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Economics of zoonoses surveillance in a 'One Health' context: an assessment of *Campylobacter* surveillance in Switzerland

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SUMMARY

Cross-sectorial surveillance and general collaboration between the animal and the public health sectors are increasingly recognized as needed to better manage the impacts of zoonoses. From 2009, the Swiss established a *Campylobacter* mitigation system that includes human and poultry surveillance data-sharing within a multi-sectorial platform, in a 'One Health' approach. The objective of this study was to explore the economics of this cross-sectorial approach, including surveillance and triggered interventions. Costs and benefits of the One Health and of the uni-sectorial approach to *Campylobacter* surveillance were identified using an economic assessment framework developed earlier. Cost information of surveillance activities and interventions was gathered and disability-adjusted life years (DALYs) associated with the disease estimated for 2008 and 2013. In the first 5 years of this One Health approach to *Campylobacter* mitigation, surveillance contributed with information mainly used to perform risk assessments, monitor trends and shape research efforts on *Campylobacter*. There was an increase in costs associated with the mitigation activities following integration, due mainly to the allocation of additional resources to research and implementation of poultry surveillance. The overall burden of campylobacteriosis increased by 3·4–8·8% to 1751–2852 DALYs in 2013. In the timing of the analysis, added value associated with this cross-sectorial approach to surveillance of *Campylobacter* in the country was likely generated through non-measurable benefits such as intellectual capital and social capital.

Key words: *Campylobacter*, economic assessment, One Health, One health surveillance, zoonoses.

INTRODUCTION

Campylobacter poses an important public health threat, and it is currently identified as the most important zoonotic infectious agent in Europe [1]. In Switzerland, human campylobacteriosis has been a notifiable disease since 1988 and the most frequently recorded zoonotic infection since 1995. Overall, an increasing trend of the disease in humans has been observed, with a peak of notified cases of 105 reports per 100000 inhabitants in 2012 [2, 3]. Its impact in the country in terms of healthcare costs of laboratory-confirmed campylobacteriosis patients has been recently estimated as €8·3 million [4]. There is a distinct two-peak seasonality of reported human cases in the country: a summer peak, likely to be connected to a higher infection rate in poultry flocks, higher

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frequency of exposure via barbecue activities and foreign travel, and a winter peak mainly related to consumption of chicken meat in the traditional festive dish *Fondue Chinoise* [5–7]. The chicken reservoir has been identified as the main source for human campylobacteriosis in Switzerland, with 71% of human cases attributed to chicken based on the comparison of isolates from humans and animals [8]. In poultry, the prevalence of *Campylobacter* in cloacal swabs ranged from 33% to 38%, from 2010 to 2013 [6].

In response to the observed increasing trend in human campylobacteriosis cases, the animal and the human health authorities enhanced collaborative disease surveillance and intervention efforts with the intention of improving disease management. A stakeholder group composed of the poultry industry, researchers and public health and animal health national and cantonal authorities – the *Campylobacter* platform – was formed with the aim of exchanging information, coordinating and evaluating control measures, and identifying gaps of knowledge and funding of research [2]. A regular surveillance system in broiler chicken was also implemented. This constituted a shift from the previously instituted system, which was essentially based on the monitoring of human cases.

Such change, from a uni-sectorial to a multi-sectorial approach to *Campylobacter* mitigation, is also in line with increased recognition at the international level of the need for collaboration between the animal and the public health sectors as a means of improving the management of zoonotic threats. The One Health movement is based on the principles that collaborative or integrated efforts across multiple disciplines can result in a decrease of the burden of zoonotic disease and generate a better health status, and that a multi-sectorial approach best captures the interrelationships of health of different species [9, 10]. This includes strengthened integrated surveillance systems for zoonotic pathogens and sharing of information, currently seen as key to an effective health system [11–14].

The need to identify better ways to mitigate the impact of campylobacteriosis has triggered research work into the cost-effectiveness of control options for *Campylobacter* at different levels of the food chain in different countries [15–17]. However, similar to economic assessments of other zoonotic diseases, the focus of these assessments is largely on the economics of disease control, with no specific focus on the costs and benefits of efforts for surveillance or collaborative mitigation activities for *Campylobacter*. Surveillance activities require resource spending that may be significant and information on the extent of expenditure associated with these activities is needed to inform prevention, surveillance and control strategy decisions. Furthermore, from an economic perspective, it is of interest to consider whether overall resources are used more efficiently by integrated, One Health surveillance, than by a surveillance system with disconnected, sector-specific components. Such increased efficiency in resource use can be attained either through cost savings and/or by added benefits associated with a reduced impact at the societal level of zoonotic threats [18].

It has been shown in previous work that the economic assessment of surveillance activities needs to be underpinned by the understanding of how the surveillance activities link to interventions and to the broader mitigation process [19]. An assessment of the overall mitigation approach including surveillance and intervention is therefore needed when exploring the economics of surveillance. In the case of One Health surveillance, this extends to the understanding of how surveillance information is used and how it triggers health consequences and benefit streams across different sectors [18].

In this study, we explored the cross-sectorial costs and benefits associated with the sharing of surveillance information on *Campylobacter* in Switzerland during the period 2009–2013. The objective is to provide information on the economics of this cross-sectorial approach to *Campylobacter* mitigation and to test the practical implementation of an assessment framework previously developed.

METHODS

General approach

The One Health approach to *Campylobacter* mitigation was considered as the system in place since 2009 to 2013 (in this study). In this period information generated by surveillance activities in the poultry population and in the human population was shared in the *Campylobacter* platform and fed into cross-sectorial policy discussions, triggering public health and animal health targeted interventions. The collaborative nature of the analysis of information generated by the animal and human surveillance streams in the *Campylobacter* platform fits into the concept of 'One Health surveillance', as currently described [20, 21]. This One Health approach was compared with the system in place prior to establishment of the *Campylobacter*

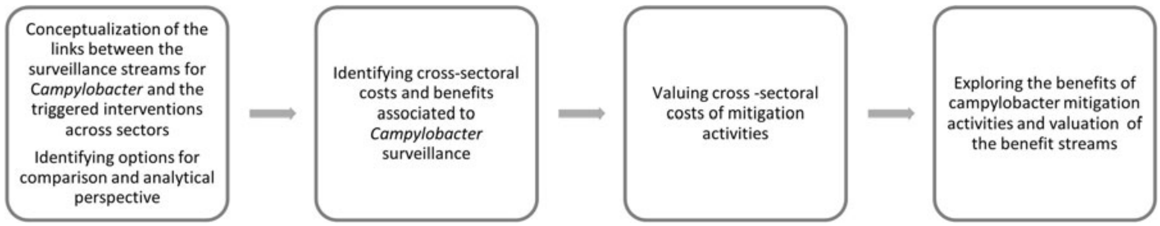

Fig. 1. Overview of the steps taken in the economic assessment of *Campylobacter* surveillance in Switzerland in a One Health perspective following the conceptual framework used in this study [18].

platform, the 5-year period from 2004 to 2008. The mitigation activities during this period were predominantly public-health-based, with a monitoring system centred on mandatory notification of human cases, triggering public health messaging activities.

As mentioned before, costs and benefits of surveillance are intrinsically linked to the interventions triggered by the information generated. Taking this into consideration, and to guide our assessment, we applied a framework previously developed [18] to identify surveillance activities across the two sectors, their links to public health and animal health decision-making and triggered interventions in the two time periods. The framework entails an initial step that involves a conceptualization of the links between surveillance and triggered interventions, followed by the identification of costs and benefits and their valuation. An overview of the steps taken in this analysis is provided in Figure 1.

Only official surveillance systems and interventions were considered in this assessment and industry-borne costs and benefits were not incorporated in the analysis.

Initial framing and identification of cost and benefit items associated with *Campylobacter* surveillance

The initial framing for the analysis entailed the conceptualization of the links between the surveillance streams for *Campylobacter* and the triggered interventions across sectors. Information on the type of surveillance activities, integration mechanisms and interventions prompted by the information generated in both the animal and human health sectors were identified for the One Health and uni-sectorial systems, based on discussion with experts involved in the surveillance activities and in the *Campylobacter* platform and literature review [2]. The information was mapped enabling the identification of the costs items and potential benefit streams of the mitigation systems (Fig. 2).

Valuing costs and estimating the break-even point

Data used to parameterize the cost estimation model were collected for the two periods in analysis from the Swiss Federal Food Safety and Veterinary Office (FVO) and Federal Office of Public Health (FOPH). Labour costs and expenses accrued by planning and preparation tasks of the surveillance systems, sampling and test costs, including analysis and transport of materials and samples were included where appropriate, as well as labour costs and expenses related to data analysis and interpretation, and information dissemination. Running costs of the *Campylobacter* platform as well as costs associated with interventions that were triggered by surveillance information were also estimated. For the human monitoring system, only labour and expenses associated with the notification of cases upstream of the laboratory diagnosis were considered, as all costs downstream to that point could not be directly allocated to the monitoring system. Intangible costs were not included in the analysis. Table 1 summarizes the inputs considered for the cost estimate.

Labour costs for scientific and administrative level staff were calculated considering the wage table established by the Swiss Confederation for 2014 and using an average variation of 1·2% [22] to establish the corresponding wages for the years in analysis. A working month of 182·7 hours was used as a basis for the calculation of the hourly cost associated with the *Campylobacter* mitigation activities.

The break-even point for the system, i.e. the point at which cost or expenses and benefits are equal and the system would recover its costs, was calculated in terms of the number of disability-adjusted life years (DALYs) – the metric used to assess marginal benefits of the system – that would have to be averted. To compare a monetary metric for costs [Swiss Francs (CHF)] with a non-monetary metric, break-even points were calculated using three point estimates of health burden and associated cost-of-illness (converted into CHF,

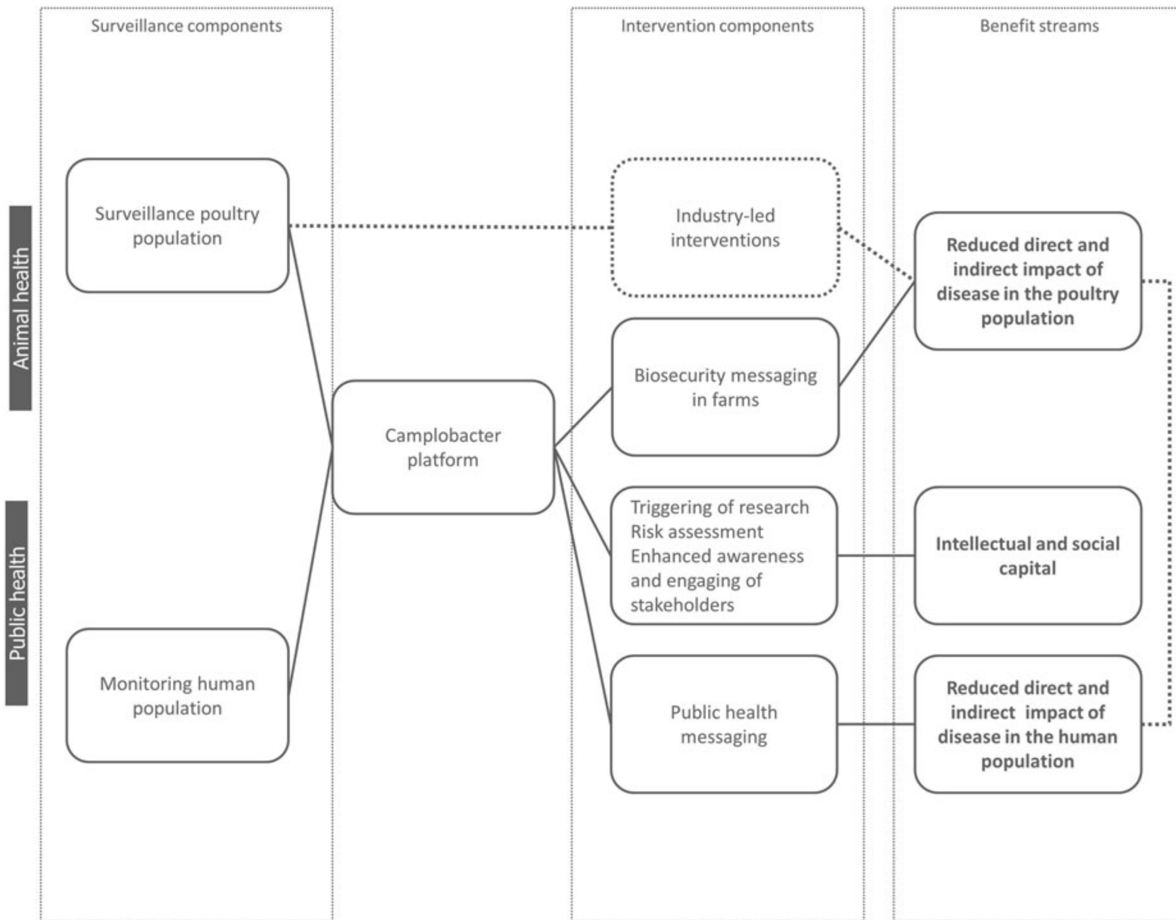

Fig. 2. Conceptual representation of the links between *Campylobacter* surveillance and triggered activities across the public health and the animal health sectors and the benefit streams generated, in 2009–2013.

using the yearly average exchange rate of 2013) available in the literature: 8437 CHF/DALY [23], 61 362 CHF/DALY [24] (considering the average DALY estimate) and 21 534 CHF/DALY [25].

Valuing benefits

From the benefit streams identified (Fig. 2), we explored in more detail potential changes regarding the impact of disease in the human population. The potential benefits of *Campylobacter* mitigation in the poultry population, in terms of direct impact, were not assessed considering the relatively minor role of *Campylobacter* as a pathogen for poultry [26]. Similarly, potential benefits in terms of mitigation of potential indirect impacts (e.g. effects on market access and trade) were not assessed.

Burden of disease was calculated using DALYs, applying the methodology developed by Murray & Lopez [27] and building upon the model recently used in Denmark for the estimation of the burden of foodborne disease [28]. The estimates of burden for 2013 (5 years after the start of the approach) were compared to the estimated burden of disease in 2008 (the year prior to the implementation of the *Campylobacter* platform).

Table 2 summarizes the inputs used to parameterize the DALY model. To correct for underdiagnoses and underreporting and to estimate the total incidence of disease in the community, multiplication factors of 3·4 [23] and of 9·3 [29] as a best- and worst-case scenario, respectively, were used in the 2 years estimated – 2008 and 2013. Underreporting and underdiagnoses were considered as constant in 2008 and 2013 as there were no changes to the human monitoring system. Health outcomes associated with *Campylobacter* infection considered were gastroenteritis (GE), reactive arthritis (RA), irritable bowel syndrome (IBS), inflammatory bowel disease (IBD) and Guillain–Barré syndrome (GBS). Data pertaining to these health outcomes were sourced from national data whenever possible and from data available in the literature from elsewhere and recently reviewed in [28].

Table 1. *Inputs considered for the cost analysis per system component*

Mitigation system component	Inputs considered for cost calculation
Surveillance programme in poultry	Working time involved in sample size calculation and sampling plan, planning of activities, sampling, data analysis, report writing, and dissemination activities; expenses with transport of sampling material, tests, shipment of samples and translation.
Monitoring programme of cases in humans	Working time involved in data management, analysis and dissemination.
Campylobacter platform	Working time involved in preparation and participation in meetings, and post-meeting activities including reporting of outcomes; expenses with transport costs.
Pre-harvest interventions	Working time on leaflets development and dissemination activities; expenses with printing.
Post-harvest interventions and research funding	Working time and expenses on commissioned research and public health messaging activities.

Disability weights (DWs) used were based on the Global Burden of Disease 2010 study [30]. When the DW for a specific health outcome was not available, a DW from an outcome with similar health effects was used. When DWs for specific health outcomes differentiated between multiple degrees of severity, an overall DW was calculated on the basis of the estimate of the proportion of cases with those severity levels in Switzerland. Life expectancy estimates were obtained from the Swiss population statistics for 2013 [31]. Age weighting and discounting were not applied.

Total years of life lost to disability (YLD), to mortality (YLL), and overall DALYs for the years under analysis were calculated by applying a stochastic model using the DALY Calculator interface developed in R [38]. In addition to the estimate of best- and worst-case scenarios to explore the uncertainty resulting from data limitations in the incidence of campylobacteriosis, sensitivity analysis using a linear regression-based analysis was conducted with the same software to explore the contribution of each stochastic variable in model input parameters to the overall uncertainty of the end result.

RESULTS

From 2009 to 2013, the information generated by surveillance in the animal population and by human case monitoring shared in the *Campylobacter* platform, triggered activities concerning biosecurity messaging in poultry farms and public health messaging on hygienic measures for chicken meat handling and prevention of cross-contamination. Integration of surveillance information was also used to perform cross-sectorial risk assessments and to identify gaps in the knowledge base for *Campylobacter* infection in the country and research needs. The links between information generated by the animal health sector and triggered interventions in the public health sector through the integration of this information in a One Health approach are presented in Figure 2.

Through its links to public health messaging, surveillance of *Campylobacter* in poultry and integration of information has the potential to generate a reduction in the direct and indirect impact of the disease in the human population, namely on the burden of disease or cost-of-illness. Equally, through its links to biosecurity messaging at the farm level, it has the potential to reduce the direct and indirect impact of disease in the animal population, ultimately contributing to a reduction in human infection.

Intermediate or intangible benefits were identified, related to enhanced knowledge, performance of risk assessments and triggering of research, such as intellectual capital, and to social capital, generated through the intrinsic value of multi-sectorial collaboration and networking.

The overall mitigation activities surrounding *Campylobacter* in Switzerland in the period 2009–2013 had an associated cost of ~1·85 million CHF, corresponding to a yearly average expenditure of ~ 370 000 CHF. This figure does not include mitigation costs borne by industry as these were not available but known to be >0. The overall marginal cost of such an enhanced effort was of 1·2 million CHF (over 5 years) in relation to the 5-year period 2004–2008 when the activities were mainly public-health based. Almost half (48%) of the total expenditure in 2009–2013 was absorbed by commissioned research on *Campylobacter* in Switzerland, followed by the

Table 2. *Input parameters for DALY calculation and data sources*

Parameter	Input		Source
Incidence of human campylobacteriosis	Reported cases per year and per age group (2004–2013)		FOPH
Underdiagnoses and underreporting factor	3·4 and 9·3		[23, 29]
Health outcomes	GE	Estimated true incidence	FOPH and multiplying factors
		Mortality. Calculated based on excess mortality risk for laboratory-confirmed cases (0·9). This multiplier was applied to age-specific mortality risk by all causes (Statistics Netherlands' data used as surrogate)	[32, 33]
	RA	Calculated based on: • Probability of having RA for a GE patient visiting a GP [RiskBeta (46;565)] • Probability of a patient with RA seeking care for [RiskBeta (10;37)], • Probability of hospitalization for RA patients who visit a GP [RiskBeta (2;45)]	[33]
	IBS	Pert (7·2;8·8;10·4)	[34]
	IBD	Calculated based on the age specific risk of IBD and the excess risk IBD	[33]
	GBS	Beta(60;29,942) Mortality: RiskPert (0·01;0·02;0·05)	[35]
Duration of illness (years)	GE (diarrhoea)	Pert (0·007;0·02;00·9)	[5]
	RA	0·608219178	[36]
	IBS	5	[34]
	IBD	Life-long	[25, 37]
	GBS	Life-long	[35]
Disability weight	GE (diarrhoea)	Mild: 0·061 Moderate: 0·202 Severe: 0·281 Overall: 0·1049555	[30]
	RA	0·21	[30]
	IBS	0·042	[34]
	IBD	0·26	[25, 37]
	GBS	0·445	[35]
Life expectancy	Men: 80·5; women: 84·8; average: 82·65		Swiss statistics
Onset of disease and average age at death	Average age of the population group		
Hospitalization	14·5%		[5]

DALY, Disability-adjusted life year; FOPH, Federal Office of Public Health; GE, Gastroenteritis; RA, reactive arthritis; IBS, irritable bowel syndrome; IBD, irritable bowel disease; GBS, Guillian–Barré syndrome.

surveillance and monitoring activities in poultry and humans, respectively. Table 3 shows the cost analysis results by system component for the One Health approach.

The average total burden of disease of campylobacteriosis was estimated to be 1751 [95% confidence interval (CI) 1478–2069] to 2852 (95% CI 2520–3227) DALYs in 2013, in the best- and worst-case scenarios, respectively. This represents a 3·4–8·8% increase since 2008 when the estimated burden of disease was of 1609 (95% CI 1330–1947) DALYs to 2756 (95% CI 2412–3140) (undiscounted). From the total results, 746–802 to 820–942 of the DALYs were related to GE in 2008 and 2013, respectively, with the remaining burden allocated to disease sequelae. The total DALYs correspond to 20·19–34·59 and to 21·96–35·08 DALYs/100 000 inhabitants in 2008 and 2013, respectively. Table 4 shows these results in more detail.

The One Health mitigation approach would recover its costs if 6–43·8 DALYs were averted per year,

Table 3. *Estimated cumulative cost of the One Health mitigation system per component, in the period 2009–2013 (in CHF)*

Mitigation system component	Estimated cost in CHF, 2009–2013
Surveillance programme in poultry	531 000
Monitoring programme of cases in humans	358 570
Campylobacter platform	66 700
Pre-harvest interventions	8340
Post-harvest interventions and research funding	884 900

depending on the cost-of-illness to DALY match estimate used in the break-even point calculations.

Figure 3 summarizes the results of the cost analysis and burden calculation by showing the evolution of costs per activity in the 10 years of the analysis and the campylobacteriosis burden estimate from 2008 to 2013.

In addition to the impact of the estimated true incidence input parameter shown above, the sensitivity analysis indicated that, from the stochastic inputs to the model, changes in the duration of symptoms of GE had the highest impact on the model outcome. One standard deviation change in duration of GE symptoms would lead to a difference of 34·2 DALYs in the overall DALY estimate.

DISCUSSION

We assessed the costs and benefits associated with *Campylobacter* surveillance in Switzerland from a One Health perspective.

Our results suggest that, in the first 5 years of the system, the level of the expenditure increased with a cross-sectorial approach to surveillance and intervention for *Campylobacter* in the country, particularly in research funding and surveillance activities in poultry. In the period of this work, integrated surveillance information contributed mainly to the assessment of trends, to perform risk assessments and to inform discussion on gaps and information needs regarding *Campylobacter* in the country, thus contributing to the shaping of research efforts and strengthening of the knowledge base regarding the disease. Consequently, in these initial 5 years, *the nature of benefits was intangible, including the generation of* intellectual capital. The latter relates to the intangible value (information, intellectual property, experience) in the knowledge and relationships of employees, management staff, and other stakeholders of a company or institution, that can be used, in the future, to generate wealth. In the public sector context, measurement of intellectual capital and knowledge assets has been carried out by universities and research funding institutions [39].

Such intellectual capital created by surveillance can later generate measurable value when it is translated into control measures that mitigate the impact of the disease. In fact, from 2014, the *Campylobacter* mitigation system in Switzerland shifted from a main focus on assessment and knowledge-generation to the implementation of interventions targeting the food chain. New national regulations in place from January 2014 require that poultry liver from *Campylobacter*-positive herds can only be sold frozen and that pre-packed fresh poultry meat and meat preparations should be labelled with information on the need to thoroughly cook the products before consumption and on hygiene rules [6].

The timing of our analysis is therefore particularly relevant for the benefits assessment. A time delay between initiating research and implementing interventions with possible health effects can be expected. Furthermore, it can be expected that the power of an integrated surveillance system increases with time as information is gathered and trends and sources are more accurately identified. This has been shown with other integrated surveillance approaches such as the Danish Integrated Antimicrobial Resistance Monitoring Programme [40].

The estimated burden of disease increased from 1609–2756 in 2008 to 1751–2852 DALYs in 2013. The increase of overall burden of disease in Switzerland of 96–142 DALYs from 2008 to 2013 reflects not only an increase in overall incidence of disease, but also a shift in the age structure of cases, with a steady increase of case reports in the elderly aged >65 years, where the *Campylobacter*-associated mortality rate is higher, from 49/100 000 inhabitants in 2004 to 100/100 000 in 2013 [6]. Simultaneously, an increase in chicken meat consumption from 10·88 to 11·42 kg *per capita* has been observed in the country over the same period (Proviande data). Such increase needs to also be interpreted considering that in the period of this analysis there was no direct control interventions implemented in the food chain, and therefore a direct health effect and measurable benefit of surveillance in this time-frame would not

Table 4. *Estimated total DALYs, YLD and YLL associated with campylobacteriosis in Switzerland in 2008 and 2013 in two scenarios of estimated total incidence*

Reported cases		2008 7384	2013 7473
Estimated total cases	BCS	27 906 (27 534– 28 281)	28 442 (28 064– 28 828)
	WCS	75 516 (74 889– 76 137)	76 470 (75 838– 77 090)
Estimated deaths	BCS	50 (37–65)	64 (49–80)
	WCS	49 (36–73)	64 (49–80)
DALY total	BCS	1609 (1330–1947)	1751 (1478–2069)
	WCS	2756 (2412–3140)	2852 (2520–3227)
DALY/case	BCS	0·057	0·061
	WCS	0·036	0·037
DALY/100 000	BCS	20·32	21·98
	WCS	34·59	35·08
YLD	BCS	926 (774–1102)	990 (842–1163)
	WCS	2071 (1844–2335)	2075 (1842–2339)
YLL	BCS	678 (451–970)	757 (540–1031)
	WCS	681 (437–972)	781 (549–1058)

DALY, Disability-adjusted life year; YLD, total years of life lost to disability; YLL, total years of life lost to mortality; BCS, best-case scenario; WCS, worst-case scenario.
The results are expressed in mean and 95% confidence intervals.

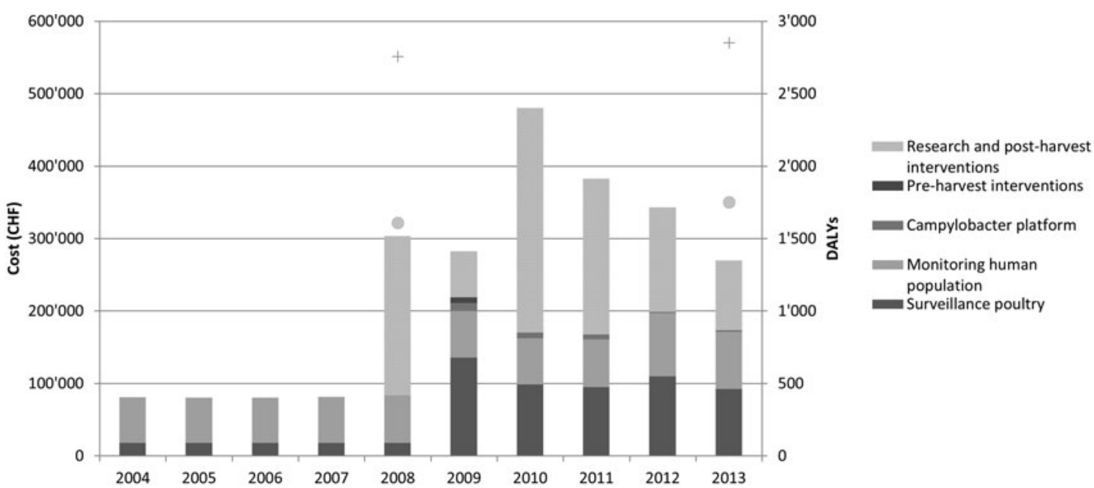

Fig. 3. Costs of *Campylobacter* mitigation activities in Switzerland per activity undertaken, from 2004 to 2013 (CHF) and estimates of overall campylobacteriosis burden of disease (DALYs) for 2008 and 2013 (best- and worst-case scenarios for estimated true incidence).

be expected. Additional economic analysis further in time could allow to understand if measurable benefits were generated by the intervention measures implemented from 2014 described above. Such benefits could be quantified by assessing the effect of the interventions and by comparing it with baseline scenarios as described in studies estimating the cost-effectiveness of interventions targeting *Campylobacter* along the food chain (reviewed in [23]). Increasing the time-frame would allow the capture of possible measurable health effects and the estimation of cost-effectiveness of the One Health approach compared to uni-sectorial approaches.

The break-even point analysis for the One Health approach suggests that a return on investment can be achieved with a small reduction in cases reported. Although this information provides a perspective on how intervention costs can be recouped, it does not provide evidence on how this system compares in terms of costs per DALY avoided with other mitigation system designs. For *Campylobacter* in particular, a reduction in cases does not seem to be easily achievable [41] as shown by the increasing trends on disease incidence until 2012 in most countries facing this challenge. Interventions in the poultry meat production chain, such as biosecurity alone, have limited effect and the most effective interventions such as freezing are costly and face consumer acceptance constraints [41].

Some limitations to our estimates should be considered. The cost analysis and results for marginal cost increase associated with the cross-sectorial mitigation efforts for *Campylobacter* in this study focused on official surveillance programmes and interventions reliant on public spending. Yet, in addition to the official surveillance and control activities, the poultry industry has also been carrying out mitigation activities to tackle *Campylobacter* at *pre*-harvest and *post*-harvest levels. Since our estimates do not account for the costs of such activities, our results are likely an underestimation of the societal efforts in terms of expenditure in *Campylobacter* surveillance and mitigation. In the same way, we did not exhaustively assess all benefit streams potentially linked to surveillance integration. Fluctuations in terms of consumption and production due to trade at the country level and potential alleviation effects on changes in consumer perception and loss of sales could have implications in the overall benefits assessment from a societal perspective. Benefits could therefore also be undervalued in this study.

Our DALY estimates of 21·98–35/100 000 inhabitants in 2013 are in agreement with results recently observed elsewhere in Europe. For other countries, the most recent estimates point to a burden of campylobacteriosis of 19·8 DALYs/100 000 in The Netherlands [33] and of 28·4 DALYs/100 000 in Denmark [28]. However, the burden of disease estimation in this study was limited by the fact that many parameters in the DALY model relied on assumptions and data sourced from literature of studies developed elsewhere. Particularly, the underreporting factor used to estimate the true incidence of *Campylobacter*-associated disease in the human population may be influential. In our estimation, we used a multiplier factor available in the literature for Switzerland [23] as a best-case scenario. That value was calculated using relative risks for Swedish travellers as a proxy for relative incidence in local residents. There are many caveats surrounding such calculations, namely underdiagnoses of travel-related cases, late expression of symptoms and inability to attribute cases to countries, absence of information on the nature and duration of travel and immunity in the resident population [42]. Preferably, the construction of national disease surveillance pyramids should be informed by country-specific information collected as part of multiplier studies [42] and involving data such as care-seeking behaviour, probabilities of stool sample submission, positive laboratory results reporting and testing for a specific pathogen and the sensitivity of the laboratory tests [28]. Since multiplier studies are not available for Switzerland, and the reported factor was inferior to all other recent estimates of multiplier factors in Europe (reviewed in [28]), we also used a multiplier factor calculated for the UK to model a worst-case scenario. Similarly, the use of a multiplier factor from another country can be disputed as differences in healthcare systems may lead to bias [42]. The reliance on scenarios and data sourced from studies conducted elsewhere, suggests that the human case-monitoring system based upon case reporting was not generating sufficient information to be able to determine more accurately the burden of disease in the country. Future burden of disease or cost-of-illness estimations would greatly benefit from information on the parameters that seem impact the model results most, notably human incidence and prevalence data.

Gains in information and knowledge have been recognized as benefits from One Health approaches [43, 44]. However, the lack of ability to measure the final outputs in tangible indicators means that it is infrequent to have such benefits incorporated into economic assessments. The same situation is observable in overall economic assessment of disease control [45]. We believe that to accurately understand the added value of One Health and surveillance integration for decision making, the assessment of these assets needs to be an integral part of the analysis. This is particularly relevant for the surveillance systems that are at a similar maturity stage, i.e. mainly informing assessment and producing knowledge, as the *Campylobacter* mitigation system in Switzerland in the period 2009–2013. Further work on the importance of these intangible assets generated by surveillance integration would enrichen our understanding of the economic aspects of zoonoses surveillance and policy making.

Overall, the framework used as the basis for economic assessment allowed the identification of cross-sectorial cost items and benefits streams, associated with *Campylobacter* in Switzerland in the period in analysis, through the conceptualization of its links to intervention. By providing information on the economics of cross-sectorial surveillance of *Campylobacter* as well as the tools for this assessment, the results of this work can be directly applicable and can inform planning of effective and efficient future surveillance programmes for zoonoses. Such assessments require an understanding of how information generated by surveillance is part of the zoonoses mitigation process, and availability of data on costs of activities conducted and on the impacts of such activities in terms of intangible and tangible benefits. The latter set of benefits can only be accurately assessed if adequate surveillance information allows capturing changes in disease dynamics in the populations.

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DECLARATION OF INTEREST

None.

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