

EXECUTIVE SUMMARY

Foodborne diseases are an important cause of morbidity and mortality, and a significant impediment to socio-economic development worldwide, but the full extent and burden of unsafe food, and especially the burden arising from chemical and parasitic contaminants, has been unknown. Precise information on the burden of foodborne diseases can adequately inform policy-makers and help to allocate appropriate resources for food safety control and intervention efforts.

This report, resulting from the WHO Initiative to Estimate the Global Burden of Foodborne Diseases and prepared by the WHO Foodborne Disease Burden Epidemiology Reference Group (FERG), provides the first estimates of global foodborne disease incidence, mortality, and disease burden in terms of Disability Adjusted Life Years (DALYs). For the global estimates, thirty-one foodborne hazards causing 32 diseases are included, being 11 diarrhoeal disease agents (1 virus, 7 bacteria, 3 protozoa), 7 invasive infectious disease agents (1 virus, 5 bacteria, 1 protozoan), 10 helminths and 3 chemicals.

Together, the 31 global hazards caused 600 (95% uncertainty interval [UI] 420–960) million foodborne illnesses and 420,000 (95% UI 310,000–600,000) deaths in 2010. The most frequent causes of foodborne illness were diarrhoeal disease agents, particularly norovirus and *Campylobacter* spp. Foodborne diarrhoeal disease agents caused 230,000 (95% UI 160,000–320,000) deaths, particularly non-typhoidal *Salmonella enterica* (NTS, which causes diarrhoeal and invasive disease). Other major causes of foodborne deaths were *Salmonella* Typhi, *Taenia solium*, hepatitis A virus, and aflatoxin. The global burden of foodborne disease by these 31 hazards was 33 (95% UI 25–46) million DALYs

in 2010; 40% of the foodborne disease burden was among children under 5 years of age. Worldwide, 18 (95% UI 12–25) million DALYs were attributed to foodborne diarrhoeal disease agents, particularly NTS and enteropathogenic *Escherichia coli* (EPEC). Other foodborne hazards with a substantial contribution to the global burden included *Salmonella* Typhi and *Taenia solium*.

Foodborne burden estimates are also reported for a further 4 bacterial and 1 chemical hazards, but only for some subregions; a global estimate was not feasible.

There were considerable differences in the burden of foodborne disease among subregions delimited on the basis of child and adult mortality. The highest burden per population was observed in Africa (AFR) (AFR D and AFR E subregions), followed by South-East Asia (SEAR) (SEAR B and SEAR D) subregions and the Eastern Mediterranean (EMR) D subregion. Diarrhoeal disease agents were the leading cause of foodborne disease burden in most subregions. NTS was an important burden in all subregions, particularly in Africa. Other main diarrhoeal causes of foodborne disease burden were EPEC, enterotoxigenic *E. coli* (ETEC) and *Vibrio cholerae* in low-income subregions, and *Campylobacter* spp. in high-income subregions. The burden of aflatoxin was high in the AFR D, Western Pacific (WPR) B and SEAR D subregions. In the SEAR subregions there was a considerable burden of *Salmonella* Typhi. The burden of *Opisthorchis* spp. was concentrated in the SEAR B subregion, where the seafood-borne trematodes *Paragonimus* spp. and *Clonorchis sinensis* were also important. In the Americas (AMR) B and D subregions, *Taenia solium* and *Toxoplasma gondii* contributed

significantly to the foodborne disease burden. The global burden of foodborne diseases is considerable, with marked regional variations. The burden of foodborne diseases is borne by individuals of all ages, but particularly by children under 5 years of age, and by persons living in low-income subregions of the world.

These estimates are conservative; further studies are needed to address the data gaps and limitations of this study.

In addition to providing global and regional estimates, the Initiative sought to promote actions at a national level. This involved capacity building through national foodborne disease burden studies, and encouraging the use of burden information in setting evidence-informed policies. A suite of tools and resources were created to facilitate national studies of the foodborne

burden of disease, and pilot studies were conducted in four countries (Albania, Japan, Thailand and Uganda). Data gaps were the major hurdle in estimating the foodborne disease burden in these national studies, and the global and regional estimates provided by FERG offer an interim solution, until improved surveillance and laboratory capacity is developed.

Despite the data gaps and limitations of these initial estimates, it is apparent that the global burden of foodborne disease is considerable, and affects individuals of all ages, but particularly children under 5 years of age and persons living in low-income subregions of the world. All stakeholders can contribute to improvements in food safety throughout the food chain by incorporating these estimates into policy development at national, regional and international levels.





INTRODUCTION

1.1 Motivation: the importance of food safety

Safer food saves lives. With every bite one eats, one is potentially exposed to illness from either microbiological or chemical contamination. Billions of people are at risk and millions fall ill every year; many die as a result of consuming unsafe food.

Concerns about food safety have skyrocketed in more affluent societies. However, the real tragedy of foodborne diseases is played out in the developing world. Unsafe water used for the cleaning and processing of food; poor food-production processes and food-handling (including inappropriate use of agricultural chemicals); the absence of adequate food storage infrastructure; and inadequate or poorly enforced regulatory standards—these all contribute to a high risk environment. Moreover, as a country's economy develops, the agricultural landscape changes. Intensive animal husbandry practices are put in place to maximize production, resulting in the increased prevalence of pathogens in flocks and herds. The tropical climate of many developing countries favours the proliferation of pests and naturally occurring toxins, and the risk of contracting parasitic diseases, including worm infestations.

While exposed to more hazardous environments, people in developing countries often have difficulty coping with foodborne disease. For many living at or below the poverty line, foodborne illness perpetuates the cycle of poverty. The symptoms of foodborne diseases range from mild and self-limiting (nausea, vomiting and diarrhoea) to debilitating and life-threatening (such as kidney and liver failure, brain and neural disorders, paralysis and potentially cancers), leading to long periods of absenteeism and premature death.

Foodborne pathogens take advantage of weak immune systems. Infants and young children, pregnant women, the elderly as well as those immuno-compromised, are particularly at risk of contracting and dying from common food-related diseases. Malnourished infants and children are especially exposed to foodborne hazards and are at higher risk of developing serious forms of foodborne diarrhoeal diseases; these infections in turn exacerbate malnutrition thus leading to a vicious circle of debilitation and mortality. Those who survive may suffer from delayed physical and mental development, depriving them of the opportunity to reach their full potential in society.

Beyond the individual level, foodborne diseases affect economic development, particularly challenging the tourist, agricultural and food (export) industries. Developing countries' access to food export markets will depend on their capacity to meet the international regulatory requirements determined by the Agreement on the Application of Sanitary and Phytosanitary Measures (SPS) of the World Trade Organization (WTO). Unsafe exports can lead to significant economic losses.

1.2 The value of foodborne disease burden estimates

Foodborne diseases (FBD) are an important cause of morbidity and mortality worldwide but the full extent and cost of unsafe food, and especially the burden arising from chemical and parasitic contaminants in food, is still unknown. Detailed data on the economic costs of foodborne diseases in developing countries are largely missing.

Despite the growing international awareness of foodborne diseases as a significant risk to health and socio-

economic development, food safety remains marginalized. A major obstacle to adequately addressing food safety concerns is the lack of accurate data on the full extent and cost of foodborne diseases, which would enable policy-makers to set public health priorities and allocate resources. Epidemiological data on foodborne diseases remain scarce, particularly in the developing world. Even the most visible foodborne outbreaks often go unrecognized, unreported or uninvestigated, and may only be visible if connected to major public health or economic impact. Precise information on the burden of FBD is needed to adequately inform policy-makers and allocate appropriate resources for food safety control and intervention efforts.

In order to fill this data vacuum, the World Health Organization (WHO) Department of Food Safety, Zoonoses and Foodborne Diseases (FOS) together with its partners launched the Initiative to Estimate the Global Burden of Foodborne Diseases. The primary goal of the Initiative is:

To enable policy-makers and other stakeholders to set appropriate, evidence-based priorities in the area of food safety.

1.3 Purpose and audience

This report is a supplement to the scientific papers published in journals from the Public Library of Science (PLOS), which cover the estimates generated by the WHO Initiative to Estimate the Global Burden of Foodborne Diseases. In addition to collating the results, this report is intended to provide background and context on the project itself, as well as examining particular scientific issues in more detail. As such, it provides a comprehensive source of information on the Initiative.

1.4 Scope

This report covers:

- ▶ history of the project;
- ▶ participants;
- ▶ scientific work commissioned by the project;
- ▶ overview of approach to estimating burden of foodborne disease;
- ▶ methods, results, discussion, using a hazards-based approach;
- ▶ outputs, implications and context of results; and
- ▶ future plans.

1.5 History and structure

In September 2006, FOS launched the Initiative to Estimate the Global Burden of Foodborne Diseases at an international consultation attended by over 50 international experts. This consultation provided the strategic framework for the assessment of FBD burden, and mandated WHO to establish a Foodborne Disease Burden Epidemiology Reference Group (FERG) to engage in:

- ▶ assembling, appraising and reporting on currently existing burden of foodborne disease estimates;
- ▶ conducting epidemiological reviews for mortality, morbidity and disability in each of the major FBDs;
- ▶ providing models for the estimation of FBD burden where data are lacking;
- ▶ developing cause and source attribution models to estimate the proportion of diseases that are foodborne, and
- ▶ developing user-friendly tools for burden of FBD studies at country level.

Following a public call for advisers in the scientific press the WHO Director-General appointed the FERG members who met for the first time in November 2007. This multi-disciplinary meeting commenced with a stakeholder consultation that informed the technical discussions of FERG. The meeting

saw the establishment of the FERG Core or Steering Group (coordinating and overseeing the burden work) as well as several thematic Task Forces (TFs) to advance the work in specific areas, including:

- ▶ Enteric Diseases Task Force (EDTF);
- ▶ Parasitic Diseases Task Force (PDTF); and,
- ▶ Chemicals and Toxins Task Force (CTTF).

Subsequently, three additional Task Forces were established to address the following topics:

- ▶ Source Attribution Task Force (SATF) (established 2008);
- ▶ Country Studies Task Force (CSTF) (established 2009), with a sub-group, the Knowledge Translation and Policy Group (KTPG) (established 2010);
- ▶ Computational Task Force (CTF) (established 2012).

As shown in Figure 1, FERG consists of a Core (or Steering) Group to coordinate and oversee the scientific work, Thematic TFs advancing the work in specific areas;

and external resource and technical advisers who are invited on an *ad hoc* basis to provide specific expertise.

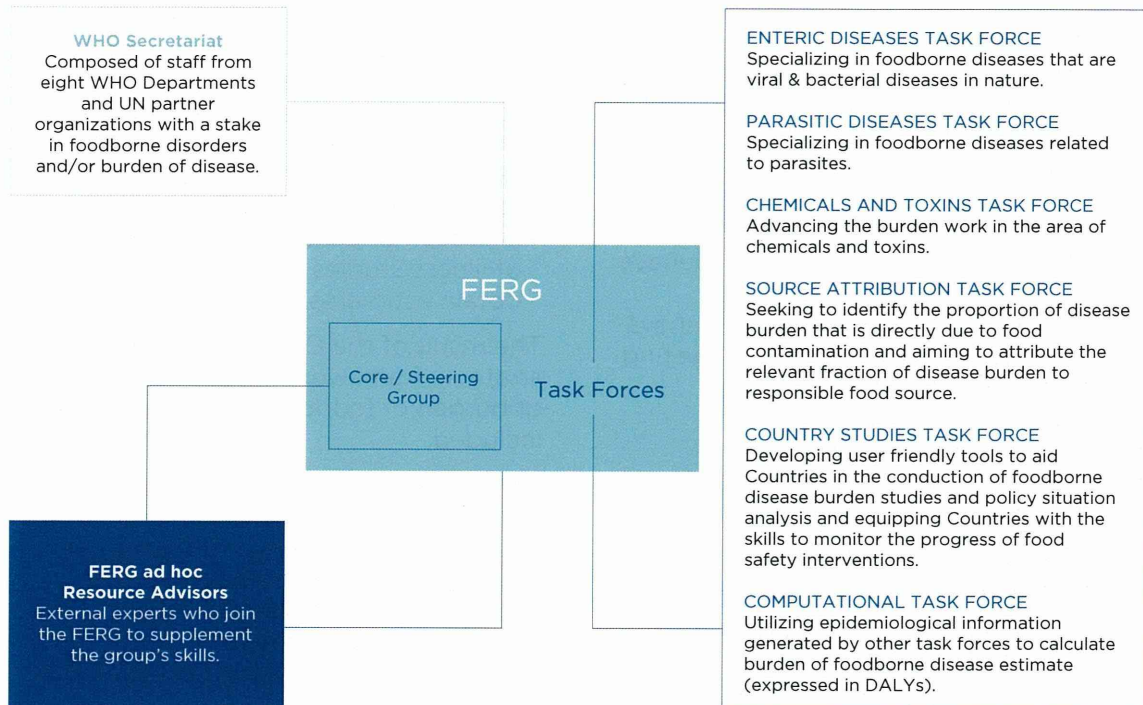
1.6 Objectives

The first report from the Initiative, published in 2008, described the following objectives¹:

- ▶ To strengthen the capacity of countries in conducting burden of foodborne disease assessments and to increase the number of countries who have undertaken a burden of foodborne disease study.
- ▶ To provide estimates on the global burden of foodborne diseases according to age, sex and regions for a defined list of causative agents of microbial, parasitic and chemical origin.
- ▶ To increase awareness and commitment among Member States for the implementation of food safety standards.
- ▶ To encourage countries to use burden of foodborne disease estimates for cost-effective analyses of prevention, intervention and control measures.

¹ http://www.who.int/foodsafety/foodborne_disease/Summary_Doc.pdf?ua=1 Accessed 9 July 2014

Figure 1. Structure of the initiative to estimate the global burden of foodborne diseases



To meet these goals and objectives, the Initiative took two approaches.

- ▶ A Foodborne Disease Burden Epidemiology Reference Group (FERG) was established to assemble, appraise and report on burden of foodborne disease estimates.
- ▶ In-depth country studies to supplement the work of FERG and enable countries to conduct their own burden of disease studies.

1.7 Other relevant burden of disease estimates

Estimates for the burden of diseases considered to be at least partially foodborne have been published by a number of research groups. The most comprehensive estimates are those published by the following:

- ▶ Global Burden of Disease 2010 (GBD2010) study, undertaken by the Institute of Health, Metrics and Evaluation (IHME)²
- ▶ Mortality and Burden of Disease Unit of WHO³
- ▶ Estimated Cancer Incidence, Mortality and Prevalence 2012, published by the International Agency for Research on Cancer (GLOBOCAN)⁴

Throughout the course of the burden of foodborne disease project, FERG communicated with these groups, to share data and promote consistency of the estimates.

² <http://www.healthdata.org/gbd> Accessed 24 September 2014

³ http://www.who.int/topics/global_burden_of_disease/en/ Accessed 24 September 2014

⁴ <http://globocan.iarc.fr/Default.aspx> Accessed 24 September 2014

1.8 Timeline: FERG Meetings

1.8.1 Overview

- ▶ 25–27 September 2006 – Establishment of the initiative, Geneva⁵
- ▶ 26–28 November 2007 – FERG 1, Geneva⁶
- ▶ 17–21 November 2008 – FERG 2, Geneva⁷ (plus Stakeholder Meeting)⁸
- ▶ 26–30 October 2009 – FERG 3, Geneva (plus Stakeholder Meeting)
- ▶ 8–12 November 2010 – FERG 4, Geneva⁹
- ▶ 7–10 November 2011 – Strategy Meeting and Commencement of Country Studies, Durrës, Albania
- ▶ 8–12 April 2013 – FERG 5, Geneva¹⁰
- ▶ 23–25 June 2014 – Review Meeting, Copenhagen

1.8.2 Extracts from reports of major meetings

25–27 September 2006– Establishment of the initiative, Geneva

WHO's Department of Food Safety, Zoonoses and Foodborne Diseases (FOS) launched an initiative to estimate the global burden of foodborne diseases from all major causes, including chemicals and zoonoses, at an international consultation. This was held in Geneva, Switzerland, from 25 to 27 September 2006, and was attended by over 50 experts from around the world.

The objectives of the meeting were:

- ▶ to launch an appeal for wider collaboration, with a detailed plan of action and time frame;
- ▶ to develop a strategic framework for burden of disease estimation that involved all relevant partners; and
- ▶ to propose elements of a standard protocol for conducting burden of illness studies in countries to obtain estimates.

The result of the Consultation was a draft strategic framework for the assessment of burden of foodborne diseases, which included:

- ▶ the outline of an evidence map for assimilating existing information on the burden of disease [along themes of
 - (i) acute infectious diseases,
 - (ii) chronic manifestations of infectious diseases; and
 - (iii) acute and chronic non-infectious illness]; and
- ▶ a time frame outlining the individual strategic activities in relation to the evidence framework.

In order to complete the strategic and technical framework, participants mandated WHO to establish a Foodborne Disease Burden Epidemiology Reference Group (FERG) and proposed the relevant skill mix required for this group. A number of funding agencies were identified that might be approached by WHO to enable the execution of this work. The Consultation concluded with the drafting of a Joint Statement of Support for the Initiative.

A summary document describing the initiative was published in 2008¹¹.

26–28 November 2007 – FERG 1, Geneva

⁵ http://www.who.int/foodsafety/publications/burden_sept06/en/ Accessed 21 April 2015

⁶ http://www.who.int/foodsafety/publications/burden_nov07/en/ Accessed 21 April 2015

⁷ <http://www.who.int/foodsafety/publications/ferg2/en/> Accessed 21 April 2015

⁸ <http://www.who.int/foodsafety/publications/ferg-stakeholders/en/> Accessed 21 April 2015

⁹ <http://www.who.int/foodsafety/publications/ferg4/en/> Accessed 21 April 2015

¹⁰ <http://www.who.int/foodsafety/publications/ferg5/en/> Accessed 21 April 2015

¹¹ http://www.who.int/foodsafety/foodborne_disease/ferg/en/ accessed 21 April 2015

Following a public call for advisers in the scientific press, the Director-General of WHO appointed the FERG members, who met for the first time in November 2007. This multi-disciplinary meeting commenced with a stakeholder consultation that informed the technical discussions of FERG. The meeting saw the establishment of the FERG Core or Steering Group (coordinating and overseeing the burden of the work), as well as several thematic Task Forces (TFs) to advance the work in specific areas, including:

- ▶ parasitic diseases;
- ▶ chemicals and toxins; and
- ▶ enteric diseases.

In their respective areas, the TFs provided: (1) priority lists of causative agents for which burden assessments should be conducted; (2) developed concrete and very detailed work plans to commission the individual burden work; and (3) agreed on the logistic and technical steps to be taken by FERG over the next year.

17-21 November 2008 – FERG 2, Geneva (plus Stakeholder Meeting)

The second formal meeting of FERG in November 2008 (FERG 2) highlighted the progress made during the Initiative's first year, which included:

- ▶ an appraisal of the methods, and preliminary results of ten systematic reviews commissioned in the areas of enteric, parasitic and chemical causes of foodborne diseases, as well as mortality;
- ▶ the development of detailed new work plans for all FERG TFs for 2009, including new burden work to be commissioned;
- ▶ establishment of the FERG Source Attribution Task Force (SATF) and execution of its technical recommendations;
- ▶ agreement on the terms of reference of the new FERG Country Studies Task Force (CSTF) in 2009;
- ▶ formal evaluation of the activities, processes and outputs of the first year of FERG activities; and
- ▶ A major, multisectoral stakeholder meeting, which provided valuable input and recommendations to WHO in the areas of technical reviews, communication and policy.

26-30 October 2009 – FERG 3, Geneva (plus Stakeholder Meeting)

The Third Foodborne Diseases Stakeholder Meeting brought together international representatives from the various constituencies and sectors with an interest in ensuring food safety, be it through decision-making, research, production, consumption or advocacy. They included: WHO Member States; bilateral and multilateral donors; non-governmental organizations (NGOs); consumer groups; industry; and public and scientific media. The purpose of the meeting was to enable stakeholders to:

- ▶ actively engage with the Foodborne Disease Burden Epidemiology Reference Group (FERG) and its research;
- ▶ open new channels for multisectoral cooperation; and
- ▶ provide direct input into discussions about how to bridge the gap between evidence and policy.

8-12 November 2010 – FERG 4, Geneva

Continuing on the path taken during the previous FERG meeting, a large number of new foodborne disease morbidity, mortality and burden estimates were presented and discussed at FERG 4:

- ▶ the global burden of diarrhoeal diseases;
- ▶ the global burden of foodborne trematodiasis;