The burden of foodborne disease in the UK

Report by Vanna Aldin

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1. Summary

1.1 Over the last 5 years, an extensive programme of work has been undertaken by the FSA economists, in collaboration with external experts and academics, to build a Cost of Illness (COI) model, which for the first time allows us to estimate the burden of foodborne illness in the UK.

1.2 The aim of this paper is to share with the Board the output of the COI model for foodborne illness, which has now been completed and quality assured internally and externally by independent experts. This new model comprises two elements: a £3bn societal burden arising from the 13 main foodborne pathogens, and a second component estimated at £6bn for foodborne illness that is unattributed. Taken together, the two estimates lead to a headline figure of £9bn, as the annual cost burden of foodborne illness in the UK in 2018. The Board will wish to note that there are ranges for these estimates, covered in detail in the body of this paper, and these headline figures represent the median.

1.3 The paper will summarise the COI framework, present the key findings, identify how these will be used and how the output could inform the FSA in setting strategic priorities. It will also summarise the dissemination plan.

1.4 The Board is invited to:

- **consider and approve** the approach taken and the key findings of the work;
- **agree** that the COI output should become an accepted tool for considering the priorities and the potential risk management approaches for tackling foodborne illness;
- **consider** what the COI outputs can contribute to and current limitations in its application; and
- **review** the programme of work underway to estimate the burden of food hypersensitivities and **agree** on the timeframe for the team to report back to the Board.

2. Introduction

2.1 Working with academics from leading UK universities, the FSA economists have built a Cost of Illness (COI) model, whose objective is to identify and measure all the costs of a particular disease, including the direct, indirect, and intangible dimensions. The output, expressed in monetary terms, is an estimate of the total burden of foodborne illness to society. The FSA COI for foodborne disease is loosely based on the Cost to Britain model which the Health and

Safety Executive (HSE) uses to estimate the annual cost to Britain of workplace fatalities, self-reported injuries and ill health. [1] In September 2019, the Board endorsed the approach being taken to develop an approach based on that model, to achieve a robust and comprehensive estimate of the cost to UK society of illness caused by foodborne pathogens.

2.2 The FSA paper "The burden of Foodborne Illness in the UK" provides details on the methodology and approach used, alongside the main findings for the societal burden of 13 main foodborne pathogens (Table 1) and of the unattributed foodborne illness cases, that for 2018 are estimated to be approximately 2.4 million per year[2].

2.3 This COI analysis represents a significant improvement from the previous, much simpler model, which has been used internally within FSA to estimate the burden of foodborne illness. Using a bottom-up approach and a prevalence method, we can now estimate the burden for each of the 13 main foodborne pathogens by identifying the direct and indirect costs, including the pain, grief and suffering for individuals and carers affected by them.

2.4 The COI analysis provides decision-makers with a perspective on the magnitude of the societal burden of a particular disease or condition. This can, in turn, improve our organisational capability in a number of ways. For example, it can support economic appraisals, policy evaluation, impact assessments and measures to monitor the impact of food safety measures at macro-level.

2.5 However, it must be recognised that costs alone are only one approach and cost-benefit and/or cost-effectiveness analysis are the most reliable tools for systematically assessing and comparing the costs and benefits of different interventions, which may be used to reduce food-related risks and detriment to consumer wellbeing.

3. Evidence and Discussion

3.1 A bottom-up approach is used to calculate and estimate the cost of foodborne illness based on the number of cases, severity category (presenting to a GP, hospitalisation, not presenting to a GP) and relevant unit prices (medical costs, wages etc). When aggregated, an estimate of the total cost of the burden of FBD in the UK is obtained.

[1] https://www.hse.gov.uk/statistics/pdf/cost-to-britain.pdf
[2] Foodborne Disease Estimates for the United Kingdom in 2018 https://www.food.gov.uk/sites/default/files/media/document/foodborne-disease-estimates-for-the-united-kingdom-in-2018.pdf

Table 1: List of foodborne pathogens included in the Cost of Illness model

Campylobacter spp.	*Giardia lamblia*
Clostridium perfringens	Adenovirus
VTEC O157	Astrovirus
Listeria monocytogenes	Norovirus
Salmonella spp. (non-typhoidal)	Rotavirus
Shigella spp.	Sapovirus (SRSV)
Cryptosporidium	Unattributed foodborne illness

3.2 The above pathogens were selected as the most important ones to include, based on a range of criteria, including the significance and the availability of data from the different data sources, such as incidence data from the latest Infectious Intestinal Diseases studies, IID1 and/or IID2, and foodborne disease outbreak data.

3.3 Unattributed cases (also referred to as 'unknown aetiology') are also included, so that we build a model of the *overall* cost burden figure for foodborne disease. This is important, as up to 60% of all IID cases caused by contaminated food are never attributed to a specific pathogen. As a result, to ignore these unattributed cases, would significantly underestimate the total burden of foodborne disease.

3.4 The COI model looks at the costs borne by individuals, their carers, businesses and government. In doing this, it comprises two main components: the financial and the non-financial costs.

Financial costs are structured under two broad categories:

Direct costs	*Includes medical care expenditures associated with diagnosis, treatment, management and other financial costs directly related to the illness. This includes resource use and costs to the NHS and personal expenses.*
Indirect costs	*Includes loss of earnings due to illness for the affected individuals and their careers and disturbance costs to business related to the in-house reorganization of the workload. The model derives lost earning due to FBD based on number of cases and length of the disease, as well as, production disturbance costs to business. The model has also been extended to reflect those costs associated with absence from school of for children of primary and secondary school age.*

Non-Financial Cost comprises the human cost of pain, grief & suffering.

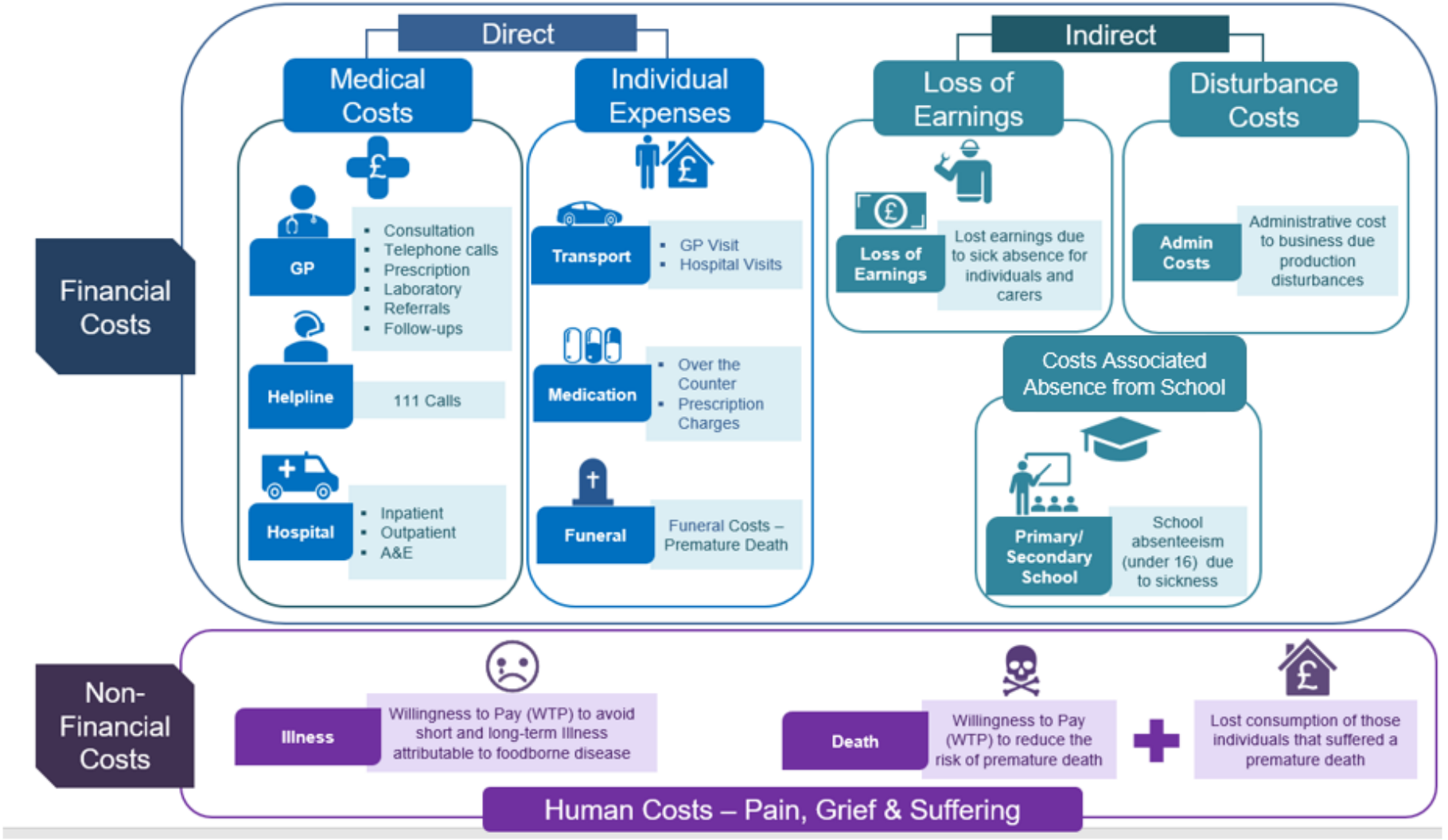
3.5 By considering also the non-financial aspects, the model is able to identify the full social cost of the burden of FBD, which extends far beyond the financial consequences. The HM Treasury Green Book Guidance is clear that wider social and environmental impacts must be brought into any cost-benefit assessment, as far as possible. The non-financial component of the COI model accounts for the intangible valuation of the 'pain, grief & suffering' - the human cost of foodborne-related illness, chronic disability and fatalities. These are concepts which are difficult to measure on a simple monetary basis, as they represent a 'non-market cost' and thus need to be valued by other means. In such circumstances, where market prices do not exist or where they are unknown, there are "non-market valuation" methods that can be used to estimate its value. Prior to the work presented here, the FSA had never used these methods in relation to FBD.

3.6 The COI model is now underpinned by substantially more robust, monetised estimates of the pain, grief & suffering of individuals with a foodborne illness. A valuation study commissioned by the FSA in 2016. This study – *Estimating Quality Adjusted Life Years and Willingness to Pay (WTP) Values for Microbiological Foodborne Disease (Phase 2)* – provided these estimates, using a stated preference Discrete Choice Experiment (DCE) survey design to elicit WTP measures to avoid illness caused by different foodborne pathogens.

3.7 The key components of the revised COI model are shown below in Figure 1. Using this model, for the first time, the FSA is able to provide:

- estimates of the UK societal burden attributed to 13 individual foodborne pathogens based on the up-to-date estimates as recently published by FSA (*Foodborne Disease Estimates for the United Kingdom in 2018*)
- cost estimates for the foodborne unattributed cases (which represent more than 60% of total foodborne illness)
- estimates of willingness -to-pay (WTP) to avoid pain, grief and suffering associated with illness specifically related to FBD. Previously the FSA relied on non-fatal injury valuations related to road traffic accidents derived from the Department of Transport, which were not well-suited to FBD related illnesses;
- estimates for disturbance costs to businesses, and costs associated with absence from school to children, aged 16 and under, in terms school days lost due sick absence

Figure 1: Overview of The Cost of Illness Model

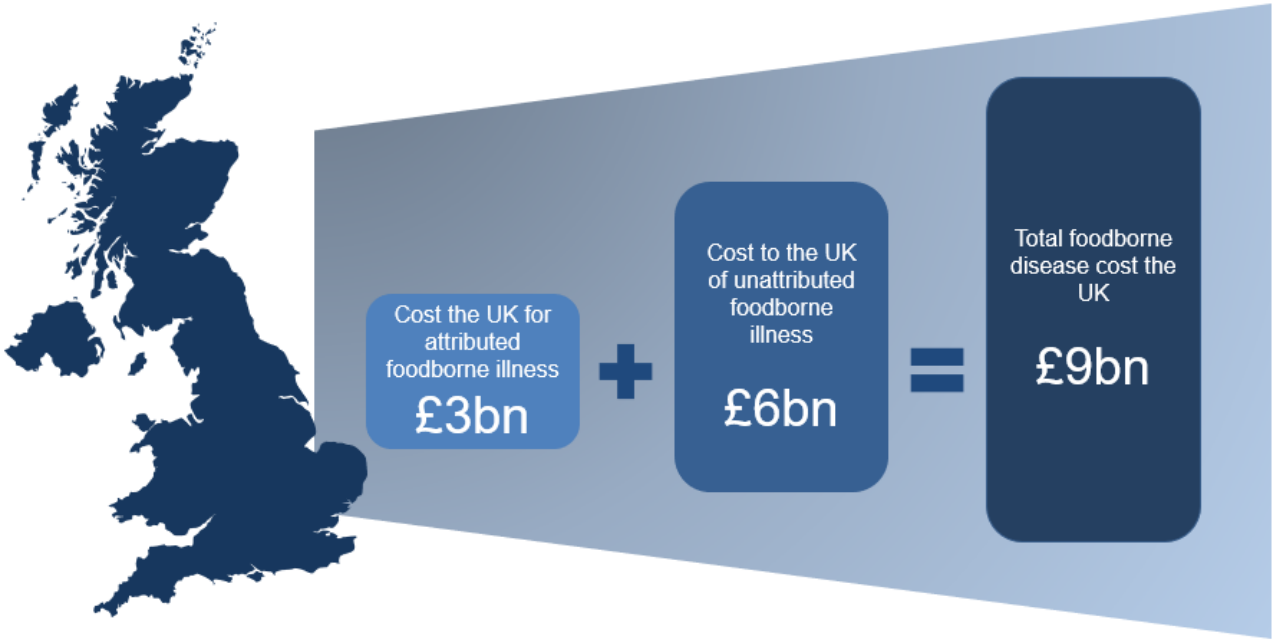


3.8 Based on latest (2018) human FBD estimates of 2.4m cases per year, the new COI model allow us to estimate that the total burden for the UK from foodborne illness is approximately £9bn (£3bn for known cases and £6bn for unattributed cases), see figure 2 below. This is a significant increase over previous estimates.

3.9 The previous FSA COI model, attributed an annual cost to FBD in the UK that was exceeding £1bn, based on approximately 1m foodborne disease cases.

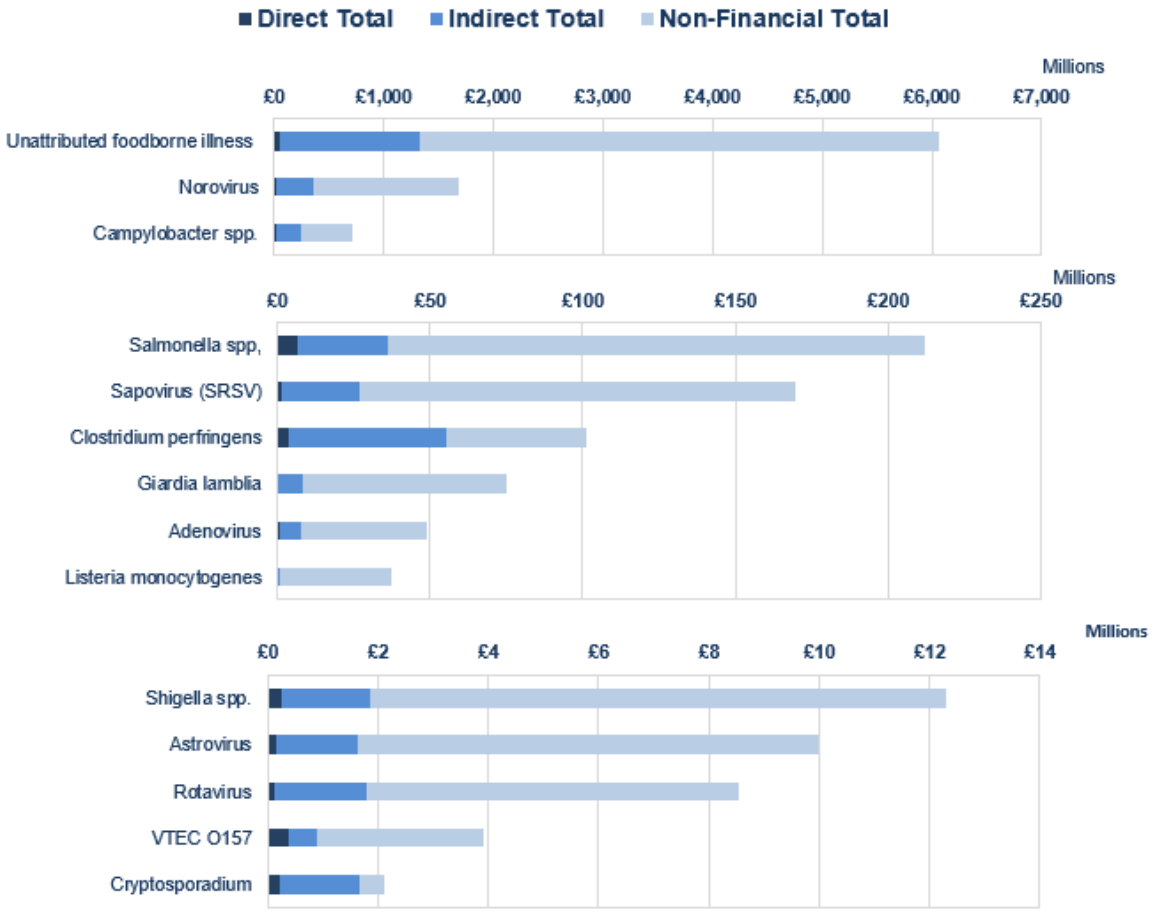
3.10 For comparison, using a similar methodology, the HSE estimates the cost to Great Britain of workplace injuries and new cases of work-related ill health was £15bn in 2017/18.

Figure 2: Total cost to UK of foodborne disease in 2018



3.11 The total burden of FBD in the UK is predominantly driven by the number of individual cases. Of known cases, norovirus imposes the greatest economic and societal burden at an estimated annual cost of £1.68bn followed by Campylobacter spp. (£0.71bn) and Salmonella spp. (non-typhoidal) (£0.21bn). VTEC O157 (£0.04bn) and Cryptosporidium (£0.02bn) impose the least burden. With unknown cases accounting for 60% of total FBD cases, this by far imposes the greatest burden when compared to known cases. Figure 3 presents total costs for each of the 13 pathogens and for unattributed foodborne illness cases. These are based on median estimates of the number of cases, which present, to a certain extent some uncertainty (for further details refer to Annex A).

Figure 3: Total cost by pathogen 2018



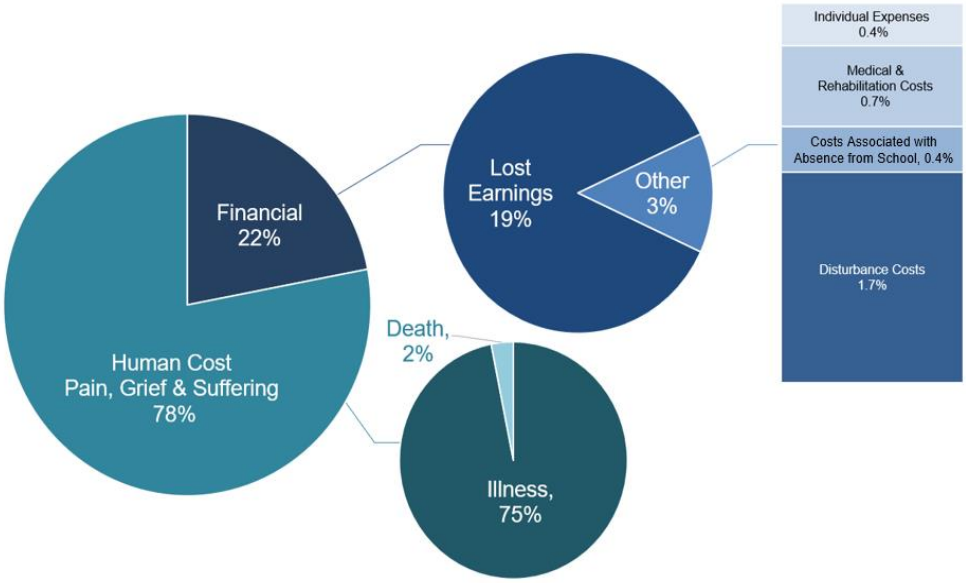
3.12 In 2018, the average cost per case for FBD in the UK was £4,000 (£3,500 excluding unattributed cases). Variation in the average cost per FBD case is highly dependent on the composition of cases, according to type of pathogen and its varying degree of severity, which could change year on year. Each pathogen is defined by their own cost profile and reflecting population characteristics such as age.

3.13 Cost per case by pathogen is shown in Figure 4. *Listeria monocytogenes* has the highest cost per case estimate for 2018 at £230,748, driven primarily by the high proportion of fatalities (accounting for a fifth of all cases). This is 27 times the size of VTEC O157 lamblia, which has the second highest cost per case estimate at £8,386. *Cryptosporidium parvum* has the lowest cost per case figure at £1,016, while Campylobacter and Clostridium perfringens also report relative low cost per case figures at £2,380 and £1,196 respectively.

Figure 4: Cost per Case by Pathogen 2018

3.14 The human cost of pain, grief & suffering attributed to foodborne illness and related fatalities was estimated at £7.06bn for 2018, accounting for almost 80% of the total burden of FBD to the UK. Illness including long-term complications and sequelae, made up the majority of the cost, estimated at £6.8bn, followed by fatalities valued at £221m. Financial costs account for almost a quarter (£2.06 bn) of the total burden of FDB. The largest financial cost component is lost earnings, estimated at £1.8bn for 2018, followed by disturbance costs to businesses at £157.5m. Medical costs accounts for the third highest proportion of financial costs at £60.5m followed by costs associated with absence from school at £34.3m. Individual expenses accounted for the smallest share estimated as £32m. The percentage breakdown by cost component presented in Figure 5.

Figure 5: COI percentage breakdown of cost components



3.15 The FSA is not alone amongst food safety regulators in the use and application of the COI model approach. Organisations such as: the US Food and Drug Administration (US FDA), United States Department of Agriculture - Economic Research Service (USDA-ERS), Canadian Food Inspection Agency (CFIA), Food Standards Australia New Zealand (FSANZ) and the Dutch National Institute for Public Health and the Environment (RIVM); have all developed and use COI models to identify and measure the cost of a particular foodborne disease, including the direct, indirect and intangible dimensions (all expressed in monetary terms in estimating the total burden of a particular disease to society).

3.16 For example:

- the USDA-ERS produces cost estimates of foodborne illnesses caused by 15 major pathogens that account for over 94% of foodborne disease incidence in the United States (US) from identifiable pathogens. Estimates are comprised of associated outpatient and inpatient expenditures on medical care, and loss of earnings, and individuals' willingness to pay (WTP) to reduce mortality risk associated with these foodborne illnesses. Foodborne pathogens are estimated to impose over $15.5 billion (2013 US dollars) economic burden on the USA citizen each year. This does not include the value of avoided pain and suffering from morbidity. As it is the case for our model, the cost per case varies greatly across pathogens (to note that the $15.5bn estimate is for the foodborne illness, approximately 9.4 million cases, attributed to 15 known pathogens only; it takes no account for those unattributed cases which represents 80% of the total annual 48 million cases).

- A study by Scharff (2012)[3] produced estimates of the cost of foodborne illness in the US for 31 identified pathogens and for unattributed cases. Cost to the US were estimated at a substantial $77.7 billion (2010 US dollars) ($32.5bn for known cases and £45.2bn for unattributed cases)[4]. This estimate includes an estimate for willingness to pay to avoid pain and suffering from morbidity based on estimates of consumer willingness to pay to reduce risk of mortality.
- In Canada, the CFIA also report economic cost estimates of foodborne illness due to 30 known and unspecified pathogens at $2.8 billion (2012 Canadian dollars), of which $1.6 billion is for unattributed cases.

3.17 These are examples for illustrative purpose only: each annual estimate above is based on the available data in each country, on different methodologies and coverage in terms of direct and indirect costs and burden to individual and businesses, and on different years. Therefore, it is not possible to make comparisons.

4. Conclusions

4.1 In addition to the COI estimates, QALY (Quality Adjusted Life Years) metrics are now also available for the main foodborne pathogens and these measure the burden of diseases on individuals, in terms of quality and quantity of life lived for a given pathogen. While these QALY estimates are not presented in this paper, they are complementary to the COI estimates. By integrating these two estimates and measures, we now have enhanced evidence supporting risk-based approaches to setting food safety policy. However, these measures alone do not indicate how policy priorities should be set and further evidence on policy effectiveness, alongside the cost and concerns about the distribution of health and policy impacts, are also very important inputs to policy decision making.

4.2 The estimation of the cost of foodborne illness is an ongoing area for research for food safety regulators around the world. There are still significant gaps in the underlying data and several assumptions are required to fill these gaps. In turn, this increases the uncertainty and the degree of comparability. Nevertheless, for FSA, this COI work represents a major milestone. For the first time, we have a robust methodology to estimate the annual burden to society for the overall prevalence of foodborne illness among the UK population.

4.3 Using the new COI model regular cost updates on the burden of foodborne illness can now be provided, based on up-to-date estimates for foodborne disease cases in the UK, when these become available. It is recommended that the assumptions and

[3]Economic Burden from Health Losses Due to Foodborne Illness in the United States https://meridian.allenpress.com/jfp/article-lookup/doi/10.4315/0362-028X.JFP-11-058

[4] The difference between Scharff's 2012 estimates and USDA estimates is primarily driven by: i) number of pathogens included. Scharff (2012) included estimates for foodborne illnesses caused by 30 of 31 identifiable pathogens plus foodborne illnesses for which no pathogen source can be identified. By contrast, USDA included estimates for foodborne illness caused by only 15 identifiable pathogens; ii) valuation method – Scharff 2012 included monetized quality-adjusted life years (QALYs) to account for pain and suffering caused by foodborne illness as well as the illnesses' impact on daily activities, such as employment. USDA used a cost-of-illness estimate for nonfatal outcomes and a willingness-to-pay (for reducing deaths) measure for fatal outcomes.

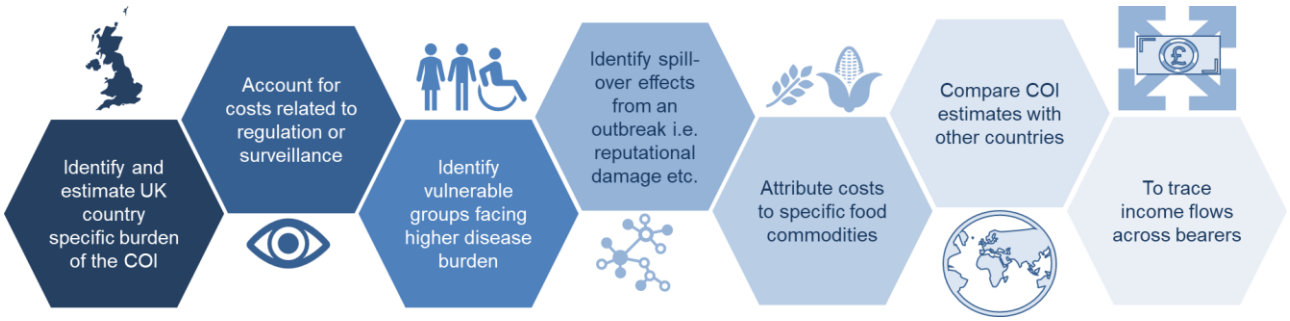
methodology underpinning the model be reviewed and revised every three or five years, to ensure it incorporates the latest developments in this research area and relies on the most up-to-date data sources that may become available overtime.

4.4 Robust and reliable cost of illness estimates allow the FSA to enhance its ability to assess the cost effectiveness of food safety policy interventions, improve impact assessments analysis, appraisals and evaluation (see Figure 6). It can identify the burden by the main cost bearers, namely: individual, businesses and government. However, the COI model only presents a UK average of the burden and cost of illness. As described in Figure 7, there are limitations in its application: for example, it cannot identify country-level costs of foodborne illness; nor can it be used to estimate spill-over effect from foodborne outbreaks (e.g. local authority enforcement) or identify vulnerable groups facing higher disease burden.

4.5 In terms of future steps, FSA economists are considering the scope of further research with a view to better understand the burden and costs across different demographics and socioeconomic groups within the UK population. This would enable us to potentially identify key vulnerable groups (by age or socio-economic group) facing the highest burden, for example in terms loss of earnings, individual expenses and medical costs; where reductions in the number of FBD cases could potentially have the greatest impact on the costs incurred by society.

Figure 6: Applications of Cost of Illness

Figure 7: Out of Scope Uses for Cost of Illness



4.6 In addition to the work presented here on FBD, a further programme of work to estimate the COI for food hypersensitivities is also underway. A consortium of academics led by Aston University is now working with FSA analysts to elicit Willingness to Pay (WTP) estimates, aiming to capture the burden sufferers face managing their condition on daily basis. In addition, there are longer term plans to estimate the financial costs associated with food hypersensitivities, such as price differentials or special equipment needs. We expect to have estimates of all cost components of the COI model for food hypersensitivities by summer 2021.

4.7 The Board is invited to:

- **consider and approve** the approach taken and the key findings of the work;
- **agree** that the COI output should become an accepted tool for considering the priorities and the potential risk management approaches for tackling foodborne illness;
- **Consider** what the COI outputs can contribute to and current limitations in its application; and
- **Review** the programme of work underway to estimate the burden of food hypersensitivities and **agree** on the timeframe for the team to report back to the Board.

ANNEX A Cost of Illness Model – Uncertainty

Table A1: Foodborne Illness Cost Ranges by Pathogen

	Aggregate Cost Ranges (in millions)		
Pathogen	**Lower 95% Bound**	**Median**	**Upper 95% Bound**
Campylobacter	£298.4	£712.6	£1,355.8
Cl. Perfringens	£25.3	£101.5	£385.0
E.coli O157	£3.0	£3.9	£4.6
Listeria	£34.4	£37.4	£40.8
Salmonella spp, Nontyphoidal	£45.6	£212.0	£954.8
Shigella spp	£0.8	£12.3	£37.9
Cryptosporidium	£0.3	£2.1	£15.3
Giardia lambia	£11.6	£75.0	£405.9
Adenovirus	£12.0	£48.7	£138.2
Astrovirus	£2.2	£10.0	£31.6
Norovirus*	N/A	£1,678.2	N/A
Rotavirus	£2.1	£8.5	£23.5
Sapovirus (SRSV)	£112.4	£169.5	£251.7
Unattributed foodborne illness (UFI)	£4,471.3	£6,059.9	£7,988.8
Excluding (UFI)	£786.8	£3,071.8	£5,588.6
Including (UFI)	£5,258.1	£9,131.7	£13,577.4

Notes: *Credible intervals for norovirus were not possible for cases due to the modelling approach. This does not mean that there is no uncertainty in these estimates. There were a number of parameters used in the NoVAS study which, while based on the best science currently available, were acknowledged to have uncertain values. Sensitivity analysis undertaken as part of the study showed that changes to the values of these parameters could make big differences to the overall estimates.

Table A2 Foodborne Illness Case Number Ranges by Pathogen

	Foodborne Illness Case Number Ranges (in thousands)		
Pathogen	**Lower 95% Bound**	**Median**	**Upper 95% Bound**
Campylobacter	127.1	299.4	571.3
Cl. Perfringens	32.0	84.9	224.6
E.coli O157	0.3	0.5	0.6
Listeria	0.1	0.2	0.2
Salmonella spp, Nontyphoidal	6.8	31.6	147.2
Shigella spp	0.1	1.6	5.0
Cryptosporidium	0.3	2.1	12.2
Giardia lambia	2.0	13.1	71.1
Adenovirus	3.1	12.5	34.7
Astrovirus	0.6	2.6	8.0
Norovirus*	N/A	383.2	N/A
Rotavirus	0.5	2.1	5.7
Sapovirus (SRSV)	28.9	43.6	64.7
Unattributed foodborne illness (UFI)	1,046.5	1,449.2	1,991.6
Excluding (UFI)	702.3	909.4	1,225.2
Including (UFI)	1,795.0	2,362.3	3,149.7

Notes: *Credible intervals for norovirus were not possible for cases due to the modelling approach. This does not mean that there is no uncertainty in these estimates. There were a number of parameters used in the NoVAS study which, while based on the best science currently available, were acknowledged to have uncertain values. Sensitivity analysis undertaken as part of the study showed that changes to the values of these parameters could make big differences to the overall estimates.