 groups within the food pathway.
Methods: Food safety experts were asked to provide their estimates of the most likely range for each of the parameters. Joint probability distributions were created by probabilistic inversion (PI).
Results: Sixteen experts participated in the study. PI resulted in good fits for most pathogens. Qualitatively, expert estimates were similar to earlier published studies but the estimated fraction of foodborne transmission was lower for most pathogens. Biologically less plausible pathways were given some weight by the experts. Uncertainties were smallest for pathogens with dominant transmission routes.
Conclusions: Structured expert studies are a feasible method for source attribution, but methods need further development.

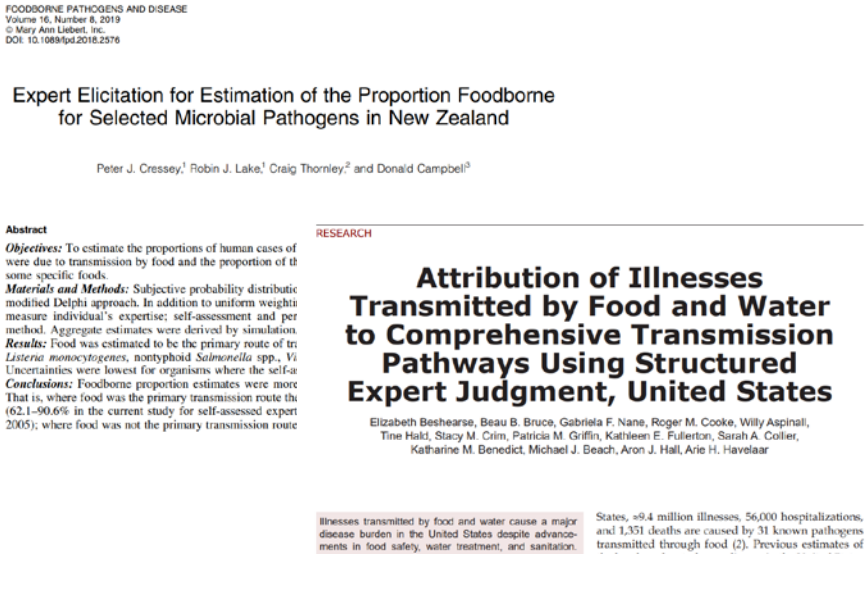
FOODBORNE PATHOGENS AND DISEASE
Volume 8, Number 3, 2011
© Mary Ann Liebert, Inc.
DOI: 10.1089/fpd.2010.0766

Food-Specific Attribution of Selected Gastrointestinal Illnesses: Estimates from a Canadian Expert Elicitation Survey

Valerie J. Davidson,[1] André Ravel,[2] To N. Nguyen,[1] Aamir Fazil,[3] and Julians M. Ruzante[4]

Abstract

The study used a structured expert elicitation survey to derive estimates of food-specific attribution for nine illnesses caused by enteric pathogens in Canada. It was based on a similar survey conducted in the United States and focused on *Campylobacter* spp., *Escherichia coli* O157:H7, *Listeria monocytogenes*, nontyphoidal *Salmonella enterica*, *Shigella* spp., *Vibrio* spp., *Yersinia enterocolitica*, *Cryptosporidium parvum*, and Norwalk-like virus. A snowball approach was used to identify food safety experts within Canada. Survey respondents provided background information as well as self-assessments of their expertise for each pathogen and the 12 food categories. Depending on the pathogen, food source attribution estimates were based on responses from between 10 and 35 experts. For each pathogen, experts divided their estimates of total foodborne illness across 12 food categories and they provided a best estimate for each category as well as 5th and 95th percentile limits for foods considered to be vehicles. Their responses were treated as triangular probability distributions, and linear aggregation was used to combine the opinions of each group of experts for each pathogen–food source group.



FOODBORNE PATHOGENS AND DISEASE
Volume 16, Number 8, 2019
© Mary Ann Liebert, Inc.
DOI: 10.1089/fpd.2018.2576

Expert Elicitation for Estimation of the Proportion Foodborne for Selected Microbial Pathogens in New Zealand

Peter J. Cressey,[1] Robin J. Lake,[1] Craig Thornley,[2] and Donald Campbell[3]

Abstract

Objectives: To estimate the proportions of human cases of were due to transmission by food and the proportion of th some specific foods.
Materials and Methods: Subjective probability distributic modified Delphi approach. In addition to uniform weighti measure individual's expertise; self-assessment and per method. Aggregate estimates were derived by simulation.
Results: Food was estimated to be the primary route of tr *Listeria monocytogenes*, nontyphoid *Salmonella* spp., *Vi* Uncertainties were lowest for organisms where the self-a
Conclusions: Foodborne proportion estimates were more That is, where food was the primary transmission route th (62.1–90.6% in the current study for self-assessed expert 2005); where food was not the primary transmission route

RESEARCH

Attribution of Illnesses Transmitted by Food and Water to Comprehensive Transmission Pathways Using Structured Expert Judgment, United States

Elizabeth Besherse, Beau B. Bruce, Gabriela F. Nane, Roger M. Cooke, Willy Aspinall, Tine Hald, Stacy M. Crim, Patricia M. Griffin, Kathleen E. Fullerton, Sarah A. Collier, Katharine M. Benedict, Michael J. Beach, Aron J. Hall, Arie H. Havelaar

Illnesses transmitted by food and water cause a major disease burden in the United States despite advancements in food safety, water treatment, and sanitation.

States, ≈9.4 million illnesses, 56,000 hospitalizations, and 1,351 deaths are caused by 31 known pathogens transmitted through food (2). Previous estimates of

Expert elicitation for source attribution

- The Classical Model for Structured expert judgment (Cooke, 1991)
- Method that validates and mathematically aggregates experts' uncertainty assessments
- Long history of use in many fields, including source attribution of foodborne hazards

World Health Organization

efsa European Food Safety Authority

CDC Centers for Disease Control and Prevention

AIRBUS

NASA

RIVM

esa

DRIVE AB
RE-INVESTMENT IN R&D AND RESPONSIBLE ANTIBIOTIC USE

KLM

Expert Elicitation for source attribution for the WHO Estimates 1st Edition (2015)

PLOS ONE

RESEARCH ARTICLE

World Health Organization Estimates of the Relative Contributions of Food to the Burden of Disease Due to Selected Foodborne Hazards: A Structured Expert Elicitation

Tine Hald[1]*, Willy Aspinall[2,3], Brecht Devleesschauwer[4,5,6], Roger Cooke[7,8], Tim Corrigan[9], Arie H. Havelaar[10,11,12], Herman J. Gibb[13], Paul R. Torgerson[14], Martyn D. Kirk[15], Fred J. Angulo[16], Robin J. Lake[17], Niko Speybroeck[5], Sandra Hoffmann[18]

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Citation: Hald T, Aspinall W, Devleesschauwer B, Cooke R, Corrigan T, Havelaar AH, et al. (2016) World Health Organization Estimates of the Relative Contributions of Food to the Burden of Disease Due

https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0145839

Approach for WHO estimates 2nd Edition (2025)

- Global Expert elicitation
  - For attribution to **main transmission roures** (food, environment, direct contact)
  - For attribution to **specific foods**
- Outbreak data analysis for attribution to specific foods
  - Evaluate data availability/call for data
  - Define strategie to overcome data gaps

Approach for WHO estimates 2nd Edition (2025)

Outbreak analysis

- Potential for pathogens that are associated with outbreaks
- Global representativeness?
- Methodology well established
- Call for data launched by WHO in 2023
- Results revealed limited coverage
  - Hazards
  - Countries/regions

https://www.who.int/news-room/articles-detail/call-for-data-on-foodborne-outbreak-investigations-for-source-attribution-on-foodborne-pathogens

Approach for WHO estimates 2nd Edition (2025) Expert Elicitation

- Same method (Cooke's Classical Model)
- Enhanced list of hazards
- Updated regions based on updated population and GDP information
- Elicitation available in more languages (Arabic, Portuguese?)
- Capture the evolution of source attribution in time
- Online and tailored elicitation tool for an efficient process
- Comprehensive training module for both elicitors and experts

Summary

- Source attribution of foodborne disease is an essential step of estimating the Global Burden of Foodborne Diseases
- Structured expert elicitation provides a transparent way of obtaining source attribution estimates where other methods and/or data are unavailable
- Expert elicitation makes it possible for WHO/FERG to estimate the proportion of specific diseases attributable to food and other major transmission routes and foodborne illness to foods

World Health Organization