Campylobacter in Switzerland

Risk factors and measures for dealing with the problem

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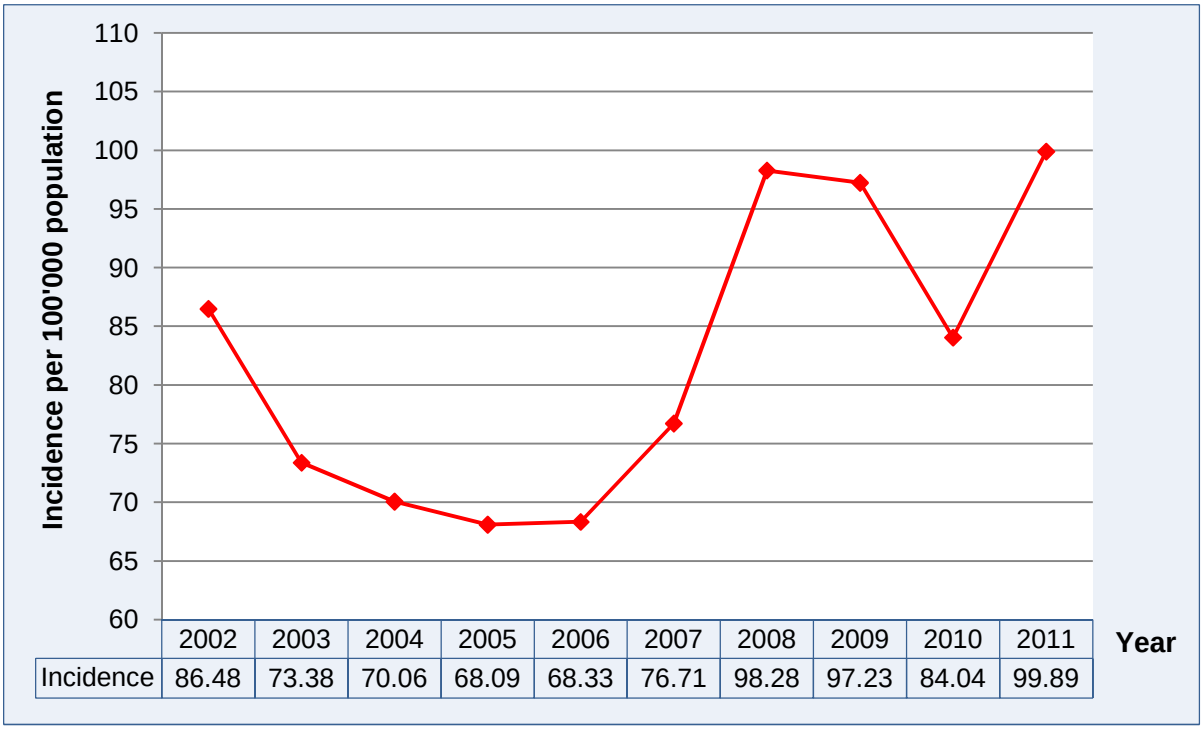
1 Introduction

1.1 Epidemiological Situation

Since a **mandatory notification** was introduced in 1988, all laboratory-confirmations of *Campylobacter* in stool samples of patients have to be notified to the Federal Office of Public Health (FOPH) [74]. The number of cases reported to the FOPH as well as the notification rate are published weekly in the FOPH Bulletin (www.bag.admin.ch/dokumentation/publikationen/01435/11505/index.html?lang=de).

In Figure 1 is shown an overview of the development of the annual **incidence** for the ten-year period 2002 to 2012.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Incidence	86.48	73.38	70.06	68.09	68.33	76.71	98.28	97.23	84.04	99.89

Fig. 1: Laboratory confirmed cases of *Campylobacter* 2002-2011; annualised incidence per 100'000 population. (source: FOPH; http://www.bag.admin.ch/k_m_meldesystem/00733/00813/index.html?lang=de)

The incidence of infections with *Campylobacter* fell significantly between 2002 and 2005, but again rose in the following years. After a striking increase of about 30% from 2007 to 2008 the number of cases again reached about the level of 2000. The incidence decreased slightly in 2009 and in 2010 also fell and even quite significantly. However, in 2011 the trend again reversed and the highest incidence of campylobacteriosis was reported since the introduction of the obligation to notify. This increase also continued in 2012.

With the exception of *Campylobacter,* the long term trend for the foodborne infections reported in the notification system (namely Salmonellae, Shigellae, Listeria, *E. coli* (EHEC) and Hepatitis A) is decreasing. Salmonellosis cases, in particular, have continually decreased since 1993 (Figure 2); this is principally due to the programme for combatting *Salmonella* Enteritidis in fresh eggs. Contributions to the improvement of the situation have also been achieved *inter alia* from the sanitisation of feed products and from technical improvements in the slaughter of broiler chicken.

In contrast, the trend curve of the campylobacteriosis cases is completely different, in that instead of a decline, a steady increase of the cases is observed, corresponding to the image of a **slowly building up epidemic.** In the 1990s *Campylobacter* had already superseded the Salmonellae as the number 1 foodborne infectious agent (Figure 2):

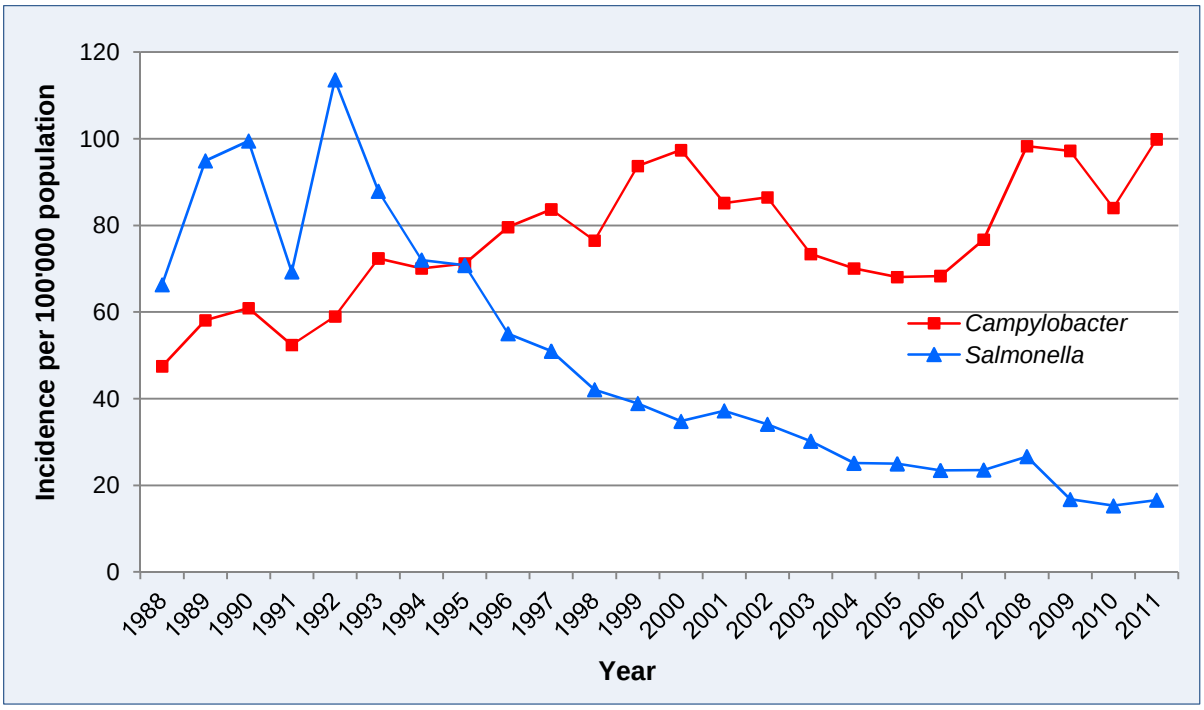


Fig. 2: Comparison of the incidence of salmonellosis und campylobacteriosis in Switzerland, 1988 - 2011 reported to the notification system; annualised incidence per 100'000 population (source: FOPH)

The significance of *Campylobacter* as a zoonotic agent in Switzerland is in line with the overall European situation: in Europe, *Campylobacter* is presently the most frequent bacterial cause of gastroenteritis in humans [34].

The notification rate of *Campylobacter* in humans annually follows a **characteristic seasonality** (Figure 3): besides a pronounced, general rise in the summer months (blue arrows), another smaller rise is observed around the turn of the year (red arrows). Experts claim that this peak in the winter months correlates with the consumption of meals such as Chinese fondue, a meal that is much appreciated in Switzerland principally around the period of the Christmas holidays. Outbreaks with *Campylobacter jejuni* in connection with Chinese fondue have already been consistently described in Switzerland [69].

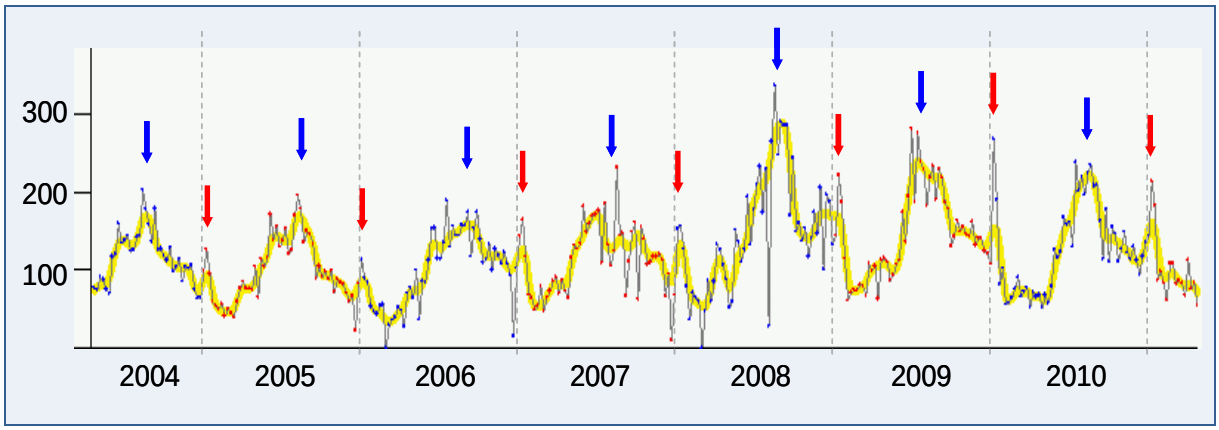


Fig. 3: Graphical representation of the weekly notification rate for campylobacteriosis (May 2004 to May 2011 (FOPH; http://www.bag.admin.ch/k_m_meldesystem)

This **"Chinese fondue peak"** was particularly pronounced around the turn of the year 2011/2012 (Figure 4), however, the cause of this is unknown:

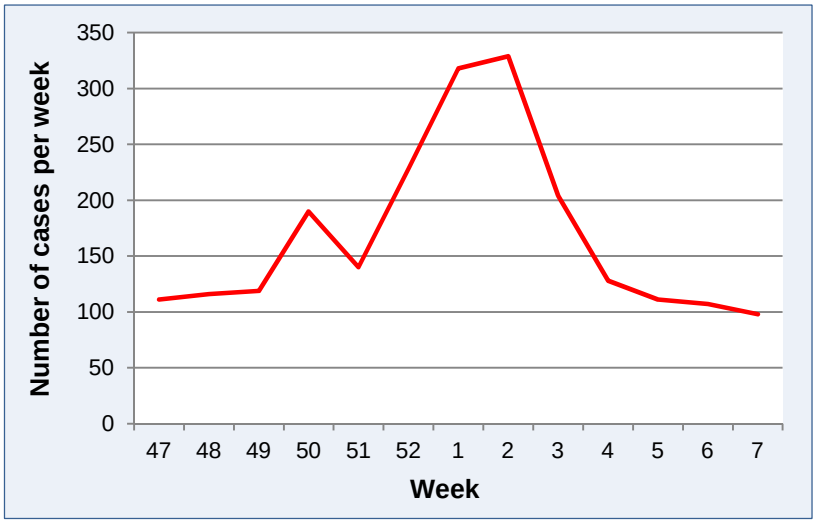


Fig. 4: weekly cases of campylobacteriosis in Switzerland reported to the notification system, turn of the year 2011/2012. (source: FOPH-Bulletin; http://www.bag.admin.ch/dokumentation/publikationen/01435/11505/index.html?lang=de)

In Switzerland, the **age groups** corresponding to adolescents and young adults as well as small children, are disproportionately affected by campylobacteriosis (Figure 5). Dietary behaviour is primarily regarded as the cause of the above average notification rate for the young adult age group. Why the notification rate is so high for small children is unknown, however, the significantly lower infection dose compared with that for adults [84] may contribute to this.

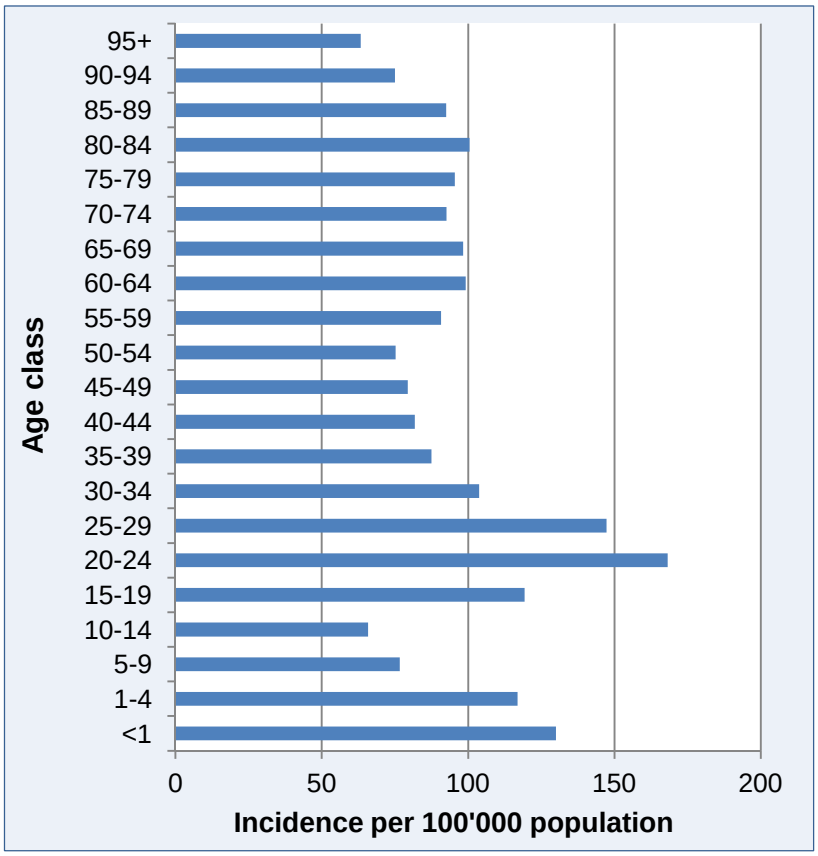


Fig. 5: The age distribution of the notification rate for human campylobacteriosis in 2011 (source: FOPH; http://www.bag.admin.ch/k_m_meldesystem)

In humans, the commonest ***Campylobacter species*** detected in Switzerland is *C. jejuni.* In 2009, 87% of the laboratory detections concerned this species (51.5% *C. jejuni* alone, 35.5% combined with *C. coli*), *C. coli* was detected in 38.2% of the samples (2.7% *C. coli* alone, 35.5% combined with *C. jejuni*) (Swiss Zoonoses report 2009 [12]). In contrast, other species, such as *C. lari*, *C. fetus* and *C. upsaliensis*, hardly play any role in the epidemiological events.

1.2 *Campylobacter* Platform

With the significant increase, especially in 2007 and 2008, the public health authorities considered that the number of *Campylobacter* infections had reached an unacceptably high level. Accordingly, the **"*Campylobacter* Platform"** was founded in December 2008 under the aegis of the Federal Veterinary Office (FVO) in order to coordinate the activities of various stakeholders in relation to the *Campylobacter* problem. The participants in the platform come from the responsible federal authorities, cantonal agencies, interest groups from agriculture, from production and processing, sales organisations, science etc.

The aim of the platform was defined beforehand by the FOPH and FVO together: the *Campylobacter* Platform should deliver a contribution to the stabilisation and reduction of the frequency of occurrence of campylobacteriosis in humans in Switzerland. In order to achieve this aim, the platform should provide the following services:

Tasks of the *Campylobacter* Platform:

- Information exchange between public authorities, experts and producers.
- Coordination of measures for risk assessment and risk management.
- Initialisation of research projects to fill knowledge gaps.

In this regard, the platform itself has an advisory function and only a very limited power of decision. The responsible public authorities, i.e. the FOPH and the FVO, are responsible for deciding on regulatory or non-regulatory measures. Three working groups were created in the context of the Campylobacter Platform:

Working groups of the Campylobacter Platform:

- The working group ***Risk factors*** should highlight the significance of individual transmission pathways of the infection;
- The working group ***Production*** focuses on possible control measures at all stages of fattening, slaughter and processing;
- The working group ***Disease Awareness*** seeks to identify opportunities for improving the level of knowledge along the total food chain from the producers to the consumers.

The platform is accompanied by an **internal working group *Roadmap*** from both Federal Offices, FOPH and FVO, with the participation of the Federal Food Chain Unit (FFCU). This working group drew up a roadmap that describes an action plan, in which the protection objectives to be achieved are defined and activities, milestones and measures are mapped out. The document is constantly updated.

1.3 Protection objectives

Given the growing importance for public health, the responsible Federal Offices FOPH and FVO have decided to deliberately tackle the *Campylobacter* problem. The following protection objectives were already defined in mid-2009:

Protection objective "Minus 2'500":

Medium term reversal of the epidemiological trend and to regain by the end of 2013 the comparable low level of campylobacteriosis in humans of 2005/2006 (i.e. slightly above 5'000 cases per year).

Translated into a mathematical model from the perspective of human epidemiology, this means, on an annual average basis, that there are less than 30 days per year when more than 30 laboratory notifications of campylobacteriosis in humans are reported to the FOPH notification system („30 / 30 vision“).

In order to achieve the stated protection objectives, the Federal authorities shall decide on suitable measures to minimise the risks. A risk assessment based on scientific facts should form the basis for these risk management measures.

2 Risk Assessment

2.1 Overview of the risk factors

The FOPH, motivated by an increase in campylobacteriosis cases, carried out a case control study already in the first half of the 1990s to determine possible risk factors [70]. In this regard, the consumption of chicken liver and chicken meat was flagged as an alimentary risk factor. Since then a great many comparable studies have been carried out throughout the world; all studies have corroborated the central role of poultry meat in the transmission of *Campylobacter* to humans (for an overview see for example [20]). A scientific opinion of the European Food Safety Authority (EFSA) concluded that ca. 50 – 80% of the human campylobacteriosis cases were traced back to the chicken reservoir [31].

Campylobacter are relatively fragile and oxygen-sensitive pathogens, that have only a limited survivability in the environment. *Campylobacter,* contrary to Salmonellae*,* cannot proliferate in foods and is partially killed off in deep-freeze conditions. The pathogen offsets this disadvantage, however, with a low average infection dose that is in the range of 500 pathogens. These characteristics of *Campylobacter* presuppose that the alimentary transmission of this pathogenic germ from the chicken reservoir to humans must occur relatively directly, either by consuming contaminated food of animal origin or from cross-contamination due to unhygienic handling.

The Swiss study, published in 1994, identified foreign travel as a further significant risk factor for a *Campylobacter* infection. Faecally contaminated drinking water likewise represents a potential source of infection, particularly during outbreaks. However, based on the high microbiological quality standard of drinking water in Switzerland, epidemiologically it is attributed only a marginal role, as with raw milk, in regard to sporadic cases. Infected domestic animals have also been cited as an additional source of infection.

The risk factors poultry meat, poultry liver, foreign travel, drinking water and contact with domestic animals will be highlighted and commented in more detail from the Swiss perspective in the following.

2.2 Poultry meat

Poultry meat is strongly contaminated with *Campylobacter* throughout the world, as has been proven in numerous studies over the last few years [82]. The infection rate of the chicken flocks with *Campylobacter* varies from country to country, as was also stated in a wide-ranging European baseline study [32].

Poultry meat is considered to play an important part in the direct or indirect transmission of *Campylobacter* [20]. This is because when slaughtered the carcasses are frequently contaminated with intestinal contents. In this way the surface of carcasses can be contaminated with *Campylobacter* that under certain circumstances can survive until sold. This is much more common for poultry than for slaughtered mammals: Due to the slaughtering process and the processing and storage techniques, there is a significantly lower probability for red meat (beef, mutton, pork) to be contaminated with *Campylobacter* [31].

Accordingly, the consumers are exposed to *Campylobacter* when poultry meat is not hygienically handled: Transmission can occur by direct contact from hand to mouth, by cross-contamination from raw meat to ready-to-eat foods or by inadequate heating [28]. The EFSA estimates that in Europe 20 to 30% of the campylobacteriosis cases could be traced back to handling, preparation and consumption of broiler chicken meat, 50 – 80% of the cases in all should be attributed to the chicken reservoir as a whole [31].

In this regard, cross contamination and the transmission from hand to mouth appear to have a greater impact than the consumption of insufficiently cooked chicken meat [28; 51].

It is undisputed and proven by numerous publications throughout the world that cases of illness in humans are caused by the presence of *Campylobacter* on poultry meat [20]. In Switzerland 15 years ago, a connection was shown for the first time by the abovementioned case-control study [70]. In the period 1994 to 2006, the FOPH received notification of 137 outbreaks, in which epidemiological evidence and/or pathogen identification indicated an involvement of foods. *Campylobacter* was involved in 23 (16.8%) of these notified outbreaks [3].

Contamination of poultry meat with *Campylobacter* on the Swiss market

The question of the degree of contamination of poultry meat at the point of sale in Switzerland is highly relevant to consumer protection. A study to determine this was coordinated and evaluated by the FOPH in collaboration with 15 official laboratories (14 cantonal laboratories and the laboratory of the Principality of Liechtenstein) over the period from April 2009 to April 2010; in all a total of 1'132 samples from the market were tested for the presence of *Campylobacter* [4]. The study was carried out over a year in order to be able to take into account the seasonally different frequencies of the presence of the pathogen. The samples were analysed by qualitative (enrichment) and quantitative (plating) ISO standard methods. The sampling plan was designed so as to reflect as far as possible the market shares of the largest Swiss wholesalers as well as the shares of imported and domestic products. The tested meat types were fresh meat with and without skin as well as meat preparations, all in both chilled as well as deep-frozen form.

38.4% (435 samples) of the 1'132 tested samples proved to be *Campylobacter* positive, wherein overall, domestic meat with 45.4% was more often contaminated than imports with 30.6% (Figure 6):

Type and origin		Sample size	Campy +	
Fresh meat with skin				
- chilled	- Switzerland	160	97	(60.6%)
	- Imported	30	15	(50.0%)
- deep-frozen	- Switzerland	117	40	(34.2%)
	- Imported	76	21	(27.6%)
		383	173	(45.2%)
Fresh meat without skin				
- chilled	- Switzerland	125	66	(52.8%)
	- Imported	145	77	(53.1%)
- deep-frozen	- Switzerland	46	15	(32.6%)
	- Imported	119	18	(15.1%)
		435	176	(40.5%)
Meat preparations				
- chilled	- Switzerland	99	48	(48.5%)
	- Imported	57	29	(50.9%)
- deep-frozen	- Switzerland	52	6	(11.5%)
	- Imported	106	3	(2.8%)
		314	86	(27.4%)

Fig. 6: Frequency of occurrence of *Campylobacter* spp. in market samples from sales departments [4]

In addition to the origin of the meat, the type of processing and chilling had an influence on the presence of *Campylobacter*: removal of the skin reduced the frequency of the presence, as *Campylobacter* was significantly more prevalent on chickens with skin than on samples without skin; even fewer germs were found in meat preparations. In all three sample categories that were tested, it was also clear that deep-freezing reduces *Campylobacter,* this effect being particularly pronounced with meat preparations. For meat preparations, still other factors in addition to freezing might have contributed to

the reduction, e.g. a longer exposure to oxygen during processing or a lower pH due to added marinades [8]. The findings of the study certainly confirm the known fragility of *Campylobacter* towards environmental influences.

The contamination rates among the sampled wholesalers varied considerably. One wholesaler had higher contamination rates than its competitors for several products. The poor results of this wholesaler (named A in Figure 7) stood out, in particular with a contamination rate of 90.0% for the category of domestic fresh chilled meat with skin.

Wholesaler	Sample size	Campy +
A	11	90.0 %
B	14	78.6 %
C	44	59.1 %
D	19	53.1 %

Fig. 7: *Campylobacter* spp. contamination frequencies in poultry meat from various suppliers of domestic fresh chilled meat with skin [4]

A comparison of the most highly contaminated samples with bacterial counts > 500 colony forming units (cfu) per gram, in total 15 samples, supports this finding: whereas such high bacterial counts were detected only twice in 44 samples (4.5%) from wholesaler C, this was the case for 4 out of 11 samples (36.4%) from wholesaler A. This result suggests that the listed wholesalers obtain their goods from different sources, and that there are differences from a hygienic standpoint at the slaughter and processing steps for broiler chickens. The Federal Veterinary Office (FVO) made similar observations in the context of a monitoring program, in which samples were taken from various Swiss slaughterhouses: Significant differences between the examined slaughterhouses were also found [15]. Moreover, differences in the frequency and level of contamination were already found in the herds taken to slaughter.

Of the 435 positive samples, *Campylobacter* could be detected in 315 (27.8%) samples only with the qualitative method. The qualitative method is very sensitive, as 25 gram samples are enriched in a selective broth. This result signifies that a considerable number of the positive samples were only weakly contaminated. In contrast, quantification was possible for 120 (10.6%) of the samples (Figure 8):

Findings	**chilled** (N_1=616)		**frozen** (N_2=516)		**total** (N=1132)	
[cfu/gram]	**number**	%	**number**	%	**number**	%
***Campylobacter* negative** (qualitative/quantitative)	284	46.1%	413	80.0%	697	61.6%
***Campylobacter* positive**						
x < 10 *	222	36.0%	93	18.0%	315	27.8%
10 ≤ x < 100	68	11.0%	9	1.8%	77	6.8%
100 ≤ x < 1'000	32	5.2%	1	0.2%	33	2.9%
1'000 ≤ x	10	1.7%	0	0.0%	10	0.9%
	332	53.9%	103	20.0%	435	38.4%

Fig. 8: Quantitative determination of the bacterial count of *Campylobacter* spp. in 1132 samples of poultry meat (*detection limit of the quantitative method) [4]

Between 100 and 1’000 cfu per gram were detectable in 2.9% of the samples, 0.9% were above 1’000 cfu per gram. Very high bacterial counts were found exclusively in fresh meat with skin (Figure 9):

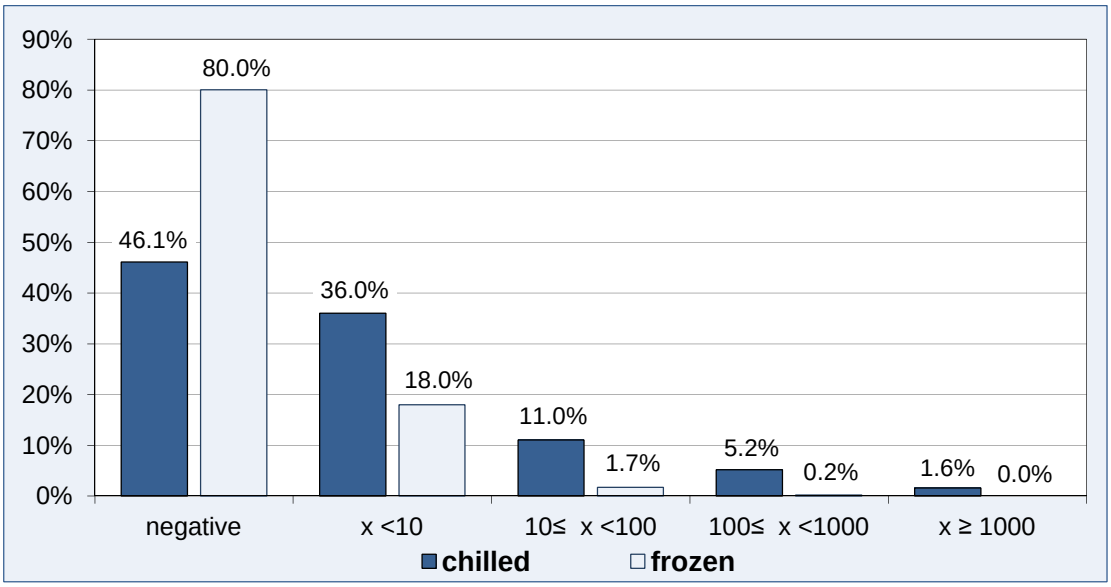


Fig. 9: Quantitative distribution of the bacterial counts (cfu/gram) of *Campylobacter* spp. in chilled and frozen chicken meat for sale [4]

Although the fraction of highly contaminated products is in the low percentage range, these findings are significant when one considers the high annual tonnages of converted meat: According to the inter-trade organisation Proviande, 11.43 kilograms of poultry meat were consumed per head in Switzerland in 2011, corresponding to a total turnover of ca. 91'700 tons [62]. Consequently, consumers are significantly exposed to *Campylobacter.* The Swiss Health Authorities were confronted at one time with comparable figures in the context of the epidemic with *Salmonella* Enteritidis and eggs. Although the frequency of contaminated eggs on the market was low, there resulted a pronounced epidemiological impact on public health, due to the high annual number of shell eggs consumed.

Relationships between the consumption of poultry meat and campylobacteriosis

In the light of these findings, the question arises of whether there is a relationship between the consumption of poultry meat and the number of cases of campylobacteriosis in humans. In fact, the consumption of poultry meat in Switzerland in the last two decades, just as the notification rate of campylobacteriosis, has significantly increased (Figure 10):

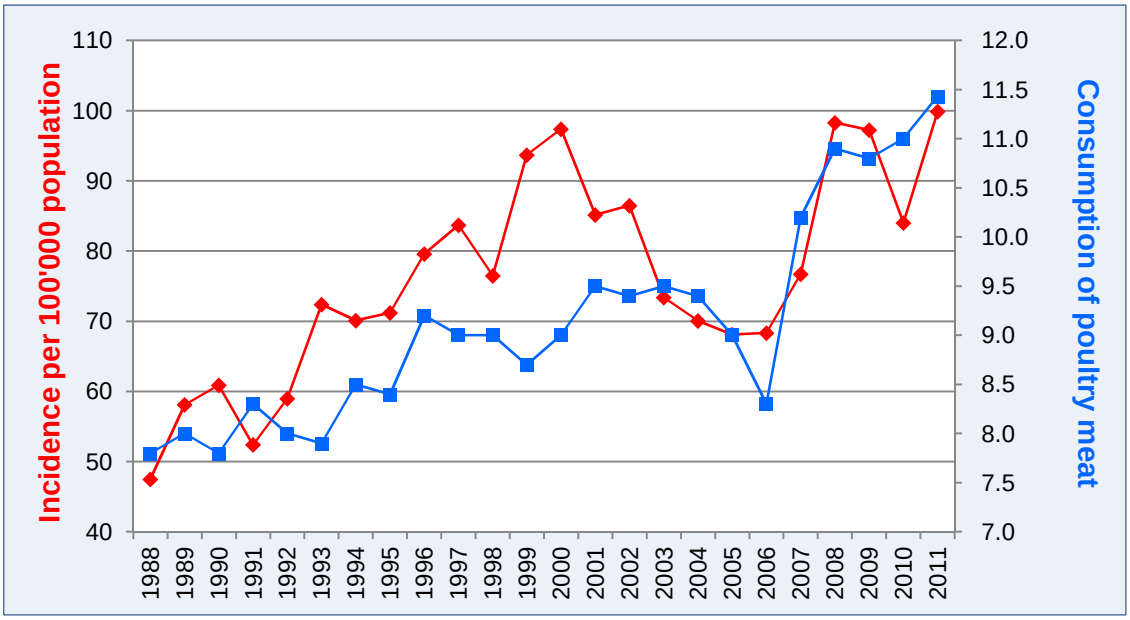


Fig. 10: Consumption of poultry meat (in kg per head and per year) and the incidence of human campylobacteriosis cases (per 100'000 population) in Switzerland from 1988 to 2011 (source: Poultry meat consumption 1988-2009 [47] and 2010-2011 [62]; Incidence: FOPH)

The increase in the per capita consumption of poultry meat and the increase in the number of human campylobacteriosis cases in Switzerland, although not exactly parallel, exhibit, however, the same overall development tendency. It should be noted that during the same period the per capita consumption of other types of meat, beef, veal and pork, has continuously and clearly declined (Figure 11):

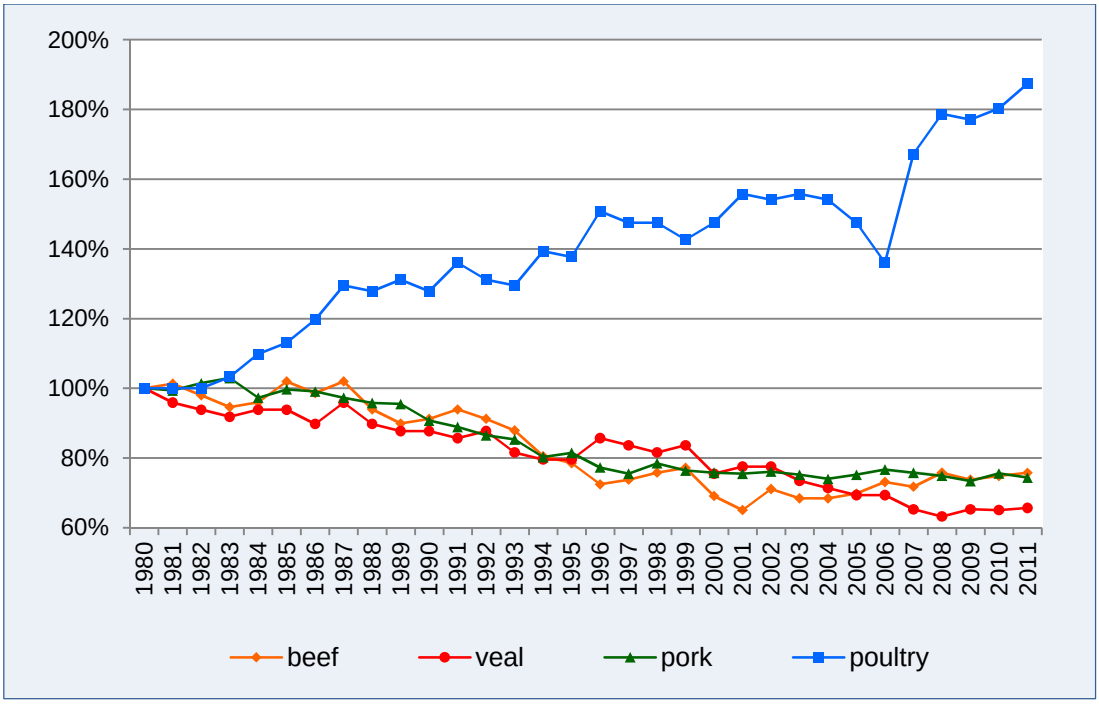


Fig. 11: Trends in the per capita consumption of various types of meat 1980 to 2010; the value for 1980 was taken as 100% in each case (source: consumption 1980-2009 [47] and 2010-2011 [62];)

The interim decline of about 17% in the per capita consumption of poultry meat in the years 2005 and 2006 compared to the year 2004 is striking, and coincides – at least partially – with a decline in the human cases in 2003 – 2006. A study on the behaviour of Italian consumers [7] concluded that a decline of about 20% in the sales of fresh poultry meat over the same period in Italy was attributable to the media coverage of “bird flu” (Influenza A-Virus H5N1). The decline in consumption of poultry meat in Switzerland in the same period could therefore likewise be attributed to an aversion of consumers against this type of meat as a result of the media coverage of the “Bird flu” topic.

In various situations, it was also observed in other countries that a reduction in consumption of poultry meat had a favourable impact on the progression of the number of campylobacteriosis cases:

- An outbreak of avian influenza in the Netherlands from March to May 2003 entailed for example the cull of 1’300 commercial and over 17’000 non-commercial flocks of laying hens and broiler chickens. In total, more than 30 million animals were culled [78]. In the same period on the one hand the national average of the incidence of human campylobacteriosis regressed by around 30% and on the other hand the sales of chicken meat regressed by up to 9%. Both the decline in the incidence (44-50%) as well as the sales quantities of broiler chicken meat (up to 12%) were the greatest in the regions of the country which were afflicted by the cull [40].
- In Belgium, already in 1999 there was a massive recall of eggs and chicken meat after a scandal with dioxin-containing feedstuffs. This market intervention resulted in a decline of the number of campylobacteriosis cases by about 40%. Two weeks after the sales of these types of Belgian products had resumed, the incidence of campylobacteriosis rose again to the previous level [85].
- In Iceland prior to 1996 as a measure against salmonellosis, only frozen poultry meat was sold. The incidence of campylobacteriosis dropped to a low level (some 10 cases per 100’000 inhabitants per year). From 1996 chilled poultry meat was allowed to be sold again. This lead to a dramatic increase of campylobacteriosis in Iceland. The incidence increased ten-fold to about 120

cases per year per 100'000 inhabitants. Thanks to the introduction of stricter measures, namely the monitoring of all flocks and the deep freezing of contaminated slaughtered carcasses, the annual incidence in humans could be reduced by almost three quarters [79; 80].

- New Zealand had the world's highest incidence of human campylobacteriosis. Various measures, in particular the introduction of maximum levels for retailed fresh chicken meat, led to a dramatic decline of the notified cases from 16'000 in 2006 to less than 7'000 in 2008. [76; 80].

Development of the prevalence in broiler chickens

The per capita consumption of meat is not the sole determinant that in relation to the poultry reservoir could have an impact on the number of human campylobacteriosis cases in Switzerland. Also variations in the prevalence of *Campylobacter* in broiler chickens might influence the human incidence. The available data indicate that broiler chicken herds displayed in the recent years quite high prevalences for *Campylobacter*. Because the data were collected heterogeneously, however, a reliable conclusion whether there is a direct correlation between the human incidence and the prevalence in broiler chickens cannot be drawn (Figure 12):

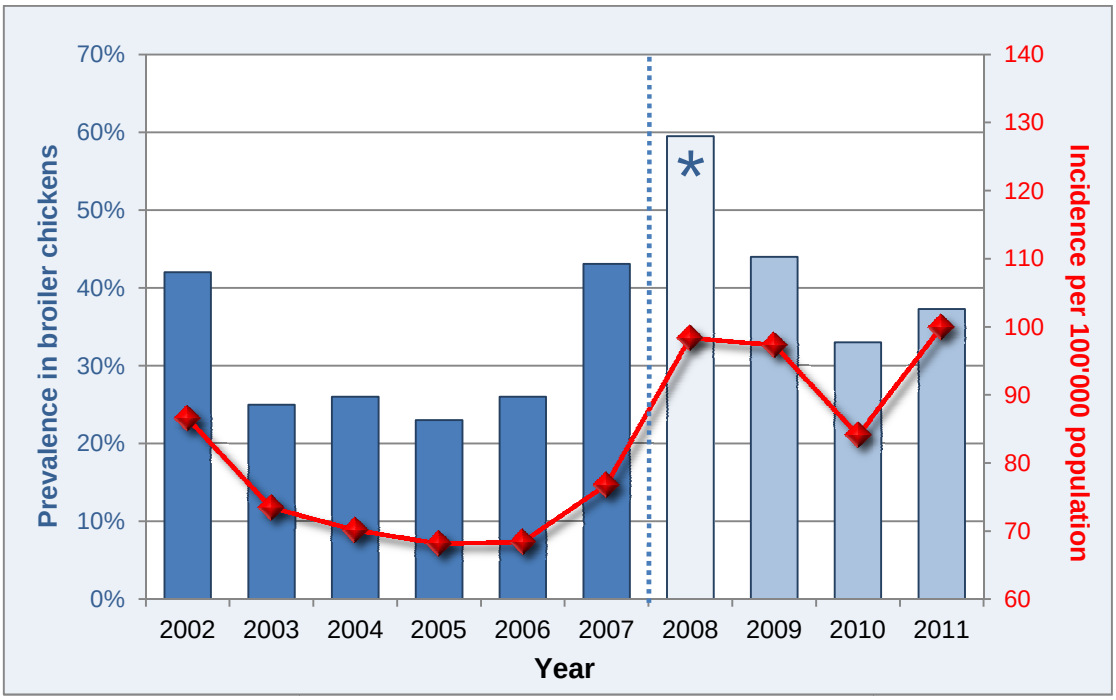


Fig. 12: Incidence of human campylobacteriosis cases (per 100'000 population) in Switzerland and prevalence in broiler chickens from 2002 to 2011 (source: FOPH; FVO (2002-2010: Swiss Zoonoses Reports [12]; 2011: [13]; for the years 2002-2007 a prevalence for individual animals is shown which was not annualised, for the years 2008-2011 an annualised flock prevalence had been determined; *the value of 59.5% for the flock prevalence 2008 should in reality be significantly lower, as the FVO could only consider data for the months May to December).

Model calculations and seasonal trends for humans and animals

It has been shown in various international studies that the incidence of human campylobacteriosis and the colonisation of broiler chicken flocks follows a consistent seasonal trend and both possess a pronounced correlation with the ambient temperatures [44; 46; 56; 59; 60; 83]. In Switzerland both the human incidence as well as the prevalence of broiler chicken flocks also follows a typical seasonal trend with low rates in winter and a significant rise in summer. At the first look, the seasonality for humans and broiler chickens appears to proceed in a similar manner. However, based on a study in the German Federal State of Niedersachsen [41], it was postulated that the rise in the laboratory notifications for humans occurred somewhat earlier than the prevalence for broiler chickens. This was considered to be an indication that the human is not firstly infected by the fowl, rather that both human and fowl are infected by a common source.

In a study by the FVO and the Veterinary Public Health Institute (VPHI) of the University of Bern the seasonal trend was therefore compared for humans and broiler chickens in Switzerland. Weekly prevalence data in chickens (incoming inspection at a large slaughterhouse) and weekly notification data for humans (laboratory notifications from the notification system) were statistically evaluated for 2008 and 2009. The evaluation showed that a temporal relationship exists between chicken prevalence and human notifications, wherein the rise for the chicken predates the rise for humans. A common (seasonal) cause for the rise was cited as the statistically most probable reason for this (Presented by Professor Gertraud Schüpbach, *Campylobacter*-Platform, 3rd session of 4th November 2010).

That poultry meat represents a dominant risk factor also emerges from a model calculation by the FVO in which 27% (17% to 39%) of the human campylobacteriosis cases could be linked to the direct consumption of poultry meat [16]. This exposure model thus arrives at similar results as the EFSA, which recently came to the conclusion that 20% to 30% of the human campylobacteriosis cases could be linked to handling, preparation and consumption of poultry meat and in total 50% to 80% to the chicken reservoir as a whole [31]. The exposure model attributed a further 27% to foreign travel, 8% to animal contact and 39% to other undefined risk factors [16].

Comparative molecular typing methods

The strongest indication of a connection between chickens and infections of humans results from comparative molecular biological investigations of simultaneously collected *Campylobacter* isolates from human patients, from slaughtered chicken carcasses and from retail chicken meat. In the meantime a great number of studies have already been published that have undertaken these types of comparisons with molecular typing methods such as PFGE (pulsed field gel electrophoresis) and MLST (multilocus sequence typing) (for example [19; 48; 53; 54; 57; 77]). These studies showed convincingly and consistently a connection between chicken meat and human illnesses with *Campylobacter.*

Investigations on the molecular typing of *Campylobacter* isolates have also been recently published in Switzerland [45]: 136 human clinical isolates as well as 243 isolates from broiler chickens [89] collected from slaughter in 2008 were compared with MLST and *flaB* typing and their resistance to antibiotics determined. It was shown that 86% of the quinolone-sensitive human isolates possess MLST-*flaB* types that overlapped with those from chickens. As resistance against quinolones exists significantly more frequently abroad than in Switzerland, the study concluded that a large fraction of the human cases originate in Switzerland from domestic chicken [45]. Further comparative typing studies involving *Campylobacter* isolates from human stool samples as well as from market samples of poultry meat, slaughtered poultry carcasses, pork and domestic animals (cats and dogs) are underway in the Institute for Veterinary Bacteriology of the University of Bern. Preliminary results of these studies also indicate a broad overlap between poultry isolates and human isolates; in contrast, *Campylobacter* from pork probably plays no great role in human infections (Presented by Professor Peter Kuhnert, *Campylobacter*-Platform, 3rd session of 4th November 2010).

2.3 Poultry liver

The results of a case-control study [70] prompted the FOPH, as early as the 1990s, to carry out a bacteriological investigation in order to further corroborate the role of chicken liver as a *Campylobacter* carrier [5]. In total, 139 and 144 samples of respectively chilled and deep-frozen liver were quantitatively tested for *Campylobacter.* A contamination rate of 31% and 16% was determined for chilled and deep-frozen livers respectively, the bacterial count being in part in the high range. It was found that 2.2% of the samples of chilled liver exhibited bacterial counts > 1’000 cfu per gram. A critical result was the observation that the contaminations were frequently not only localised on the surface but were also found inside the liver, i.e. in the bile ducts [5].

In 2010 the FOPH re-investigated a series of market samples of chilled chicken livers and for this adopted novel chromogenic agar media for the quantitative determination of *Campylobacter* [4]. Market samples of sliced chicken were also investigated as a comparison (Figure 13):

Samples	Period	Campy+	<10*	≥10-<10^2	≥10^2-<10^3	≥10^3-<10^4	≥10^4-<10^5
Sliced meat	Jan-Mar	3/30	27	3	0	0	0
	Jul-Aug	11/30	19	11	0	0	0
Liver	Dec-Jan	3/30	27	2	1	0	0
	Aug-Oct	30/30	0	4	13	10	3

Fig. 13: Quantitative determination of *Campylobacter* spp. in samples of fresh poultry liver and sliced chicken; (Analyses with CFA from BioMérieux; cfu per gram; * below detection limit of 10cfu/gram) [4]

In a first test series from December 2009 to January 2010 only 3 out of 30 (10%) of the liver samples were quantifiable and the respective bacterial counts were consistently found to be in the low range of 10 – 100 cfu per gram. However, a markedly different picture resulted with the August to October sample series: *Campylobacter* was quantitatively detectable in 30 out of 30 (100%) samples, and moreover, a massive shift to higher bacterial counts was observed, extending up to and including the range of 10‘000 – 100’000 cfu per gram! Here, one third of the samples exhibited bacterial counts of more than 1’000 cfu per gram. This finding suggests that in the summer months there results not only a higher infection rate in the poultry flocks, but also that greater numbers of bacteria are formed in the infected animals. The tests on the sliced chicken likewise showed a significantly increased frequency of contamination in the warm season, wherein the bacterial counts were consistently in the low range of < 100 cfu per gram and seasonally independent.

The recent study thus confirms the results of the 15 year old previous study that poultry liver is a high-risk product. Even though poultry liver is consumed in considerably less quantities than poultry meat in Switzerland, poultry liver, due to the high level of contamination, could play a pronounced role in the occurrence of infection. Infections are almost inevitable if the poultry liver is not sufficiently heated high enough and for long enough when preparing it.

That poultry liver is a high risk product has in the meantime also been recognised in other countries. Thus, in England and Wales, 25 out of 114 *Campylobacter* outbreaks (21.9 %) that were notified to the Health Protection Agency (HPA), the responsible public health authority, were assigned to the consumption of poultry liver [49] and various other studies reveal the link between *Campylobacter* outbreaks and the consumption of liver parfait or paté [39; 43; 58]. As a result, the HPA stressed the importance of the topic in a Health Protection Report [42] and the Food Standards Agency (FSA) published recommendations for cooking chicken livers in a correct manner [37]. A recently published study carried out in Scotland [81] again disclosed a high *Campylobacter* prevalence in retail liver from poultry (81%), beef (69%), pork (79%) and mutton (78%). In this study, molecular typing (MLST) demonstrated the highest match between strains from chicken liver and human isolates [81].

Recommendations for a correct culinary preparation of chicken liver were issued already in 1994 in Switzerland by the FOPH [6] and since then have been regularly repeated in various forms. *Inter alia* a flyer for correctly handling raw meat was also published as an internet version [10] and since publication more than 200’000 copies have been circulated in printed form. Unfortunately, the impact of these preventative actions on the number of human campylobacterios cases is difficult to determine. It can be surmised, however, that the totality of the targeted public cannot be reached, to say the least. Culinary recipes are still widely available that specify an inadequate cooking of the meat and consequently do not take into account the inherent risk potential of poultry livers.

2.4 Foreign travel

An exposure model of the FVO [16] assigns ca. 27% (22% to 32%) of the human cases in Switzerland to the foreign travel factor. The official Swiss notification system does not include the foreign travel parameter and a routine differentiation between travel-associated and inland cases of illness is not possible. However, foreign travel was already identified in a Swiss case-control study in 1994 as an important risk factor for a campylobacteriosis [70]: roughly 46% of the patients (cases) stated that they had been abroad three days before the appearance of the first symptoms.

This foreign stay fraction has significantly decreased in the following years: of the 467 strains sampled in the period June to December 2009 in the context of a genotyping study, 82% (383) of patients had not travelled abroad and only 18% (84) of patients had been abroad in the preceding two weeks [55]. This significant shift within the last twenty years allows us to conclude that the enduring camylobacteriosis epidemic is first of all a national and not an imported phenomenon.

The molecular typing (MLST and *flaB*) incidentally provided a low agreement for *Campylobacter* isolates from patients with and without a foreign stay; indeed, for *Campylobacter* strains from travel-associated cases (56%), a significantly more frequent resistance to quinolones was observed than for domestic cases (39.4%) [55]. It is known that resistance to quinolones exists considerably more often abroad than in Switzerland. The molecular typing of quinolone-resistant strains accordingly showed, as expected, only a low agreement (39%) between isolates from humans and from domestic chickens [45].

2.5 Drinking water

Campylobacter bacteria from the faeces of aquatic birds, the run-off of water from agricultural surfaces and especially from (untreated) human sewage can also attain surface water and ground water and survive there for long periods of time. The consumption of untreated drinking water can therefore represent a risk factor for human campylobacteriosis, and has been internationally proven by various case-control studies [20]. However, this factor is not general, rather it is more country- and region-specific in importance. Thus it appears that contaminated drinking water plays a role in the occurrence of infection particularly in the northerly countries of Europe [30]. The presence of *Campylobacter* in water also seems to follow a seasonal pattern. In temperate latitudes more bacteria are to be observed in water in winter than in summer, a seasonal trend, that interestingly runs counter to the seasonality in humans [1].

Using quantitative PCR, *Campylobacter* was determined in 87.5% of untreated and 64% of treated sewage from 23 different Swiss sewage works; the bacterial counts were $6.8 \times 10^4 – 2.3 \times 10^6$ and $1.1 \times 10^4 – 2.8 \times 10^4$ cells per litre in untreated and treated sewage respectively [66]. Thus, even in Switzerland, untreated human sewage can be heavily contaminated with *Campylobacter* and consequently represents a potential infection source for illnesses. Outbreaks of *Campylobacter* resulting from drinking water are generally, however, very seldom in Switzerland. *Campylobacter* has been determined only in isolated outbreaks, in particular in two extensive outbreaks in 1998 in La Neuveville and in 2008 in Adliswil [9; 52]). In both cases, due to technical failure and human error, the drinking water was heavily contaminated with contaminated sewage.

In Switzerland the drinking water originates from surface water (20%) (mainly lake water), spring water (40%) and ground water (40%). About two thirds of the natural water are subjected to a drinking water purification, among which all water that originates from surface waters. Thanks to a very good quality of the natural water, 38% of the drinking water can be injected into the supply network for direct consumption without any treatment [75]. In two investigations *Campylobacter* was found in spring water in Switzerland, that is in the natural water of a karstic spring and once from a spring fed by porous ground water aquifer [2; 63; 68]). In contrast, in a large-scale study by the Federal Office for the Environment (FOEN), *Campylobacter* could not be detected in a total of 99 crevice-, karstic- and loose

stone-ground water aquifers [61]. Therefore, one cannot accept that the Swiss groundwater and spring water could be contaminated to such a degree with *Campylobacter* that it would have any significance in the occurrence of the infection. Fundamentally, surface water could be contaminated with *Campylobacter;* however, the bacteria are eliminated by the conventional processes for the treatment of drinking water.

Accordingly, it can be assumed that – apart from exceptional situations – faecally contaminated drinking water, due to the severe microbiological quality standards, plays only a marginal role, epidemiologically speaking, in the sporadic cases in Switzerland. In comparison: An exposure assessment carried out in the Netherlands showed that there (surface) water contributes only 1% at the most to the total exposure to *Campylobacter* [35] and the responsible authorities came to the conclusion that potable water in the Netherlands does not represent an important source of infection [65]. An identical conclusion can also be drawn for Switzerland. However, based on the available data, an exact quantitative risk assessment of sporadic cases of campylobacteriosis resulting from potable water in Switzerland is not possible.

2.6 Pets

Contact with domestic animals is continually cited as an important transmission path for the campylobacteriosis. As a result of the frequently very close social contacts between owners and their domestic animals, transmission from *Campylobacter*-infected domestic animals to humans is also possible in principle. An exposure model attributes ca. 8% (6% to 9%) of the human cases in Switzerland to this factor [16].

A study [88] published in 2005 showed that cats and dogs in Switzerland can, in principle, carry the strains *C. jejuni* and *C. coli,* which are mainly responsible for infections in humans, although this is very rare (Figure 14):

Species	**Dogs (n=634)**		**Cats (n=596)**	
	number	prevalence	number	prevalence
C. jejuni	36	5.7%	24	4.0%
C. coli	7	1.1%	5	0.8%
C. lari	6	0.9%	0	-
C. upsaliensis/ C. helveticus	193	30.4%	210	35.2%
Campylobacter spp.	40	6.3%	27	4.5%
Campylobacter-positive total animals	261	41.2%	250	41.9%

Figure 14: *Campylobacter*-prevalence in cats and dogs (from [88]).

In contrast, in the majority of cases (in total ca. four fifths of the detections), *C. upsaliensis* was isolated, which is a strain that is rarely linked to illnesses in humans. On the other hand, the overwhelming majority (ca. 90%) of detections of *Campylobacter* notified to the FOPH in 2009 concerned *C. jejuni* and *C. coli.* Other *Campylobacter*-species in humans were detected only in 0.3% of cases in Switzerland (Swiss Zoonoses report 2009 [12]).

Molecular typing studies that include *inter alia* the comparison of human isolates and strains from cats and dogs and thereby should allow a valid opinion on the degree of the relationship of these isolates, are presently underway in the Institute of Veterinary Bacteriology of the University of Bern (presented by Professor Peter Kuhnert, Campylobacter-Platform, 3rd session of 4th November 2010).

However, the conclusion can already be drawn that domestic animals probably play only a minor role in the occurrence of campylobacteriosis infections in humans in Switzerland.

2.7 Summary

The findings on the most important risk factors of the human campylobacteriosis in Switzerland can be summarised as follows:

- Numerous observations and scientific studies prove that the human campylobacteriosis in Switzerland is principally ascribed to the poultry reservoir and that contaminated poultry meat represents a significant determinant in the transmission of the pathogen to humans. This finding is supported to a high degree by the international scientific literature.
- Chicken meat on the Swiss market is frequently contaminated with *Campylobacter*. The present data indicate that room for improvement exists at the slaughter and meat processing stage.
- Although the majority of chicken meat samples are weakly contaminated with *Campylobacter,* in several per cent of the samples the bacterial counts, however, are greater than 100 cfu per gram. Due to the low infection dose of the pathogen, such heavily contaminated meat represents a risk to the consumer.
- During the hot months of the year, chicken liver is contaminated with exceptionally high *Campylobacter* bacterial counts. The pathogens are partly localised inside the livers, thereby significantly increasing the risk to the consumer. Accordingly, chicken liver is a high-risk product.
- The fraction of campylobacteriosis attributed to foreign travel has halved in the last two decades, but in the same period the cases reported through the notification system have almost doubled. This clearly shows that there is a mainly homemade problem in Switzerland which has strongly increased in the last years.
- Additional risk factors such as contact with infected domestic animals, consumption of raw milk or contaminated drinking water contribute little in the main to the epidemiological occurrence in Switzerland.

3 Risk Management Options

3.1 Initial Situation

In the view of the public health authorities, the number of *Campylobacter* infections in Switzerland has reached inacceptable levels. The alimentary transmission path via poultry meat products contaminated with *Campylobacter* plays the central role in the occurrence of the infection. Pursuant to article 1 of the Federal Act on Foodstuffs and Utility Articles (Foodstuffs Act) [14], the responsible Swiss Authorities and especially the FOPH have the clear mandate to protect the consumer from foodstuffs that could endanger health. Supported by this legislative text and in view of the present epidemiological evidence, the FOPH, in the context of a microbiological risk management, is now required to determine measures in connection with the problem of campylobacteriosis. On the one hand, these measures must be commensurate, but on the other hand be suited in each case to lead to a real improvement in the situation and to achieve as far as possible the safety objectives stipulated in the scope of the "Roadmap" working group.

A microbiological risk management according to the guidelines of the Codex Alimentarius that are relevant in this regard should follow a structured approach that includes the following steps:

- Identification and selection of risk management options;
- Implementation of risk management activities;
- Monitoring and evaluation of the realisation of the selected options.

In this regard, the risk management options should protect the health of the consumer, they should be supported scientifically, be in proportion to the identified risk, be effective, practical and implementable [17].

Based on the available data, the large number of *Campylobacter* infections in Switzerland is not attributed to a single cause. In fact, numerous different factors are relevant from the entry in the primary production operation up to the preparation in the kitchen. Thus, when selecting the possible risk management options, on the one hand the total food chain should be considered, on the other hand, risk management options already established in other countries can also be taken into account.

Of the possible risk management options, five will be discussed in more detail below which are downstream of the slaughtering step in the food chain: the decontamination of slaughtered poultry carcasses, the stipulation of process hygiene criteria or food safety criteria, restrictions in the sale of poultry products and obligatory hygiene instructions on packaging. In particular, these measures, which fall essentially in the area of responsibility of the FOPH and of the cantonal chemists, could be implemented relatively quickly. On the other hand, measures relative to the primary production steps are not considered, as the FOPH would not be responsible for them, rather the FVO. In addition, measures for the information and improvement of hygiene behaviour of the consumer are ignored, as these measures have already been implemented to some extent by the FOPH.

3.2 Option 1: Decontamination of carcasses

In the context of a project triggered by the *Campylobacter*-Platform, a literature survey of the possible biological, physical and chemical decontamination treatments of poultry carcasses has been compiled and published [50]. This literature study concluded that although physical treatments with hot water or steam are effective, they often lead to qualitative impairment in the appearance of the meat. In this regard, a combination of steam and ultra-sound appears to deliver better results. Moreover, chilling with air is also effective. Organic acids as well as chlorine- or trisodium phosphate-containing substances are also suitable for a chemical treatment. Studies in regard to the chemical treatment show that under the proposed application conditions, no concerns exist in regard to food safety, and in the current state of knowledge these substances do not lead to an increased resistance against other

antimicrobially active substances [29]. Besides the chemical decontamination of carcasses, irradiation would also be fundamentally possible. Decontamination by irradiation, for example with gamma radiation, would be highly efficient and would lead to the elimination of bacteria on the carcasses.

In Switzerland the legal scope for the decontamination of poultry carcasses is very narrow. Pursuant to article 20 paragraph 1 letter c of the Ordinance on Foodstuffs and Utility Articles [72], the treatment of foodstuffs of animal origin for removing surface contaminants with processes other than rinsing with potable water is subject to authorisation. The legislation of the European Union (EU) also has an identical disposition (Regulation (EC) no. 853/2004 [27]). At present, decontamination treatments are allowed neither in Switzerland nor in the EU, but are already successfully used in several other countries and contribute to the reduction of contamination of slaughtered poultry carcasses with *Campylobacter.* Pursuant to Swiss legislation, in the context of the labelling requirements, article 2 paragraph 1 letter k in connection with article 17 of the Ordinance on the Labelling and Advertising of Foodstuffs [22], any chemical treatment has to be pointed out. However, it may be assumed that consumer acceptance of treated poultry carcasses is very low, especially if chlorine-containing substances have been employed. Whether this reserve is, however, still the case in view of the numerous campylobacteriosis cases, has not been practically verified on a pan-European basis. A study carried out in the United Kingdom [38] at least came to the conclusion that the consumer would reduce resistance to a chemical decontamination if the labelling did not awaken the impression that chemical residues are present in the product. Having said that, on the grounds of technical marketing, a declaration would meet with little sympathy from the suppliers.

Further, pursuant to article 20 paragraph 1 letter a of the Ordinance on Foodstuffs and Utility Articles [72], the treatment of foodstuffs with ionising radiation is subject to authorisation. If foodstuffs are radiation-treated the consumers are to be advised of this both for pre-packed foods and foodstuffs sold in bulk. Article 2 paragraph 1 letter n as well as article 36 paragraph 2 letter a of the Ordinance on the Labelling and Advertising of Foodstuffs [22] regulate the phrasing on the label: “treated with ionising radiation” or “irradiated”. A study carried out in the United Kingdom [38] came to the conclusion that a declaration of this type would inspire the consumer to imagine associations with cancer treatment and radioactive contamination. Therefore one assumes from this that the irradiation of carcasses would find little acceptance at this time. The suppliers, also on technical marketing grounds, would scarcely consider irradiation.

Within the current legal framework, the initiative for a chemical decontamination or irradiation of poultry carcasses would have to come from the slaughterhouses or the processors or distributors. However, it is unlikely that they will submit an application for authorisation, as long as a need for action, stipulated by a legal mandate, does not exist. Moreover, a chemical treatment or irradiation would only serve to combat the symptom and not address the root cause of the *Campylobacter* problem.

3.3 Option 2: Process Hygiene Criteria

Pursuant to article 5 paragraph 3 of the Hygiene Ordinance [21], process hygiene criteria describe in general the acceptable functionality of a production process. If a criterion is exceeded then the responsible personnel of a food company shall take the necessary corrective measures in order to ensure the process hygiene. Process hygiene criteria do not apply to products that are found in commerce.

The criteria in Switzerland for process hygiene and food safety are identical to the microbiological criteria stipulated in the Ordinance (EC) no. 2073/2005 in the EU [25]. This is because Switzerland, in the context of the bilateral agreement of 21 June 1999 between the Swiss Confederation and the European Union, concerning the trade with agricultural goods [71], agreed to accept these criteria. Solely the tolerance values [21] defined in Annex 2 of the Hygiene Ordinance form an exception.

In spite of this contractual obligation, Switzerland, like the EU Member States, could stipulate at the national level its own process hygiene criteria, as these, in contrast to food safety criteria that apply to products on the market, would not disadvantageously affect international trade. From the Swiss point of view the focus is therefore centred on the specification of a process hygiene criterion that would only apply to domestic companies. However, it may be assumed that the domestic companies concerned would question such a criterion on the basis of a legal inequality.

In order to effectively combat the *Campylobacter* problem, measures are needed along the whole food chain. Stipulating a process hygiene criterion would exert pressure in particular on the upstream processes of the processing, for example in regard to an improvement in hygiene and of the indoor housing of animals in the primary production or an optimisation of the slaughtering process. This poses the question of on which process step should a process hygiene criterion apply: a process hygiene criterion at the processing stage would have to be incorporated by the FOPH into Annex 3 of the Hygiene Ordinance [21]. In contrast, a criterion at the poultry carcass stage would be subject to the regulatory area of the FVO and would have to be regulated in the scope of the Ordinance on Slaughtering and Meat Control [73] or in the guidelines of the FVO for carrying out microbiological investigations in the scope of the self-regulation of slaughter house companies [11].

Furthermore, there is the question of the level of the process hygiene criteria: At the processing stage a value would probably be derived from the results of the base-line study carried out by the FOPH for collecting data on the prevalence of *Campylobacter* in chicken products in the retail market [4]. For a comparable process hygiene criterion at the stage of slaughtering, investigations in Europe and Switzerland could be consulted, in which are reported the levels of *Campylobacter* bacterial counts that are likely to be met in carcasses of broiler chickens.

Depending on the stage of the regulation, the cantonal chemists (processing stage) or the cantonal veterinary surgeons (slaughterhouse stage) would be responsible for monitoring and checking compliance. A process hygiene criterion is effective in principle if the public authorities carry out a consequential monitoring and, in the case of discrepancies, demand that improvement measures be undertaken. From the point of view of more direct impact possibilities for the responsibilities for non-conforming results, it seems that the stipulation of a process hygiene criterion at the poultry carcass stage is more suitable than at the processing stage.

3.4 Option 3: Food Safety Criteria

The quantitative analysis data for *Campylobacter* for chicken meat from the market [4] available for Switzerland would allow a food safety criterion (limit value) to be defined. Such a value would have to be fixed in the Hygiene Ordinance [21] and envisage in particular the most contaminated and therefore the riskiest poultry meat categories, namely fresh meat with skin and poultry liver.

A limit value would be one of the strictest and hence most effective regulatory measures that the responsible authorities could consider. In extreme cases the enforcement authorities can order the products to be destroyed; this would effectively compel companies to actively search for improvement possibilities. A food safety criterion of this type would therefore have to be proportional, i.e. also actually applicable by the poultry sector. That is the case only if the rejection rate is not too high. This therefore only deals with a quantitative criterion and not the absence of *Campylobacter* in a defined quantity of meat.

However, the abovementioned contractual obligations towards the EU are cited as the most important argument against a food safety criterion. The stipulation of a national food safety criterion would have to be notified to the EU (pursuant to Directive 98/34/EC [26]) and be scientifically solidly validated. Up to the present time, no national food safety criterion has been accepted or notified in the EU. In addition to domestic producers, importers would also be similarly affected. The free movement of goods from the EU into Switzerland would therefore no longer be ensured, which would be contrary to the

agreement of 21 June 1999 between the Swiss Confederation and the European Union, concerning trade with agricultural goods [71]. Moreover it would be problematic that the improvement measures would have to be carried out, not when placing the goods on the market, but rather at the actual producers (chicken farmers) and processors (slaughterhouses).

For the sake of completeness it should be mentioned that the enforcement authorities, in certain cases could invoke as an instrument the existing article 8 paragraph 1 of the Ordinance on Foodstuffs and Utility Articles [72]. This general article stipulates that foods may comprise microorganisms only in quantities that do not endanger the health of the consumer. However, a claim with a valid reasoning for the threat would have to be secured, which if necessary can also be accepted in court. However, as this procedure would be very costly for the cantonal enforcement authorities, in particular in view of possible legal disputes, it cannot be assumed that it would be implemented in everyday practice.

3.5 Option 4: Sales Restrictions

The microbiological investigations of poultry products which have been raised on the sales front have shown clear differences in the level of contamination between individual product categories [4]. Freshly chilled chicken liver in particular represents, at least in the summer months, a high-risk product for the consumer, but freshly chilled meat with skin is also in part apparently very highly contaminated. The idea of banning the sale of certain chicken products, wholly or partially, for example for a limited period, is therefore obvious.

Partial bans on sales would without doubt influence the number of cases of human campylobacteriosis. A ban on sales would certainly be the most drastic of all the possible measures and therefore hardly legally justifiable, in particular because with hygienic handling and correct preparation the risk of transmission even for highly contaminated products is low. Instead of a general ban on a certain product group, it would, however, be possible to stipulate technical requirements for their sale to consumers.

Thus, for example, it could be enacted that certain categories of meat may be circulated only when deep-frozen. From the results of the base-line study by the FOPH [4] it can be surmised that this measure would probably result in a significant reduction in the *Campylobacter* bacterial counts on the products in question when sold. Laboratory investigations with spiked poultry meat, (meat to which *Campylobacter* bacteria had been experimentally added), showed that, depending on the conditions of addition, deep freezing could reduce the bacterial counts by one to several $\log_{10}$-orders [24; 67]. A recently published report by the EFSA also showed that deep freezing reduces the bacterial counts, namely after some days storage by 0.91-1.44 $\log_{10}$, after three weeks by 1.77 - 2.18 $\log_{10}$ [33]. The guidelines of the Codex Alimentarius state that a storage period of 31 days at -20 °C leads to a reduction in the *Campylobacter* bacterial counts by 0.7-2.9 powers of ten [18].

Accordingly, the cold treatment represents an effective measure against *Campylobacter*. From the viewpoint of public health, deep freezing all chicken meat with skin would certainly be a sensible measure with regard to reducing the number of Campylobacter cases, as experience in particular in Iceland demonstrated [79]. Due to the high annually supplied quantities of chicken meat with skin, a requirement of this type would certainly entail considerable costs for the suppliers; these costs would no doubt be passed on to the consumer. Deep freezing on a large scale would also mean higher energy consumption. In comparison to this, poultry liver is offered for sale in significantly lower quantities. A restriction that poultry liver may only be offered in the deep-frozen state to the consumer could therefore be implemented with relatively low costs for the suppliers, and the risk inherent in this high-risk product could be relatively easily reduced.

An alternative is illustrated by the “scheduled slaughter” procedure that consists of subjecting slaughtered carcasses only from contaminated broiler chicken flocks to a cold treatment. Thus, for example in Iceland [79; 80] and Denmark [87], all flocks are tested prior to slaughter, and carcasses from posi-

tive flocks are used only for deep frozen products; this has led to a significant reduction in the number of campylobacteriosis cases. This could also be enacted in a similar manner in Switzerland, in that chicken meat or chicken liver may only be sold when chilled if they originate from *Campylobacter*-free flocks, and all other products have to be deep frozen. This would certainly require that all flocks be checked for *Campylobacter* prior to slaughtering. Nowadays cheap and sensitive rapid tests are available for this, for example also for detecting *Campylobacter* in samples of chicken faeces [86].

3.6 Option 5: Obligatory Hygiene Instructions

Some of the labelling regulations for meat and meat products that apply to hygienic handling are stipulated in article 9 paragraph 4 of the Ordinance on Food of Animal Origin [23]: for minced meat, as well as for meat preparations and meat products from poultry meat, which are destined for consumption only when thoroughly cooked, an appropriate instruction has to be attached to the packaging and to the wrapping. However, no regulation exists for fresh poultry meat.

In 2001 the FOPH already attempted to incorporate a statement in the Ordinance on Hygiene making it compulsory to warn the consumer of microbiological risks. However, a provision failed at that time due to *inter alia* the resistance from the food industry. Reacting to a program on Swiss television by a consumer protection magazine, a wholesaler, as of 1993, voluntarily added information on cooking hygiene to fresh poultry meat. With an increasing awareness of the link between poultry meat and *Campylobacter*-infections, this hygiene indication has now been established throughout Switzerland. Unfortunately however, the indications are in the main not in a prominent place, but rather sometimes even printed on the inside of the packaging, where naturally, hardly any notice is taken of them. Moreover, they are frequently printed in small letters and are sometimes not clear enough, thus making their impact questionable.

It would therefore be sensible to introduce legally binding, eye-catching hygiene indications that are understandable by the consumer. If warning labels were legally prescribed, then pro forma texts would no longer be possible on sales packaging. A hygiene indication for raw poultry meat should not only be limited to thorough cooking, but should also include the correct handling of raw poultry meat, as *Campylobacter*-infections in the private and community households are caused less by incomplete cooking than by cross-contamination [28; 51].

The Swiss labelling specifications for foodstuffs of animal origin are equivalent with those of the EU in the field of the EU-hygiene package. However, from the bilateral agreement with the EU [71], no impediment would stand in the way of additional labelling specifications on the grounds of health protection in Switzerland.

In conclusion, it should be noted that opinions are split in regard to the impact of hygiene indications on packaging: The experts who participated at a scientific colloquium of the EFSA in 2008 judged that although these types of indications were cheap to implement, they had little effectiveness [30]. The “food handling labels” on food which have been mandatory in USA since 1994 were also considered to be of limited impact [90]. Having said that, a report by the public authority in Ireland responsible for food safety [36] concluded that the requirement for easily understandable hygiene indications was an effective and cheaply implementable measure for combatting campylobacteriosis. According to an overview [64], indications on the packaging in regard to food safety were the information source preferred by the consumer.

3.7 Summary

Five different risk management options in the food chain have been highlighted in more detail by the FOPH:

1. Decontamination of slaughtered poultry carcasses by means of chemicals or irradiation;
2. Process hygiene criteria at the slaughtering or processing stage;
3. Food safety criteria for products on the Swiss market;
4. Restrictions or technical requirements in sales;
5. Obligatory hygiene indications on packaging.

Measures at the primary production stage were not considered, as they fall within the ambit of the FVO. In addition, measures to inform the consumer are ignored, as these measures have already been implemented to some extent by the FOPH.

4 Risk Management Measures

4.1 Assessment and Prioritisation

According to the guidelines of the Codex Alimentarius for carrying out a microbiological risk management [17], the risk management options should protect the health of the consumer, they should be supported scientifically, in proportion to the identified risk, be effective, practical and implementable. By taking into account these criteria of the Codex, the five risk management options in the food chain highlighted in more detail by the FOPH have been assessed and subsequently prioritised:

1. **Decontamination of poultry carcasses by means of chemicals or irradiation**
   This concerns partially highly effective measures that, in the case of irradiation, could even lead to a complete elimination of the pathogen. Due to the legal situation (requirement for authorisation) the initiative for this would certainly have to come from the poultry industry. The introduction of the required infrastructure would, however, probably mean greater investments for slaughterhouses; therefore a low level of cooperation is to be expected. Acceptance of these technologies by the consumer would also be rather low. This option would therefore only be considered after preparatory discussions with the stakeholders concerned.

2. **Process hygiene criteria at the slaughtering or processing stage**
   A certain pressure on the upstream processes of the processing could be established by means of a process hygiene criterion. The stipulation of a criterion at the poultry carcass stage is more suitable than at the processing stage, as the possibilities of influencing the responsible bodies having non-conforming results are significantly more direct. As only domestic companies would be affected, it can be assumed that this option would be rejected by the poultry industry on the grounds of a legal inequality. In contrast, the contractual obligations towards the EU would not represent an impediment, as international trade would not be disadvantaged.

3. **Food safety criteria for products on the Swiss market;**
   Limit values belong to the strictest regulatory measures available to the public authorities and would be suitable for exerting a correspondingly strong pressure on the poultry industry. However, the distributors would be primarily affected and not the producers nor the slaughterhouses, which in reality should be those to implement improvement measures against *Campylobacter* contamination. Imported goods, just like domestic goods, would be affected by these values. Consequently, the bilateral contracts with the EU represent a significant impediment to a measure of this kind.

4. **Restrictions or technical requirements in sales**
   The effectiveness of deep freezing for the reduction of *Campylobacter* contamination is undisputed and other countries have very good experience with it. However, specifying all chicken meat or the product group of meat with skin to be deep frozen would lead to considerable costs in the food industry and in commerce. Also, prior testing of the flock to be slaughtered and channelling the *Campylobacter*-positive flocks into the deep-freeze segment would meet with little or no acceptance, in spite of being logistically possible, In contrast, poultry liver represents overall only a small segment of the market. A restriction that poultry liver may only originate from *Campylobacter*-free flocks or must otherwise be deep frozen, could therefore be implemented by the supplier at a relatively low cost, and the high-risk of this product could be relatively easily mitigated.

5. **Obligatory hygiene indications on packaging**
   Whether these measures could have a sustainable effect is still open for conjecture. In comparison to the existing practice, obligatory hygiene indications would certainly represent a step forward, and combined with other measures to inform the consumer would make sense. Moreover, in comparison with other risk management measures, these measures could be implemented relatively cheaply.

In order to achieve the safety objectives defined in the scope of the *Campylobacter*-Roadmap, the FOPH decided in 2011 to prioritise the implementation of three options in the food chain. This concerns regulatory measures by the responsible federal authorities:

Priority Measures of the FOPH to combat the *Campylobacter* problem:

- Restrictions and the stipulation of technical specifications for the sale of chicken liver.
- The introduction of the obligation to attach understandable and eye-catching hygiene indications on the packaging of poultry products offered for sale.
- Specifying process hygiene criteria in regard to the slaughtering stage.

In the overall context of risk management, the respective measures will be examined in regard to their effectiveness at a suitable time. The activities should also be accompanied by suitable, targeted communication measures.

4.2 Planned implementation

The following procedure for the implementation of the planned regulatory measures was coordinated by the FOPH and the FVO in the session of the Roadmap working group on 26 April 2011 and specified:

Restrictions and the stipulation of technical specifications for the sale of chicken liver:
At the upcoming annual review in 2012 the FOPH will submit a modification of the Hygiene Ordinance [21] to the interested parties for their opinion. The modification proposed by the FOPH is to codify in the Hygiene Ordinance an obligation to deep freeze poultry liver. With this, this risk product should only able to be supplied still in the deep-frozen state to the consumer unless it can be proven that the goods originate from a *Campylobacter*-free flock. Solely in this case could it also be possible to sell the product in a chilled state. If the interested parties agree to this proposal in the consultation in summer 2012 then the modification could enter into force in 2013, wherein a reasonable transitional period would be provided.

Obligatory hygiene indications on packaging of poultry products on sale:
At the upcoming annual review in 2012 the FOPH further proposes to develop a legal basis in the Ordinance on Foodstuffs of Animal Origin [23] for an obligatory hygiene indication in regard to the handling and the preparation of poultry meat. The indication should be attached to the packaging of fresh poultry meat and poultry meat preparations in such a manner that it is highly visible to the consumer (placement, font size). The information for the consumer should firstly indicate that the products have to be thoroughly cooked before consumption. Secondly it concerns a hygiene indication so as to avoid cross-contamination, this by the clear separation of poultry meat and other foodstuffs (separate cutting board, knife, plate) as well as by thoroughly cleaning the utensils used and the hands after each use. This modification will also be submitted to the interested parties in the scope of a consultation in summer 2012 and at best could enter into force in 2013.

Process hygiene criteria at the slaughtering stage:
In its area of responsibility, the FVO intends to study in depth the definition of microbiological criteria for poultry carcasses in regard to the *Campylobacter* problem. The values could, for example, be codified in the FVO code of practice for microbiological investigations in the scope of the self-regulation of slaughterhouse companies [11]. A consolidated proposal (in regard to the levels of the values, sampling plan, detection methods etc.) should be drawn up in collaboration with the working group “Production” of the *Campylobacter*-Platform and involving the interested parties. In the context of a study (Dissertation at the Institute for Food Safety and Hygiene of the University of Zürich), it is intended to carry out a stage analysis as a monitoring tool in several slaughterhouses. The study is intended to record the effects of technological differences in various stages of the slaughtering process on the microbiological status of the poultry carcasses. The FOPH is represented in the advisory group of this

project. A decision by the FVO on the process hygiene criteria is expected once the stage analysis is completed, i.e. not before 2014.

In addition to these regulatory measures, further non-regulatory measures could be undertaken, *inter alia* an applied research project in collaboration with the poultry industry, namely a pilot project on the chemical decontamination of slaughtered poultry carcasses: Pursuant to article 20 of the Ordinance on Foodstuffs and Food Utility Articles [72], processes other than rinsing with drinking water for treating carcasses require an authorisation by the FOPH. The poultry industry would have to submit an application to the FOPH to obtain this, but there are no signs that the poultry industry itself would take the initiative in this regard. Therefore the FPOH and the FVO in the working group “Production” should clarify whether a project of this type would be of interest to representatives of the Swiss branch and could be actually undertaken in the medium term.

4.3 Outlook

The *Campylobacter* problem has reached such proportions that now oblige the responsible public authorities to take effective counter measures. Measures along the total food chain (hygiene issues in regard to the housing of flocks, slaughter, processing and consumption) are to be defined in order to attain the safety objectives stipulated for campylobacteriosis. Measures at each stage can contribute to reducing the microbial contamination of poultry meat and consequently to a prevention of campylobacteriosis in humans.

The present proposed regulatory measures are a first step in tackling the problem in a sustainable manner. Should they be implemented, then their effectiveness will be examined at an appropriate time. This examination will show whether the measures are sufficient to achieve the formulated safety objectives, or whether further measures need to be taken by the responsible public authorities.

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