International Journal of Food Microbiology 196 (2015) 84–93

Contents lists available at ScienceDirect

International Journal of Food Microbiology

journal homepage: www.elsevier.com/locate/ijfoodmicro

Cost-of-illness and disease burden of food-related pathogens in the Netherlands, 2011

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ARTICLE INFO

Article history:
Received 6 January 2014
Received in revised form 28 July 2014
Accepted 22 November 2014
Available online 3 December 2014

Keywords:
Foodborne pathogens
DALY
Costs
Direct healthcare costs
Indirect non-healthcare costs
Attribution

ABSTRACT

To inform risk management decisions on control and prevention of food-related disease, both the disease burden expressed in Disability Adjusted Life Years (DALY) and the cost-of-illness of food-related pathogens are estimated and presented. Disease burden of fourteen pathogens that can be transmitted by food, the environment, animals and humans was previously estimated by Havelaar et al. (2012). In this paper we complement these by cost-of-illness estimates. Together, these present a complete picture of the societal burden of food-related diseases.

Using incidence estimates for 2011, community-acquired non-consulting cases, patients consulting their general practitioner, hospitalized patients and the incidence of sequelae and fatal cases, estimates were obtained for DALYs, direct healthcare costs (e.g. costs for doctor's fees, hospitalizations and medicines), direct non-healthcare costs (e.g. travel costs to and from the doctor), indirect non-healthcare costs (e.g. productivity loss, special education) and total costs.

The updated disease burden for 2011 was equal to 13,940 DALY/year (undiscounted) or 12,650 DALY/year (discounted at 1.5%), and was of the same magnitude as previous estimates. At the population-level thermophilic *Campylobacter* spp., *Toxoplasma gondii* and rotavirus were associated with the highest disease burden. Perinatal listeriosis infection was associated with the highest DALY per symptomatic case.

The total cost-of-illness in 2011 of fourteen food-related pathogens and associated sequelae was estimated at € 468 million/year, if undiscounted, and at € 416 million/year if discounted by 4%. Direct healthcare costs accounted for 24% of total costs, direct non-healthcare costs for 2% and indirect non-healthcare costs for 74% of total costs. At the population-level, norovirus had the highest total cost-of-illness in 2011 with € 106 million/year, followed by thermophilic *Campylobacter* spp. (€ 76 million/year) and rotavirus (€ 73 million/year). Cost-of-illness per infected case varied from € 150 for *Clostridium perfringens* intoxications to € 275,000 for perinatal listeriosis.

Both incident cases and fatal cases are more strongly correlated with COI/year than with DALY/year.

More than 40% of all cost-of-illness and DALYs can be attributed to food, in total € 168 million/year and 5,150 DALY/year for 2011. Beef, lamb, pork and poultry meat alone accounted for 39% of these costs. Products of animal origin accounted for € 86 million/year (or 51% of the costs attributed to food) and 3,320 DALY/year (or 64% of the disease burden attributed to food). Among the pathogens studied *Staphylococcus aureus* intoxications accounted for the highest share of costs attributed to food (€ 47.1 million/year), followed by *Campylobacter* spp. (€ 32.0 million/year) and norovirus (€ 17.7 million/year).

1. Introduction

Foodborne pathogens cause acute and chronic health outcomes of widely different durations, severity and mortality. In food safety policy the relevance of pathogens by quantitative comparison of their public health impact is key – although not the only – information required to make sound decisions. National estimates of annual number of illnesses, hospitalizations, and deaths are important but incomplete measures of the societal impact of foodborne disease. Comparison of relative burden

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http://dx.doi.org/10.1016/j.ijfoodmicro.2014.11.022
0168-1605/

of diseases having diverse outcomes is possible when using integrated measures of health such as Health-adjusted life years (HALY) or cost-of-illness. HALYs, including Disability-Adjusted Life Years (DALY) and Quality-adjusted life years (QALY), are population health measures integrating morbidity and mortality into one metric (Gold et al., 2002). Cost-of-illness (COI), using societal perspective, measures 1) the costs related to the resources used within the healthcare sector; 2) the resources used by patients and their families; and 3) productivity losses and other non-healthcare related resources used that are indirectly related to illness (e.g. special education). In contrast to initiatives such as a universal infant vaccination program, the control of foodborne pathogens has an impact on several stakeholders in the society and therefore implicitly requires the use of a societal perspective (Belli et al., 2001).

There is a growing number of publications considering COI and loss of HALYs due to multiple foodborne pathogens, for example from Canada (Ruzante et al., 2010), Korea (Shin et al., 2010), New Zealand (Lake et al., 2010) and the United States (Hoffmann et al., 2012).

In the Netherlands, the National Institute for Public Health and the Environment (RIVM) has published in the last 10 years a series of disease burden estimations (Haagsma et al., 2010; Havelaar et al., 2000, 2004, 2007) and publications considering both the disease burden and the cost-of-illness (Haagsma et al., 2009; Kemmeren et al., 2006; Mangen et al., 2005; Tariq et al., 2011; Vijgen et al., 2007).

This article presents the estimates of the cost-of-illness (Euros) and disease burden (DALYs) for fourteen foodborne pathogens in the Netherlands in 2011, building on Havelaar et al. (2012). We update illness incidence and DALY estimates to 2011. In addition we present, for the first time in the peer-reviewed literature, the methodology, data, and results of cost-of-illness estimates for these same pathogens including cost estimates for *Toxoplasma gondii* and irritable bowel syndrome. We attributed the costs of the fourteen pathogens to different exposure pathways and different food groups based on expert elicitation (Havelaar et al., 2008).

2. Materials and methods

2.1. Pathogens included

The fourteen pathogens were selected based on preliminary analyses of the burden caused by the pathogens in the Netherlands and on data availability (Havelaar et al., 2012). These pathogens include seven that cause gastroenteritis (GE) including three bacteria (thermophilic *Campylobacter* spp., Shiga-toxin producing *Escherichia coli* O157 (STEC O157), nontyphoidal *Salmonella* spp.), two viruses (norovirus and rotavirus) and two protozoa (*Cryptosporidium* spp., *Giardia* spp.); three GE toxin-producing bacteria (*Bacillus cereus*, *Clostridium perfringens* and *Staphylococcus aureus*), and four pathogens causing systemic infections (*Listeria monocytogenes*, hepatitis-A virus (HAV), hepatitis-E virus (HEV), and *T. gondii*).

2.2. Health outcomes and health states considered

Using an incidence- and pathogen-based approach to assess DALYs and COI estimates for the pathogens under study, the health outcomes following infection needed to be defined using outcome trees.[3] To better represent the true burden (i.e. financial and disease burden) a health outcome was split further into subcategories, so-called 'health states'. The outcome trees used are presented in full detail in Havelaar et al. (2012). Briefly, for GE, we distinguished four health states: mild (patient does not seek medical help, and recovers), moderate (patient visits a general practice (GP) and recovers), severe (patient is hospitalized and recovers), and death. Sequelae following disease caused by GE-bacteria were defined as:

- *Campylobacter* spp.: Guillain–Barré Syndrome (GBS) (health states: mild, severe, and fatal; furthermore we considered long-term sequelae after having had non-fatal severe GBS); reactive arthritis (ReA) (health states: mild, moderate and severe); Irritable Bowel Syndrome (IBS) and Inflammatory Bowel Disease (IBD).
- *Salmonella* spp.: ReA; IBS and IBD.
- STEC O157: Post-diarrheal Hemolytic Uremic Syndrome (HUS) (health states: severe and fatal), and End-Stage Renal Disease (ESRD) (health states: dialysis, transplantation, functioning graft, death).

In the case of HAV and HEV, hepatitis was the only health outcome considered. For listeriosis we distinguished between acquired listeriosis (AL) with or without meningitis (health states: severe and fatal), and perinatal listeriosis (PL) having meningitis with or without sepsis (health states: severe and fatal). Furthermore, we considered neurological sequelae after having had non-fatal listeriosis with meningitis. In the case of acquired toxoplasmosis (AT), the only health outcome considered was chorioretinitis. For congenital toxoplasmosis (CT) we considered as health outcomes: stillbirth, neonatal death, chorioretinitis, intracranial calcifications, hydrocephalus, and Central Nervous System (CNS) abnormalities. Furthermore, asymptomatic CT cases at birth were assumed to be at risk of developing chorioretinitis later in life (referred to as post-1-year chorioretinitis).

2.3. Incidence of illness

Following the methodology described in Havelaar et al. (2012), incidence of illness was estimated for the year 2011 using surveillance data and demographic information for this year. Briefly, incidence of GE in the entire Dutch population, the proportion of cases visiting their GP, and attribution of cases to pathogens were based on a population-based cohort study and associated case–control studies (de Wit et al., 2001a, 2001b). These estimates based on the original studies were updated to 2011 with trends based on laboratory surveillance, on hospitalized viral GE cases or on active surveillance. Estimates for GE hospitalization were based on data from the National Medical Register and attributed to pathogens using results from an observational study on the etiology of GE in six Dutch hospitals (Friesema et al., 2012a, 2012b). For systemic infections, incidence estimates were based on enhanced surveillance for *L. monocytogenes* (Friesema et al., 2011), continuous notifiable reporting system for HAV (Van de Laar et al., 2000), 2-year monitoring of lab-confirmed non-travel related cases for HEV (Borgen et al., 2008) and a large study on dried-blood spots of neonates for *T. gondii* (Kortbeek et al., 2009). For more details see web-appendix A.

2.4. Disease burden

Using incident cases for 2011 we estimated the disease burden in DALYs as described by Havelaar et al. (2012). The DALY estimates are presented undiscounted and discounted at a discount rate of 1.5% for health outcomes in accordance with Dutch guidelines for health economic evaluations (Hakkaart-van Roijen et al., 2010).

2.5. Cost-of-illness

2.5.1. General approach

A societal perspective was taken when estimating the COI, considering direct healthcare costs (DHC), direct non-healthcare costs (DNHC) and indirect non-healthcare costs (INHC). We also considered the

[3] Developing an outcome tree, using the incident- and pathogen-based approach is not only the most appropriate approach for infectious diseases when estimating DALYs (see Mangen et al., 2013 and in particular Appendix A for the methodology), but is also the most appropriate approach when estimating COI.