

# Inverse trends of *Campylobacter* and *Salmonella* in Swiss surveillance data, 1988–2013

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Clinical isolates of *Campylobacter* spp. and *Salmonella* spp. are notifiable in Switzerland. In 1995, *Campylobacter* replaced *Salmonella* as the most frequently reported food-borne pathogen. We analysed notification data (1988–2013) for these two bacterial, gastrointestinal pathogens of public health importance in Switzerland. Notification rates were calculated using data for the average resident population. Between 1988 and 2013, notified campylobacteriosis cases doubled from 3,127 to 7,499, while *Salmonella* case notifications decreased, from 4,291 to 1,267. Case notifications for both pathogens peaked during summer months. *Campylobacter* infections showed a distinct winter peak, particularly in the 2011/12, 2012/13 and 2013/14 winter seasons. *Campylobacter* case notifications showed more frequent infection in males than females in all but 20–24 year-olds. Among reported cases, patients' average age increased for campylobacteriosis but not for salmonellosis. The inverse trends observed in case notifications for the two pathogens indicate an increase in campylobacteriosis cases. It appears unlikely that changes in patients' health-seeking or physicians' testing behaviour would affect *Campylobacter* and *Salmonella* case notifications differently. The implementation of legal microbiological criteria for foodstuff was likely an effective means of controlling human salmonellosis. Such criteria should be decreed for *Campylobacter*, creating incentives for producers to lower *Campylobacter* prevalence in poultry.

## Introduction

*Campylobacter* spp. and *Salmonella* spp. are the most frequently reported zoonotic infections in Switzerland. The Federal Office of Public Health (FOPH) monitors communicable diseases in Switzerland. The National Notification System for Infectious Diseases (NNSID) is an integral part of ensuring compliance with this obligation and was implemented nationwide, in a standardised way, in 1987. The regulation on communicable

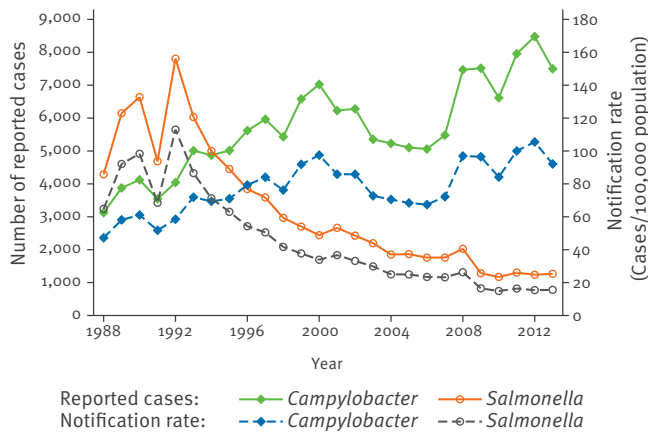
disease notifications determines which diseases have to be reported, by whom and in what timeframe [1]. Among food-borne pathogens, *Campylobacter* spp., *Salmonella* spp., *Listeria* spp., enterohaemorrhagic *Escherichia coli*, *Shigella* spp., and hepatitis A virus are notifiable. Laboratories must report isolates of *Campylobacter* and *Salmonella* within one week of discovery. For patients with suspected bacterial diarrhoea, basic stool culture including *Campylobacter* spp., *Salmonella* spp. and *Shigella* spp. is the routine method of laboratory diagnosis [2].

In humans, campylobacteriosis is most frequently caused by *Campylobacter jejuni* and *C. coli* [3]. Signs and symptoms include watery or bloody diarrhoea, fever, abdominal cramps, vomiting and malaise and usually occur after an incubation period of 2–5 days [4]. The disease usually resolves without antibiotic treatment within one week. A recent study on determinants of the disease in Switzerland showed that laboratory-confirmed campylobacteriosis can lead to severe illness in patients [5]. Complications such as Guillain-Barré syndrome can follow *Campylobacter* infections, although this is rare [4,6]. Fatal cases are possible, but the reported case fatality rate of 0.1% is small and four times lower than the fatality rate for salmonellosis [7].

There are more than 2,600 serovars of *Salmonella*, of which *S. enterica* subspecies *enterica* serovars Enteritidis (*S. Enteritidis*) and Typhimurium (*S. Typhimurium*) are the most frequently reported [8]. Signs and symptoms of salmonellosis are similar to those of campylobacteriosis but the incubation period is shorter at 6–72 hours (usually 12–36 hours) [9]. In a group of volunteers, the minimal infectious dose was found to be at least 200 times higher for *Salmonella* than for *Campylobacter* ( $10^5$ – $10^9$  vs 500 organisms) [10]. However, *Salmonella* outbreaks have been reported

**FIGURE 1**

Number of *Campylobacter* and *Salmonella* case notifications and notification rates registered at the Federal Office of Public Health, Switzerland, 1988–2013



where fewer than 100 organisms had caused disease [11].

In Switzerland, *Campylobacter* replaced *Salmonella* as the most frequent food-borne pathogen isolated from clinical specimens in 1995 [12]. In Europe, predominance of *Campylobacter* has been reported from 2005 onwards [13]. *Campylobacter* notifications were stable in European Union (EU) countries between 2009 and 2013 while *Salmonella* notifications declined. Nonetheless, reported food-borne outbreaks were more often caused by *Salmonella* spp. than by *Campylobacter* spp. (1,168 vs 414 in 2013).

The aim of this study is to describe the epidemiological patterns and trends of *Campylobacter* and *Salmonella* case notifications in Switzerland and to identify factors leading to the inverse trends observed from the NNSID.

## Methods

Medical diagnostic laboratories in Switzerland are obliged by law to report positive *Campylobacter* and *Salmonella* test results to the FOPH and to the cantonal chief medical officer in the patient's canton of residence within one week of discovery [1]. Reports must include information on laboratory diagnosis (test result, interpretation, type of sample, detection method and date), patient data (sex, date of birth and place of residence) and physician- and diagnosing laboratory-related data (name, phone and fax number, and address). The FOPH enters the information into the NNSID database. If the patient's canton of residence is unknown, the canton of the reporting laboratory is entered.

The present study used *Campylobacter* and enteric *Salmonella* case notification data from the present NNSID's first full year of data collection (1988) until the end of 2013. Data on patients residing outside of Switzerland were excluded. If residency was not specified, the record was kept in the analysis. Notification

rates, defined as the number of cases per 100,000 resident population, were calculated. The term 'notification rate' was used instead of 'incidence rate' to be consistent with other authors [13] and because the numbers calculated should not be equated with a true population incidence. To calculate notification rates, data on the average permanent resident population, obtained from the Federal Statistical Office's STAT-TAB database, were used [14]. Data was analysed and graphically represented using the statistical software Stata (Version 13.0).

## Results

### Campylobacteriosis trends

A 2.5-fold increase in the number of reported campylobacteriosis cases, from 3,127 cases in 1988 to 7,499 cases in 2013, was observed (Figure 1).

Case numbers increased steadily from 1988 to 2000, until they reached 7,000. Thereafter, *Campylobacter* case notifications dropped and levelled off at 5,000 cases annually and then rose steadily again from 2007, exceeding the peak level reached in 2000. The highest number of cases reported to date was 8,480 cases in 2012. In each year since 1988, a peak was observed during the summer months (June–August) (Figures 2 and 3).

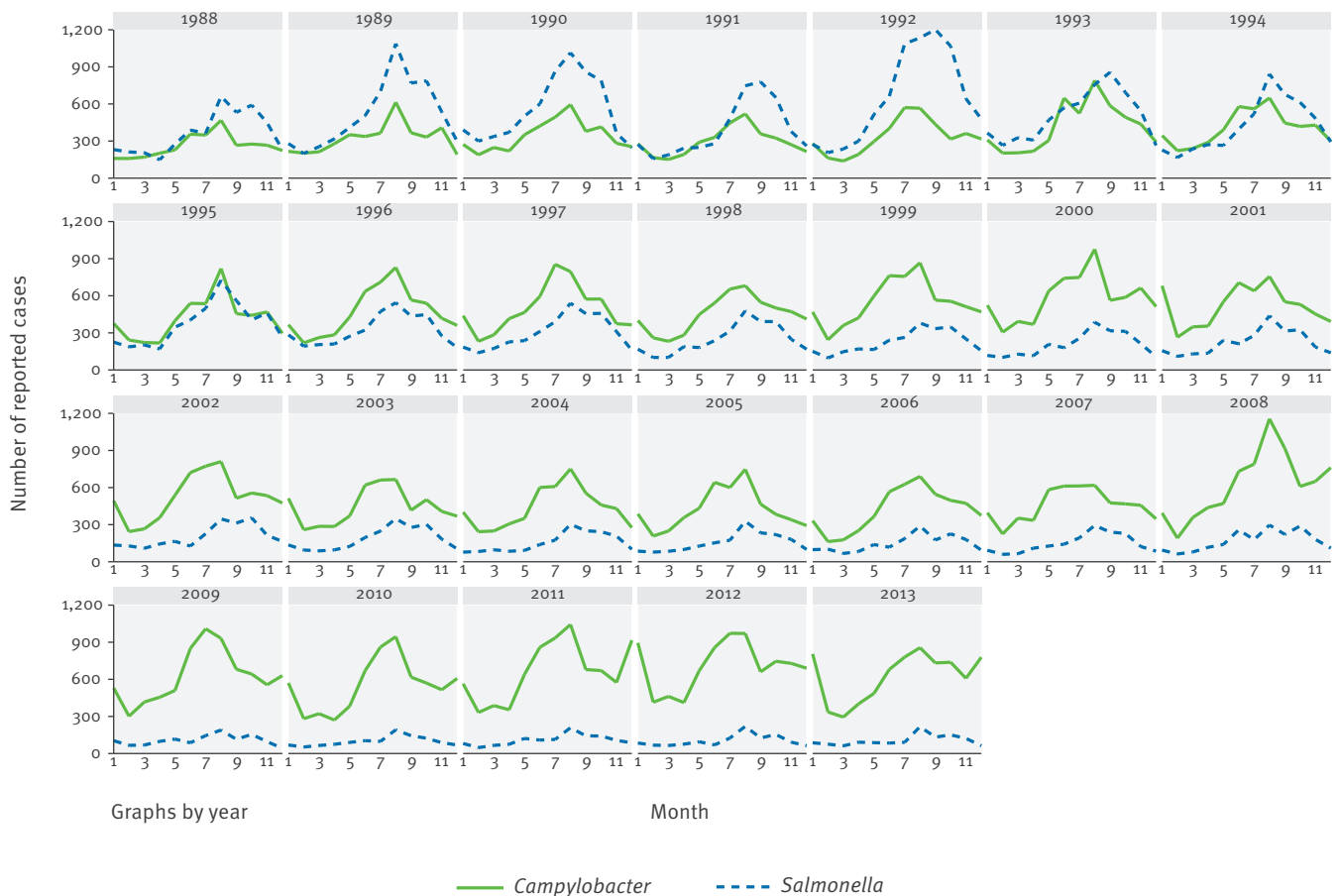
A second, much shorter peak was noted in December and January in all years. This winter peak has been especially pronounced in the past few years. While the highest weekly case numbers during the summer and winter peaks were comparable in 2009 and 2010, weekly case numbers were much higher during the winter peaks of 2011/12, 2012/13 and 2013/14 compared with the preceding summer peaks (Figure 3).

The increase in *Campylobacter* case notification rates differed by age (Figure 4). Among younger age groups, the increase in notification rates over the years was less pronounced than among older age groups. In children younger than five years old, the notification rates decreased from 105.3 to 102.3 cases per 100,000 population between 1988 and 2013 (-3%) (Table 1).

This decrease was statistically significant (permutation test for trend,  $p=0.03$ ). There was no statistically significant (decreasing or increasing) trend in the 5–9 year-olds; in all older age groups, the increasing trend was statistically significant (permutation test for trend,  $p=0.01$  for 20–24 year-olds,  $p<0.01$  for all other age groups). Among those aged 85 years and older, the notification rate increased more than seven-fold, from 11.7 to 92.2 cases per 100,000 population during the same time period. The median age of campylobacteriosis patients increased from 25 years (interquartile range, IQR: 17–38) in 1988 to 39 years (IQR: 23–59) in 2013. In all but the 20–24 year-old age group, notification rates were higher for males than for females (Figure 4). Males accounted for 53.4–57.5% of total case notifications each year.

**FIGURE 2**

Monthly number of notified campylobacteriosis and salmonellosis cases, Switzerland, 1988–2013



*Campylobacter* diagnostics identified *C. jejuni* or *C. coli* in the majority of clinical samples (88.5–96.8% every year; data not shown). For most of the remaining cases, the species was not identified or not reported. Reported sample material came from stool (98.8%), blood or serum (0.4%), and other or unspecified materials (0.8%). The majority of cases were tested using culture-based methods directly or confirmatively after PCR (>97%).

### Salmonellosis trends

Salmonellosis cases reported to the FOPH increased from 4,291 cases in 1988 to 7,806 cases in 1992 (Figure 1). Since 1992, *Salmonella* case notifications steadily decreased until reaching 1,267 cases in 2013. The highest number of *Salmonella* case notifications each year was registered in late summer (July–October), indicating a seasonal pattern (Figures 2 and 3).

Time trends did not differ between sex and age groups (Table 1, Figure 5).

Each year, 49.6–56.2% of reported cases occurred in males. The median age of salmonellosis patients increased from 25 years (IQR: 7–44) in 1988 to 29 years (IQR: 11–56) in 2013. In terms of notification rates, the highest absolute reduction occurred in the youngest

age group (under five years, Figure 5). The reduction was, however, similar for all age groups when looking at percentage decrease (Table 1). The decreasing trend for all age groups from 1988 to 2013 was statistically significant (permutation test for trend,  $p < 0.01$  for all age groups).

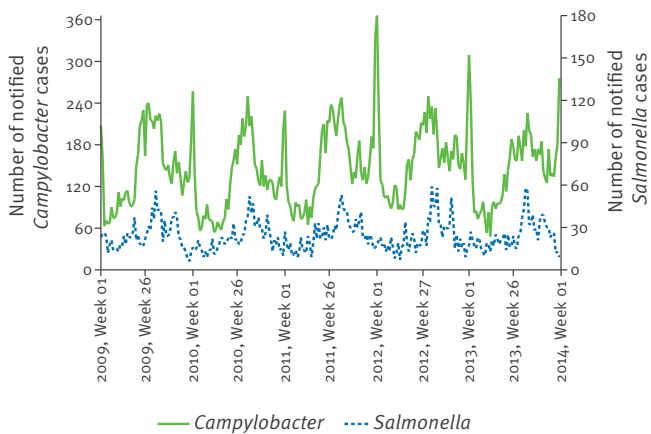
The two most frequently reported serovars were *S. Enteritidis* (54.0%) and *S. Typhimurium* (13.7%). Other reported *S. enterica* serovars included Virchow, Infantis and the monophasic Typhimurium 4,12:i:- (only differentiated in the notification system since 2010).

### Discussion

In Switzerland, there has been a marked increase in *Campylobacter* case notifications since 1988, when surveillance began, while case numbers have decreased for salmonellosis. The number of *Campylobacter* infections nowadays is similar to levels of *Salmonella* 20 years ago. Salmonellosis has reduced considerably since then, due to control programmes targeting poultry production. Campylobacteriosis has also increased throughout the EU, though the numbers seem to have stabilised between 2009 and 2013; for salmonellosis, a decreasing trend continues [13]. Time trends for *Campylobacter* in Switzerland differ between age groups, even when looking at age-group-specific

**FIGURE 3**

Weekly number of notified campylobacteriosis and salmonellosis cases, Switzerland, 2009–2013



notification rates and adjusting for demographic changes in the population.

### True increase in campylobacteriosis frequency

One study from the Netherlands showed that stool-testing frequency increased between 1998 and 2008, which might help to explain the increase in campylobacteriosis cases [15]. Along these lines, the decrease in salmonellosis cases would be even larger in the absence of intensified testing.

It is difficult to interpret the changes in the number of positive test results without knowing more about changes in the number of individuals seeking medical consultations, in the proportion of patients being prescribed stool testing and in the total number of tests performed (positive and negative) in Switzerland. Different factors can influence notification data such as changes in risk factors, in patients' health-seeking behaviour, in physician testing practices, in human susceptibility, or in the virulence or pathogenicity of *Campylobacter* spp. and *Salmonella* spp.

When a patient presents with acute gastroenteritis necessitating further laboratory testing, Swiss physicians most commonly request basic stool bacteriology, which includes testing for *Campylobacter*, *Salmonella* and *Shigella* (data not shown). Therefore, a change in testing frequency without a change in disease epidemiology would most likely lead to a similar change in both *Campylobacter* and *Salmonella* case notifications. Some improvements in stool culture methodology have been made in the past 25 years; however, changes cannot explain the inverse trends observed (personal communication, Roger Stephan, 30 July 2015). Furthermore, negative test results are not notifiable and, hence, the total number of tests (denominator) is unknown. Knowing the denominator would help to confirm or reject the hypothesis that a change in testing frequency does not explain the increase in *Campylobacter* case notifications and would allow for a better interpretation

of the trends observed in the NNSID. Though stool culture methods did not change significantly, the physicians' awareness towards campylobacteriosis is likely to have increased. It is not known to what extent this might have influenced notification data. Changes in patients' health-seeking behaviour are unlikely to influence *Campylobacter* and *Salmonella* case notifications in different ways. Consequently, we assume that the decrease in *Salmonella* case notifications and the increase in *Campylobacter* case notifications represent real epidemiological trends.

The revised Swiss Epidemics Act effective since January 2016, and its allocated ordinances obligates diagnostic laboratories to report annually the total number of positive and negative *Campylobacter* and *Salmonella* tests performed [16]. This innovation will allow basic routine analysis of trends in testing frequency and positivity rates in the future.

### The influence of sex and age on food-borne disease notifications

*Salmonella* case notifications do not differ between sexes, even when stratified by age groups. In contrast, *Campylobacter* case notifications reveal higher notification rates among males in all age groups, except for those in the 20–24 year-old group. Interestingly, studies from Germany and England and Wales also show that females in their twenties are more frequently affected by campylobacteriosis than males, while male cases dominate in all other age groups [17,18]. Schielke et al. [17] suggested that women in this age group are more frequently involved in childcare activities, which might lead to increased human-to-human transmission. They also suggest that women in this age group are more often exposed to potentially contaminated chicken because they prepare and eat chicken more frequently than men of the same age. They may also be in closer contact with pets, which often harbour the same strains as their owners [19]. Different help-seeking behaviour of patients in this age group or different testing practices of physicians could also explain variations. Moreover, it seems likely that genetic or hormonal factors lead to differences by sex, as notification rates in males and females differ already in the youngest age group (under five years) (Figure 4) [20]. We assume that in the youngest age group, health-seeking behaviour and eating habits are not yet dependent on sex and are rather driven by parents or other persons engaged in childcare.

Available information from England and Wales also shows that adults, including the elderly, increasingly test positive for *Campylobacter* [18]. It has been suggested that the increasing use of proton pump inhibitors (PPIs) might explain a part of this phenomenon, especially among the elderly. Several studies have found that the use of PPIs is a risk factor for infection with *Campylobacter* and other enteric pathogens [21]. However, one study revealed that patients prescribed PPIs were already at increased risk of gastrointestinal

**FIGURE 4**

Trends in *Campylobacter* notification rates between age groups and sexes, Switzerland, 1988–2013



infection, even before prescription of these drugs [22]. In any case, conditions leading to PPI use or prescription are likely associated with acute infectious gastroenteritis. Why the aforementioned risk factor would only influence the frequency of *Campylobacter* but not *Salmonella* case notifications remains unknown. One possible explanation is that the infective dose of *Campylobacter* is generally lower than that of enteric *Salmonellae*. A recent study of poultry consumers' behaviour, risk perception and knowledge related to campylobacteriosis and domestic food safety showed that unsafe cooks were more likely to be male and of younger age [23]. Even though this finding is consistent with high *Campylobacter* notification rates observed among young adults, it does not explain the increasing rates among the elderly.

### Food safety regulations

*Campylobacter* and *Salmonella* infections are assumed to be mainly food-borne. Genotyping and epidemiological studies in Switzerland have shown that chicken meat is the most likely source of infection in the majority of human campylobacteriosis cases [5,24–26]. In concert with these findings, a recent time-series analysis showed a significant association between *Campylobacter* prevalence in broiler chickens and human illness [27]. In Switzerland, poultry consumption

has increased in the past 25 years. While the average per capita consumption was 7.8 kg in 1988, it was 11.4 kg in 2013 [28,29].

Eggs and egg-containing products were shown to be risk factors for salmonellosis in Switzerland in 1993 [30]. The legislating authorities addressed the risk of these food-borne pathogens by setting and enforcing microbiological criteria.

As early as 1969, an official method to detect enteric *Salmonella* in foods was published in the Swiss Food Manual [31]. Also, guidance levels for *Salmonella* in different food categories were given.

In 1981, legal microbiological criteria for foods were decreed for the first time in a Federal Ordinance [32]. Criteria for *Salmonella* were as follows. For baby foods and diet products: not detectable (nd) in 50 g; drinking water: nd in 5 l; other products: nd in 20 g. For 'other products', authorities could refrain from measures if the product in question had to undergo treatment (e.g. cooking) prior to consumption. In 1995, after a revision of the ordinance, criteria for *Salmonella* were set at as follows. For baby foods: nd in 50 g; drinking water: nd in 5 l; ready-to-eat foods: nd in 25 g; and spices: nd in 25 g [33]. In 2005, Swiss food legislation adopted

**FIGURE 5**

Trends in *Salmonella* notification rates between age groups and sexes, Switzerland 1988–2013



the European Union’s microbiological criteria for *Salmonella* in food [34].

*Salmonella* limits for some categories of raw meat were issued as the national law adapted to EU hygiene regulations in 2006 [35]. To combat the epidemic with *S. Enteritidis* in eggs, mandatory screening of layer hens and measures to eradicate positive flocks were decreed by the Ordinance for the Control and Eradication of Epizootic Diseases as early as 1993 [36]. Apart from a ban on battery-caged chicken rearing (in effect since 1992 [37]), no further measures (such as vaccinations of layer hens against *S. Enteritidis*) are implemented in Switzerland.

As early as 1987, a limit for *Campylobacter* was decreed in the Ordinance on Hygiene, which was ‘not detectable in 10 g of ready-to-eat foods’ (later, not detectable in 25 g) after enrichment. This microbiological criterion was abrogated in 2006. To address the risk of *Campylobacter* in connection with poultry liver, since 2014 the Ordinance has stipulated that poultry liver must be sold frozen if it cannot be shown that the product comes from a *Campylobacter*-free flock [35]. Furthermore, a process hygiene criterion to minimise *Campylobacter* in poultry slaughterhouses is underway and should enter into force in 2016. However, criteria

for *Campylobacter* on raw poultry meat are not currently being considered.

### Relevant epidemiological studies in Switzerland

In 2013, 37.7% (169/448) of broiler flocks and 65% (226/348) of rectum-anal swab samples taken from pigs at slaughter tested positive for *Campylobacter* [38]. In the same year, only 1% of 3,636 samples of fresh poultry meat, poultry meat preparations and poultry meat products at different stages of processing tested positive for *Salmonella*. Twenty-three years prior, *Salmonella* contamination levels in Switzerland were much higher. In a 1990 study, 19.2% of chicken neck skin lobes and 47.7% of broiler flocks were found to be *Salmonella*-positive [39]. As a consequence, *Salmonella* control measures as described above were implemented in the 1990s and led to a significant reduction in the number of human cases reported.

In Switzerland, salmonellosis and campylobacteriosis case curves crossed in 1995; in Austria, it was in 2006 [40]. The reason for this striking difference might be that Switzerland addressed the epidemic of *S. Enteritidis* in eggs at a very early stage.

The reduction of domestic salmonellosis cases resulted in a higher prominence of travel-associated

**TABLE**

Comparison of notification rates for *Campylobacter* and *Salmonella* among different age groups, Switzerland, 1988 and 2013

Age group	<i>Campylobacter</i>			<i>Salmonella</i>		
	Notification rate		% increase	Notification rate		% increase
	1988	2013		1988	2013	
<5	105.3	102.3	-3%	216.1	51.5	-76%
5-9	49.9	62.9	+26%	85.1	23.4	-73%
10-14	29.7	58.1	+96%	59.1	15.1	-74%
15-19	54.7	108.1	+98%	63.4	18.1	-71%
20-24	97.4	160.7	+65%	68.1	25.3	-63%
25-44	49.2	91.2	+85%	51.6	10.6	-79%
45-64	24.4	78.3	+221%	41.1	10.9	-73%
65-84	19.2	100.1	+421%	38.6	15.1	-61%
85+	11.7	92.2	+688%	62.7	9.3	-85%

transmission risks in relative terms, which was shown by Schmid and Baumgartner: the (relative) proportion of travel-associated *S. Enteritidis* cases increased substantially from 20% in 1993 to 45% in 2011/12 [41]. Two case-control studies on campylobacteriosis [5,26] and a case-control study on salmonellosis [30] conducted in Switzerland identified travel abroad as a risk factor for the diseases. However, this finding has to be interpreted with care, as patients with travel history are more likely to be tested (data not shown) and all studies recruited laboratory-confirmed cases.

The observed winter peak in *Campylobacter* infections can be attributed partly to the traditional consumption of meat fondue over Christmas and New Year [5]. However, it is not known why this winter peak has been more pronounced in the past few years. Given the increasing per capita consumption of poultry meat [28,29], one could hypothesise that poultry has become more popular in meat fondues.

Outbreaks due to *Campylobacter* or *Salmonella* also occurred in Switzerland. However, the number of food-borne outbreaks decreased significantly between 1993 and 2010, mainly due to the reduction of salmonellosis [12]. The number of registered *Salmonella* outbreaks dropped from 27 in 1993 to one in 2010 while the number of *Campylobacter* outbreaks varied between none and five throughout this time period. In relation to the number of cases, *Salmonella* is causing more outbreaks than *Campylobacter* both in Europe and in Switzerland.

### Public awareness and knowledge about the diseases

Public awareness and people's knowledge of *Campylobacter* and *Salmonella* in Switzerland are as different as the trends observed in the two pathogens in the NNSID. In 2011, a consumer survey showed that 76% of participants were 'very concerned' or 'somewhat concerned' about *Salmonella* in foods [42]. Only

1% of respondents stated that they had not heard of the *Salmonella* bacterium. In contrast, only 33% were 'very concerned' or 'somewhat concerned' about *Campylobacter* and more than half (52%) had not heard of the pathogen. Unpublished data from a recent case-control study in Switzerland [5] confirm those figures: 55% of people infected with campylobacteriosis (cases) and 68% of healthy people (population-based controls) had never heard of *Campylobacter*, while only 2% of cases and 3% of controls had never heard of *Salmonella*.

The lack of knowledge about safe food handling and avoidance of cross-contamination, and low personal risk perception are the main reasons for unsafe food handling [23,43]. The high prevalence of *Campylobacter* in chicken products, the low infective dose of *Campylobacter* and the increasing consumption of chicken meat combined with the apparent lack of knowledge about the *Campylobacter*-pathogen are all factors facilitating infection.

### Conclusions

*Campylobacter* spp. infections are a serious and increasing public health concern in Switzerland. For *Salmonella* spp. infections, an epidemiological turnaround has been achieved through concerted efforts and legal regulations of the poultry- and food-production industries, but little has been done to date to prevent *Campylobacter* infections on a large scale. Food safety interventions before the sale of poultry meat are urgently required to reduce *Campylobacter* contamination frequencies. Since the number of control options is limited, the hygienic treatment of chicken carcasses with chemicals, for example peracetic acid, should not be excluded from discussion [44]. However, the population's limited awareness of *Campylobacter* must also be addressed. It seems reasonable to believe that the same type of behaviour changes that reduced *Salmonella* infections can be applied to prevent *Campylobacter* infections and that caution can be extended from eggs to raw poultry meat, cutting boards and knives.

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### Conflict of interests

The authors declare that they have no conflict of interest.

## Authors' contributions

DM and MM conceived the idea of and designed the study with CS; MJ provided the data; CS and DM analysed the data and CS wrote the first draft; MJ, AB, MM and DM contributed to the interpretation of the data, writing and reviewing of the manuscript.

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