David Pigott | *Institute for Health Metrics and Evaluation, University of Washington, USA and Wellcome Trust Centre for Human Genetics, University of Oxford, UK*

The Burden of Foodborne Disease – an IHME Perspective

The burden of foodborne disease requires estimation across a diverse range of pathogens and hazards. FERG has undertaken systematic reviews on the key identified conditions and created and integrated these assessments into an independently developed and refined systematic framework to calculate both deaths and DALYs attributable to or influenced by these risks.

The Global Burden of Disease project, with many common objectives and outputs to those of FERG derived from related yet different approaches, allows for a point of comparison providing the opportunity for feedback, critique and mutual improvements.

This talk will discuss general methodological differences and potential impacts on the estimates produced as well as demonstrate some points of comparison in specific disease estimates.

The final discussion will address next steps planned for the GBD process, what mutual lessons can be learned from these two estimation projects and how we can better move forward together to answer the same common goal and provide interested parties with the most accurate representation of the issues they want to be answered.

Arie Havelaar | *University of Florida, Gainesville, FL, USA*

The Global Burden of Foodborne Disease: Overview and Implications

Illness and death from diseases caused by contaminated food are a constant threat to public health and a significant impediment to socio-economic development worldwide. To measure the global and regional burden of foodborne disease (FBD), the World Health Organization (WHO) established the Foodborne Disease Burden Epidemiology Reference Group (FERG), which here reports their first estimates of the incidence, mortality, and disease burden due to 31 foodborne hazards. We find that the global burden of FBD is comparable to those of the major infectious diseases, HIV/AIDS, malaria and tuberculosis.

The most frequent causes of foodborne illness were diarrheal disease agents, particularly norovirus and *Campylobacter* spp. Diarrheal disease agents, especially non-typhoidal *Salmonella enterica*, were also responsible for the majority of deaths due to FBD. Other major causes of FBD deaths were *Salmonella* Typhi, *Taenia solium* and hepatitis A virus.

The global burden of FBD caused by the 31 hazards in 2010 was 33 million disability-adjusted life years (DALYs); children under five years old bore 40% of this burden. The 14 subregions, defined on the basis of child and adult mortality, had considerably different burdens of FBD, with the greatest falling on the subregions in Africa, followed by the subregions in South-East Asia and the Eastern Mediterranean D subregion. Some hazards, such as non-typhoidal *S. enterica*, were important causes of FBD in all regions of the world, whereas others, such as certain parasitic helminths, were highly localised. Thus, the burden of FBD is borne particularly by children under five years old – although they represent only 9% of the global population – and people living in low-income regions of the world.

These estimates are conservative; further studies are needed to address the data gaps and limitations of the study. Nevertheless, all stakeholders can contribute to improvements in food safety throughout the food chain by incorporating these estimates into policy development at national and international levels.

Rob Lake | *Institute of Environmental Science and Research (ESR), Christchurch, New Zealand*

Country Studies as a Component of the WHO Initiative to Estimate The Global Burden of Foodborne Disease

The World Health Organization (WHO) initiative to estimate the global burden of foodborne diseases established the Foodborne Diseases Burden Epidemiology Reference Group (FERG) in 2007. In addition to 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 encouragement of the use of burden information in setting evidence-informed policies. To address these objectives a FERG Country Studies Task Force was established and has developed a suite of tools and resources to facilitate national burden of foodborne disease studies.

This talk will describe the process and lessons learned during the conduct of pilot country studies under the WHO FERG initiative. Pilot country studies were initiated in Albania, Japan and Thailand in 2011 and in Uganda in 2012. A brief description of each study will be given.

The major scientific issue is a lack of data, particularly in relation to disease etiology, and attribution of disease burden to foodborne transmission. Situation analysis, knowledge translation, and risk communication to achieve evidence-informed policies require specialist expertise and resources.

The FERG global and regional burden estimates will greatly enhance the ability of individual countries to fill data gaps and generate national estimates to support efforts to reduce the burden of foodborne disease.

Frederick Angulo | *Centers for Disease Control and Prevention, Atlanta, Georgia, USA*

The Global Burden of Foodborne Disease : From Science to Public Health Policy

Recognizing the need for global and regional estimates of foodborne diseases, the World Health Organization (WHO) launched the 'Initiative to Estimate the Global Burden of Foodborne Diseases' in 2006 and established the Foodborne Disease Burden Epidemiology Reference Group (FERG) in 2007 to implement this initiative. The goal of this initiative is to enable policy makers to set appropriate, evidence-based priorities in the area of food safety. The FERG estimates of the incidence, mortality and disease burden due to 31 foodborne hazards, reported at this symposium, which demonstrate the enormous worldwide human health burden of foodborne diseases, represent an important step towards the goal of WHO initiative. However, much additional work is needed to achieve the initiative's goal and thereby enhance prevention of foodborne diseases. The urgency for enhanced foodborne disease prevention efforts worldwide is illuminated by the considerable difference between the FERG estimates of the burden of foodborne disease between low-income and high-income regions which indicates that a major proportion of foodborne diseases is avoidable.

As recognized by the goal of the WHO initiative, an essential component of foodborne disease prevention efforts is the establishment, worldwide, of rigorous evidence-based national food safety policies. FERG has sought to facilitate progress towards this goal by striving, through the FERG Countries Studies Task Force, to provide tools and technical assistance to improve the abilities of countries to assess their burden of foodborne diseases. FERG, with the assistance of a 'knowledge translation subgroup' within the Country Studies Task Force, has also sought to increase awareness of foodborne diseases among WHO Member States and improve their commitment to implement food safety standards, and encourage countries to use estimates of foodborne diseases to inform their policy making.

But more needs to be done. To provide the needed evidence-base for national food safety policies, more countries need to develop national estimates of foodborne diseases. To provide the data for conducting such national estimates of foodborne diseases, to monitor changes in foodborne diseases resulting from food safety policies, and to detect and control foodborne disease outbreaks, national laboratory-based foodborne disease surveillance systems need to be strengthened. To strengthen such foodborne disease surveillance systems, capacity building efforts such as the WHO Global Foodborne Diseases Network and the Global Health Security Agenda need to be expanded. Most importantly, the FERG estimates of the human health burden of foodborne diseases emphasizes the need of a sustained, multi-sectoral effort from governments and international organizations to reduce the foodborne disease burden by establishing and enforcing food safety standards and effective surveillance networks.

Karen Keddy | *National Institute for Communicable Diseases, Johannesburg, South Africa*

Now you see me, now you don't: The elusive goal of foodborne disease burden estimates in a developing country

South Africa is classified as AFR-E by World Health Organization, based on high child and very high adult mortalities. Major health challenges exist due to HIV and tuberculosis, the country having among the highest disease burdens in the world, despite programmes for these diseases. Against this backdrop, diseases with a low mortality have a low priority. Nonetheless as a country with a large agricultural economy and a highly vulnerable population, the importance of foodborne disease cannot be ignored.

Current South African legislation requires that a foodborne outbreak affecting two or more persons be notified, but this rarely happens. In addition, sporadic cases are rarely identified and many patients don't seek healthcare or are identified by surveillance systems. In certain instances however, follow up of notifications has been very good and never more so than during the FIFA World Cup in 2010.

In the absence of reliable notifications, the most consistent data are derived from the laboratory-based surveillance system, an active surveillance system that characterises isolates of Salmonella, Shigella, diarrhoeagenic Escherichia coli, Vibrio cholerae, Campylobacter and more recently, Listeria. Sentinel surveillance for diarrhoea in under-fives provides further information in this age group. Data are lacking however, linking these isolation rates to population denominators, enabling burden of disease calculations.

Data for invasive disease are more robust, but may be affected by complex routes of acquiring traditionally foodborne pathogens, such as non-typhoidal salmonellosis. FERG data in this instance confirmed two differing disease burdens in South Africa: one reflecting the burden in HIV-infected and the second in HIV-uninfected individuals.
FERG data have also been invaluable for critically re-examining laboratory protocols. Based on a reported burden of 48,000,000 in children under the age of five years, reference laboratory protocols were revised to include molecular diagnostics, increasing diagnostic rates from 1 per 1000 stools in sentinel surveillance to ~5-10%.

Changing frequency in the isolation rates of Salmonella Typhimurium versus Salmonella Enteritidis has highlighted the need to review current routes of transmission and source attribution. New data suggest Salmonella Enteritidis may equally have adapted to human to human transmission and is currently associated with a global pandemic. As Salmonella Enteritidis is a controlled pathogen in food products, including eggs and chicken in South Africa, this means novel methods are required to define the source(s) of the current increase in cases and to relate this back to global burdens.
In-country, further work would be to define pathogen-specific disease burdens, which has been partly done for selected disease e.g. Salmonella Typhi. In addition, better understanding of the long term sequelae as well as YLLS and DALYs need to be defined for these diseases and better data are needed to understand diseases that are just being introduced into surveillance.

Complementary work from WHO would provision of online tools to undertake burden of disease studies and to start defining the economic costs, which would act as a powerful motivator to research these often neglected and overlooked disease in developing countries.

Yuko Kumagai | *National Institute of Infectious Diseases, Ministry of Health, Labour and Wefare, Tokyo, Japan*

The foodborne disease burden in Japan: a pilot study

In Japan, the selection of which foodborne diseases to make control priorities is primarily based on the apparent public health significance of each disease, although other factors – e.g. impact on the food market, consumers' risk perceptions and public opinion – are also taken into consideration. Japan's Food Sanitation Act and Infectious Disease Control Act require the routine and regular collection of data on the incidences of food poisoning and infectious diseases, respectively. However, as there has never been a comprehensive, internally consistent and robust assessment of the burden posed by foodborne disease in Japan – in terms of both disability and death – the prioritization of particular foodborne diseases has not been based on robust and objective standards.

To assess the burden posed by foodborne disease, we selected three common causes of foodborne disease in Japan: *Campylobacter* and *Salmonella* species and enterohaemorrhagic *Escherichia coli* (EHEC). We conducted systematic reviews of literature on the disabling sequelae from foodborne disease caused by these pathogens. We estimated the annual incidence of acute gastroenteritis from reported surveillance data, after adjusting for the probabilities that a case would be visited by a physician and confirmed. Estimates of the proportion of this incidence attributable to foodborne disease allowed us to calculate the disability-adjusted life-years (DALYs) lost in Japan in 2011 as the result of such disease.

As a result, in 2011, foodborne disease caused by *Campylobacter* species, *Salmonella* species and EHEC led to an estimated loss of 6,099, 3,145 and 463 DALYs in Japan, respectively. These estimated burdens – which were more the result of morbidity than of mortality – were much higher than those indicated by routine surveillance data. Routine surveillance data may indicate foodborne disease burdens that are much lower than the true values. Most of the burden posed by foodborne disease in Japan comes from the disabling sequelae of such disease.

Despite these limitations, the present study confirmed the feasibility of the burden of foodborne disease estimation based on the WHO/FERG framework in Japan. In order to identify priorities for risk management, it is essential to enhance the bottom-up approach of epidemiological survey systems for foodborne diseases and food safety risk analysis. Improvements to methods for estimating the burden of disease from food consumption, contamination data, and the food-attributable proportion are also important. By combining these approaches, significant progress can be made towards a suitable prioritization framework for foodborne risks in Japan

Gijs Theunissen | *Ministry of Economic Affairs, the Hague, the Netherlands*

The use of disability-adjusted life years (DALY's) in food safety policy prioritization and evaluation in The Netherlands

The level of food safety in the Netherlands is high, and has been for many years. It is nevertheless important to remain alert to potential threats, and even to improve on the current situation. The Dutch National Institute for Public Health and the Environment (RIVM) estimates that in The Netherlands yearly around 680.000 persons still get ill from pathogens in contaminated food. Micro-organisms may enter the food chain for instance during primary production and processing (national and abroad) or during home preparation.

The RIVM annually publishes for the Netherlands a ranking of the most relevant micro-organisms in relation to food safety using the disability-adjusted life years (DALYs) metric.
DALYS are a measure of overall disease burden, expressed as the number of years lost due to ill-health, disability or early death. The DALY's makes it possible to compare the impact of diseases and pathogens causing different diseases.

In The Netherlands, policy makers use the DALY's, among other parameters like the societal and economic impact, for the prioritization and evaluation of their food safety policy. By using DALY's they get a better insight in the national health risk of the different pathogens causing foodborne diseases. In The Netherlands Toxoplasma gondii and Campylobacter spp. are causing the most DALY's among foodborne diseases. This was a reason to give more policy attention to these pathogens.

Lisa Indar | *Caribbean Public Health Agency, Port of Spain, Trinidad and Tobago*

Estimating the Burden and Impact of Foodborne Illness in the Caribbean

Background: The burden of foodborne illness and specific pathogens causing foodborne illnesses is unknown in the Caribbean. Public health surveillance systems in the Caribbean, have common challenges. Only a small proportion of people who have contracted illness from food seek medical care. Only a fraction of those cases medically attended had a sample taken and associated with a hazard in food and only a fraction is reported to public health surveillance system. Thus, foodborne diseases in the Caribbean is under-reported, under-diagnosed and its impact on public health and economy under-estimated. To account for the current data gaps and determine the true burden and impact of AGE and FBD, the Caribbean Epidemiology Center (CAREC), now part of the Caribbean Public Health Agency (CARPHA), and the Pan American Health Organization PAHO/WHO), and the Caribbean Eco Health Program executed a Caribbean Burden of Illness (BOI) study from 2008-2013 in nine countries.

Methods: BOI studies were conducted in Barbados, Belize, Bermuda, Dominica, Guyana, Grenada, Jamaica, St Lucia and Trinidad & Tobago from 2008-2013. In each country, cross-sectional population surveys, were conducted during the low and high AGE seasons, and laboratory surveillance of AGE for selected pathogens was conducted for a year. The economic burden of AGE was based on medical care costs and loss of productive days.

To estimate the extent of foodborne illness caused by unspecified agents, we estimated the number of acute gastroenteritis illnesses reported to CARPHA from 2005-2014. To account for uncertainty, we used probability distributions to describe a range of plausible values for two inputs of the model: the under-reporting due to medical seek (data from the Caribbean Burden of Illness study, J.Health Popul Nutr, 2013 suppl) using a uniform distribution; and for the proportion of gastrointestinal illness attributed to food, we used a simple PERT distribution using parameters derived from the work on Ravel et al, 2010. One thousand Monte Carlo simulations of the input parameters were generated to calculate 1000 estimates. These 1000 estimates were then summarized by their mean values with 90% credible intervals (90%CrI). To estimate the extent laboratory-confirmed cases of pathogens we used the total cases reported by pathogen to CARPHA from 2005-2014 and scaled up to account for under ascertainment due to under diagnosis and under-reporting using a probabilistic framework parametric distribution for all multipliers using a uniform distribution. On the basis of 1000 simulations, we obtained empirical distributions summarized with an average value and upper and 90%CrI.

Results: The countries chosen showed the diverse and common regional characteristics of the Caribbean (small, medium and large islands, mainland countries, tourism dependent). Underreporting of syndromic AGE in the nine countries ranged from 64%-83%. Monthly prevalence of AGE ranged from 4.03%-12.7% and the yearly incidence from 0.52 to 1.4 episodes/year. Children 1-4 years had the highest prevalence of AGE (13%- 25%). Prevalence of AGE also varied by season, income, and district/parish level in countries. Between 15.4% -36% of cases of AGE sought medical care and 12.5-28% of these were requested to submit a stool specimen. The proportion of AGE that tested positive for a FBD pathogen ranged from 8.5%- 40.9%. Loss of productive days due to AGE ranged from 1-20 days. Salmonella had the highest estimated burden, followed by Norovirus, Campylobacter and Giardia infections. Aannual economic costs of syndromic AGE ranged from $US2.2M- 40.4M. Underreporting, infrequent stool collection, inadequate laboratory capacity and underdiagnoses were the major surveillance gaps identified.

The study estimated that each year roughly 1 in 49 Caribbean persons (142,000 persons) acquire a foodborne illness. Forty three percent of the foodborne cases in the region were in children aged 1-4 years of age (60,595 cases, 90% CrI of 37,291-98,313). For each case of Salmonella, Norovirus, Shigella and Campylobacter reported to CARPHA there were actually 123, 167, 118 and 87 more cases occurring a regional level respectively. Thus the overall mutipliers were high for each pathogen studied. The estimated annual number of foodborne illness by pathogens were Salmonella (89,450 cases), Norovirus (6,997) Shigella (19,935) and Campylobacter (8,056).

Conclusions: This is the first time such a study has been carried out in the Caribbean, and provides meaningful information to guide resource allocation and prevention measures. There is an urgent need to improve the surveillance of AGE and FBD and implement appropriate and targeted food safety measures in the countries. In addition to providing Caribbean estimates, these studies promoted capacity building and encouraged the use of burden information in setting food safety policies. However, we acknowledge that these estimates should be interpreted carefully since there are important data gaps and limitations. Despite the data gaps and limitations of these initial estimates, it is clear for us that the burden of foodborne disease is substantial, and affects individuals of all ages, but particularly children <5 years of age.

Mohammad Rokni | *Tehran University of Medical Sciences, Iran*

Significance of the FERG Results for Food Policy and Public Health in Iran and Middle East Region

Foodborne diseases are of great importance in Iran and other countries of Middle East. Many outbreaks resulted from consuming different contaminated foods have been reported throughout these countries.

The last outbreak in Iran occurred in Apr 2015 with 8969 people infected *Shigella flexneri* in Isfahan and Charmahal va Bakhtiari provinces, central Iran. Contaminated vegetables were detected as source of infection. Much more outbreaks originated form *Salmonella* spp., *Entamoeba histolytica*, *E. coli*, *Staphylococcus aureus* etc. have been reported in Iran so far. FERG outcome and outputs, although not released completely, have been presented to authentic policy makers by the author or were presented in different symposiums.

For the first time, in the history of Iran, the Vice-Chancellor of the Ministry of Health decided to manage educational curriculum and future programing based on burden of disease. FERG results would assist colleagues in the office to proceed the case. Parasitic disease task force results were presented in some countries such as Turkey, Thailand, Pakistan, and Afghanistan by the author and were welcomed by audiences.

Due to increasing conflictions in the countries of the region, unfortunately the number of cases and outbreaks originated from contaminated foods are increasing remarkably and some countries like Iraq have planned a wide spread plan to monitor the issue. In Iraq, a national strategy for food safety and managing the food illnesses was developed in 2004 and boosted in 2006 by WHO and Food and Agriculture Organization of the United Nations.

No doubt after releasing all FERG outputs, all countries of the region, would base their strategy mostly based on those data. Although, non-communicable diseases cause much more premature death and disability in the region than in the past, but still food illness encompass a remarkable portion of morbidities and mortalities.

Speaker biographies