

Prevalence and Risk Assessment of *Campylobacter jejuni* in Chicken in China

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Abstract

Objective To understand the occurrence and distribution of *Campylobacter jejuni* in chicken in China, assess its health risk to the Chinese population, and provide recommendations for effective risk control.

Methods Data from the National Food Safety Risk Surveillance Network on *Campylobacter jejuni* between 2007 and 2010 and from published articles were analyzed. Eleven parameters were used based on the whole chicken preparation process and prevalence of *Campylobacter jejuni* for risk assessment by using the Ross-Sumner Method.

Results The detection rates of *Campylobacter jejuni* in raw chicken were between 0.29% and 2.28% during 2007-2010 in China (more than 20 provinces). The probability of illness caused by *Campylobacter jejuni* due to chicken consumption was around six out of one million consumers per day in urban areas and around one out of one million consumers per day in rural areas. Total predicted illnesses per year was about 736 000, accounting for 1.6‰ of the general population in urban areas and about 301 000, accounting for 0.37‰ of the total population in rural areas. The risk rankings of *Campylobacter jejuni* in chicken were 52 and 49 in urban and rural areas, respectively.

Conclusion A high risk score for *Campylobacter jejuni* in chicken was obtained in China. This result may contribute to development of food safety management strategies. Key efforts should be made to control the risk of *Campylobacter jejuni* in chicken in China, especially in chick breeding and chicken preparation processes.

Key words: *Campylobacter jejuni*; Chicken; Semi-quantitative; Risk assessment

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INTRODUCTION

Campylobacter jejuni is a common cause of bacterial gastroenteritis in human beings. The number of people infected with *Campylobacter jejuni* has significantly increased during the last two decades and the prevalence rates of *Campylobacter jejuni* have exceeded those of *Salmonella* in Denmark, Sweden, Finland, Norway, the Netherlands and Britain^[1]. In 1997, the prevalence rate of *Campylobacter jejuni* determined through clinical diagnosis was 25.2 cases per 100 000

people in the United States of America, while the prevalence of other bacteria was less than 1%^[1]. However, few surveillance and disease burden data on *Campylobacter jejuni* in developing countries have been available. *Campylobacter jejuni* is commonly found in poultry, cattle, pigs, sheep, wild animals, birds, dogs, and cats. However, studies have found associations between the *Campylobacter jejuni* strains separated from human beings and chicken, indicating that chicken is an important source of *Campylobacter jejuni* disease for human beings^[2]. FAO and WHO have identified the risk

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assessment of *Campylobacter jejuni* as one of the priority research areas for food safety^[1]. To date, very limited risk assessment studies on *Campylobacter jejuni* in chicken have been conducted in China. This article analyzed the epidemic of *Campylobacter jejuni* among chicken in China and conducted a preliminary health risk assessment of Chinese people's dietary exposure to *Campylobacter jejuni* in chicken.

MATERIALS AND METHODS

Epidemic of *Campylobacter jejuni* in Chicken

We used the *Campylobacter jejuni* contamination data among raw chicken from the National Food Safety Risk Surveillance Network covering more than 20 provinces and municipalities in 2007-2010, as well as from some published articles^[4-8].

Sampling and Testing of *Campylobacter jejuni*

Four sampling sites were randomly selected from each province (municipality), including poultry production, wholesale and retail sites. Poultry samples were collected based on the asepsis principle and tested in 3-24 h after sampling.

Chicken samples were treated with pre-grown bacteria at 36±1 °C for 4 h, and then placed on Skirrow and mCCD Agar Plate to be incubated for 24-48 h at 42±1 °C. Presumptive *Campylobacter* colonies were picked and placed on the Columbia Agar Plate, and cultivated for 24-48 h at 42±1 °C to examine *Campylobacter jejuni*.

Risk Assessment Method

The semi-quantitative Ross-Sumner Method was used to obtain risk estimates^[8]. The Ross-Sumner Method and tool embodies established principles in food safety risk assessment, i.e., combination of the probability of exposure to a food-borne hazard, the

magnitude of the hazard in food when it is present, and the probability and severity of outcomes that might arise from that level and frequency of exposure. There are eleven parameters in the tool, including hazard severity, susceptibility of consumers, 3 factors related to the probability of exposure to chicken (frequency of consumption, proportion of consuming population and size of consuming population), and 6 factors related to the probability of chicken contamination and infectious dose (contamination possibility of live chicken, effect of processing, potential for recontamination, effectiveness of post-processing control system, the extent of increase required to reach an infectious dose, and effect of meal preparation). Among the eleven parameters, frequency of consumption and size of consuming population were different in rural and urban areas, and the last 6 factors were determined according to the chicken preparation process.

RESULTS

Epidemic of *Campylobacter jejuni* in Chicken in China

Data on *Campylobacter jejuni* contamination of raw chicken from the National Food Safety Risk Surveillance Network covering more than 20 provinces and municipalities (including Jilin, Anhui, Beijing, Gansu, Guangdong, Guangxi, Hebei, Henan, Hubei, Hunan, Jiangsu, Liaoning, Inner Mongolia, Ningxia, Shandong, Shanxi, Shanghai, Sichuan, Zhejiang, Chongqing, Fujian, etc.) in 2007-2010. Each surveillance site was required to keep sampled raw chicken (de-feathered and eviscerated) from supermarkets or bazaars every month during a 12-month period. In addition, data from four published studies were collected and summarized together with the national surveillance data in Table 1.

Table 1. Prevalence of *Campylobacter Jejuni* in Chicken in China

Samples	Sample Size	No. of Positive	Detection Rate (%)	Data Source
Raw chicken	879	16	1.82	Surveillance data from 21 places in 2007
Raw chicken	1186	27	2.28	Surveillance data from 21 places in 2008
Raw chicken	1283	21	1.64	Surveillance data from 22 places in 2009
Raw chicken	4158	12	0.29	Surveillance data from 29 places in 2010
Hairy chicken	50	28	56.00	Baoding City ^[4]
Raw chicken	25	2	8.00	Shenzhen City ^[5]
Hairy chicken cloacal	56	16	26.80	Nanjing City ^[6]
Raw chicken*	260	19	7.31	Fujian Province ^[7]

Note. * Include *Campylobacter jejuni* and *Campylobacter coli*.

Chicken Preparation Process and Determination of Parameters for the Ross-Sumner Method

Influence of Chicken Preparation Process on *Campylobacter jejuni*

Currently, the chicken preparation process includes four major steps, i.e. transporting, slaughtering, processing and cooking.

Transporting Chicken before slaughtering is named hairy chicken. A truck with hairy chicken will be sterilized upon its arrival at the slaughtering factory, and certificate inspection and sensory examination will be conducted then. Initial *Campylobacter jejuni* contamination of raw chicken was decided by the condition of hairy chicken. Currently, it is not clear about the *Campylobacter jejuni* source and it may come from vertical transmission (hens transmitting the bacteria to offsprings through eggs) or transmission among chickens. Researchers found that about 10% of the microbes would be transmitted after touching the contaminated chicken's surface. STERN's study^[8] showed that the contamination level had no significant difference before and after transportation, namely, there was no significant difference between the *Campylobacter jejuni* contamination level of hairy chicken in the farm and the initial contamination level of hairy chicken before slaughtering.

Slaughtering This process mainly includes electric shock, bloodletting, soaking in scalding water and plucking feather, hanging chicken to remove viscera, chilling and sterilization. Usually, there are few chances for microbe contamination during electric shock because the chicks are electrically stunned while they are hung in air, not in water.

After bloodletting, chicken was soaked in scalding water to pluck feathers. If there are chicken contaminated by *Campylobacter jejuni*, cross contamination will happen through the scalding tank and plucking instruments.

As *Campylobacter jejuni* is a normal germ in chicken's gastrointestinal tract, chicken will be contaminated by this microbe in excrement whenever during the viscera removing process due to carelessness. Both inside and outside of carcasses without viscera will be cleaned by water. Studies have indicated that the cleaning process can significantly reduce the *Campylobacter jejuni* amount on chicken carcasses by 90%^[1].

During the chilling process, sodium hypochlorite containing 50-100 mg/L available chlorine was added into the chilling tank to prevent cross contamination

of microbes and microbes sticking to chicken carcasses in water as well. Chicken carcasses are moved into countercurrent water flow to make sure that clean water always surrounds chicken carcasses to reduce the contamination level. After cooling, the chicken temperature will remain below 4 °C.

Generally speaking, *Campylobacter jejuni* can survive, but does not reproduce during the above process, and the concentration of survived *Campylobacter jejuni* will decrease^[9].

Processing This process includes carcass segmentation, package, freezing, and refrigeration. Few articles have been published on the contamination during the processing phase, but some sources of potential cross contamination may exist, such as touching of chicken by some surfaces during segmentation, including those of conveyor, chop board and package materials, which may increase the microbe amount.

Cooking *Campylobacter jejuni* is very sensitive to temperatures higher than 45 °C, so it is usually difficult for *Campylobacter jejuni* to survive during cooking. (D value is 0.21-2.25 min at 55-60 °C)^[10].

Determination of Parameters for the Ross-Sumner Method

The Ross-Sumner Method is based on numerical quantification of the answers to 11 questions (parameters) related to a given hazard (e.g. *Campylobacter jejuni*), its severity, its relation with a given food (e.g. chicken), processing, preparation, consumption pattern, etc. The values for the 11 parameters are determined as below:

Hazard Severity Most people infected with *Campylobacter jejuni* do not go to hospital, but sometimes some complications, such as serious diarrhea and high fever may happen to some patients, even including Guillain-Barre syndrome (GBS). Thus, the severity of *Campylobacter jejuni* hazard to population health is set as "minor".

Susceptibility of Consumers People at all age groups are susceptible to *Campylobacter jejuni*. Children below 4 years and adults between 15-44 years are the most susceptible people and the incidence among males is 1.2-1.5 times higher than that among females^[1]. Therefore, consumers are "generally susceptible" to *Campylobacter jejuni*.

Frequency of Consumption A survey on chicken consumption among the population in Beijing conducted by Zeng and Zhang showed that frequent chicken consumers accounted for 53.87%, occasional consumers accounted for 44.78%, and those never consuming is 1.35%^[1]. In addition, the nutrition and health survey among the Chinese population in 2002

showed that poultry meat consumption (10.6 g/standard person day) in rural areas was about half of that in urban areas (22.6 g/standard person day)^[12]. Based on this survey, we can calculate that 158.2g poultry meat is consumed per person per week in urban areas, which is a reasonable chicken consumption amount per meal. We assume that rural people will eat double amount of urban people, indicating that it would take a month to reach one meal chicken consumption amount, so we set the parameter as “weekly” for urban population and “monthly” for rural population.

Proportion of Consumers in the General Population

The survey conducted by Zeng Yinchu et al. indicated that people who never, occasionally and frequently consumed chicken accounted for 1.35%, 44.78%, and 53.87%, respectively^[11]. The nutrition and health survey among the Chinese population in 2002 showed that the Chinese people’s poultry meat consumption increased by 1 fold in 2002 compared with that in 1982 and increased by 33% compared with that in 1992. Consumption of livestock and poultry meat increased by 42.5 g/standard person day and 46.2 g/standard person day between 1982 and 2002 among urban and rural populations, respectively^[12]. Thus, we set the parameter as “most-75%” for both urban and rural populations.

Size of Consuming Population Based on the data from the fifth national census, the urban population size was 455 940 000 and the rural population size was 807 390 000 in China.

Contamination Possibility of Hairy Chicken

According to the published data on *Campylobacter jejuni* contamination in hairy chickens in Baoding City^[4] (with the contamination rate being 56.0%) and the data obtained through chicken anus swab in Nanjing^[6] (with the contamination rate being 26.8%), we used the average value and set the parameter as “41.4%”).

Effect of Preparation Process According to the chicken preparation process described in the prior section, it can be learnt that the preparation process is not favorable for growth and reproduction of *Campylobacter jejuni* and even restrains it. The contamination rates were 1.82%, 2.28%, 1.64%, and 0.29% in 2007, 2008, 2009, and 2010, respectively, as shown by the survey conducted by the National Food Safety Risk Surveillance Network. Many articles^[4,7] have reported rates of lower than 10%, indicating that the chicken preparation process had significantly reduced the *Campylobacter jejuni* contamination level. According to the above analysis,

we set the effect of preparation process as “usually eliminating”.

Potential for Recontamination Chicken may be subject to cross contamination through utensils, hands of operators, and contaminated chicken during and after the preparation process. Experiments indicated that the rate of cross contamination between hands and chicken was 10%^[13]. If 10% of *Campylobacter jejuni* from the contaminated surface could be transmitted, the potential for recontamination was set as 1%.

Effectiveness of Post-preparation Control System

Currently, there are no surveillance or survey data on *Campylobacter jejuni* in cooked chicken in China. As described before, *Campylobacter jejuni* generally cannot survive after the cooking process due to its characteristics. Thus, we set the control system parameter as “no increase in pathogens”.

The Extent of Increase Required to Reach an Infectious Dose

Five-eight hundred live germs were used as an infectious dose for *Campylobacter jejuni* by researchers^[14]. With a conservative assumption that one germ exists in raw chicken, 100-time increase of bacteria would be possible to reach an infectious dose. Thus, we set the parameter as “100-time increase”.

Effect of Meal Preparation According to the Chinese diet habit, there are a lot of high temperature cooking methods, including frying and steaming, and heating leftovers before eating next time. Generally, *Campylobacter jejuni* does not grow and reproduce during these preparation processes. Therefore, we set the parameter for these preparation processes as “mostly eliminating-99%”.

Risk Assessment

We conducted semi-quantitative assessment, using the Ross-Sumner Method with all the above 11 parameters, and got the following results in Table 2.

DISCUSSION

Epidemic of *Campylobacter jejuni* in Chicken in China

Since 2007, the National Food Safety Risk Surveillance Network has been monitoring *Campylobacter jejuni* in raw chicken from supermarkets or bazaars in more than 20 provinces and municipalities. It aimed to increasingly evolve into a network covering nearly all provinces and municipalities of China by 2010. The annual detection rates from the national network vary from

Table 2. Risk Assessment Results of Dietary Exposure to *Campylobacter jejuni* in Chicken

Parameter	Urban Area	Rural Area
1. Hazard severity	minor	minor
2. Susceptibility of consumers	generally susceptible	generally susceptible
3. Frequency of consumption	weekly	monthly
4. Proportion of consuming population	most-75%	most-75%
5. Size of consuming population	455 940 000	807 390 000
6. Contamination possibility of live chicken	41.4%	41.4%
7. Effect of preparation process	usually eliminating	usually eliminating
8. Potential for recontamination	1%	1%
9. Effectiveness of post-preparation control system	no increase	no increase
10. The extent of increase required to reach an infectious dose	100 time- increase	100 time- increase
11. Effect of meal preparation	mostly eliminate-99%	mostly eliminate-99%
Probability of illness per day per consumer	5.9×10^{-6}	1.36×10^{-6}
Total predicted illnesses/annum in population	7.36×10^5	3.01×10^5
Risk ranking	52	49

0.29% to 2.28%, which is likely to be related with the expansion of the geographic surveillance scope, changes of sampling locations, and quality control methods, etc. Although the rates from the surveillance network are quite low, higher rates could also be found in some surveys, such as 8.0% in Shenzhen City^[5] and 7.31% in Fujian province^[7]. Both the prevalence from the national surveillance network and the rates from some surveys in China are much lower than those from the study conducted in Denmark, in which the *Campylobacter* spp. positive rate was 24% (and 87% were *Campylobacter jejuni*)^[15]. This may be due to different processing practices and conditions in China and Denmark.

In hairy chicken, *Campylobacter jejuni* detection rates were much higher than those in raw chicken in China. For example, the rate was 56.0% in Baoding City^[4], and 26.8% (anus swab) in Nanjing City^[6]. These contamination rates in hairy chicken were similar with the rates from Germany, Denmark and Tanzania, where the *Campylobacter* spp. positive rates were 44% (with most being *Campylobacter jejuni*)^[16], 52% (with 87% being *Campylobacter jejuni*)^[15], and 69.8% (with 91.2% being *Campylobacter jejuni*), respectively^[17]. Given the smaller sample size of these surveys, further large-scale studies need to be conducted.

Health Risk of *Campylobacter jejuni* in Chicken

The Ross-Sumner Method and its tool are in a spreadsheet software format and provide a risk

estimate, which is scaled between 0 and 100, with 0 representing (very) low risk (negligible, but not zero). The 0 value is explained as the probability of an illness of mild severity that could happen once (or less than once) in 100 billion of people every 100 years. The 100 value represents the circumstance where each member of the population consumes daily a serving containing a lethal dose of the hazardous substance. If quantitative assessments are not available, qualitative and semi-quantitative assessments become more valuable to obtain relative risk assessments for sets of pathogens/foods/situations (regions, populations at risk, seasonality, etc.). However, there are no possibilities to go into specific details of mitigation measures with this method.

Our assessment results show that chicken consumption will result in a *Campylobacter jejuni* illness probability of around six out of one million per consumer per day (5.9×10^{-6}) in urban areas and around one out of one million per consumer per day (1.36×10^{-6}) in rural areas. Total predicted illnesses per year were about 736 000 (161.4 cases /100 000 population) in urban areas and about 301 000 (37.3 cases /100 000 population) in rural areas. Studies showed that the incidence of reported *Campylobacter jejuni* infections in Northern European countries was 60-90 cases /100 000 population^[2] and 17.3 cases /100 000 population in the United States of America^[1]. However, such reported infections may represent only 1%-10% of the actual number of infections^[2]. Assuming 10 as a

multiplier for the actual infection number, the actual infections are about 600-900 cases /100 000 population in Northern European countries, much higher than our assessment results, and the actual infections in USA is about 173 cases /100 000 population, similar to the urban assessment results and higher than the rural assessment results in our study.

In addition, our study showed that the risk rankings of *Campylobacter jejuni* in chicken were 52 and 49 in urban and rural areas. Mataragas M et al.^[18] have characterized the score calculated through the Ross-Sumner method as low (<32), medium (32-48) and high (>48). Based on this assumption, a high risk score was obtained for *Campylobacter jejuni* in chicken in China, indicating that close attentions should be paid.

Measures to Control the Health Risk of *Campylobacter jejuni* in Chicken

Generally speaking, most microbes will grow and reproduce in the preparation process, such as *Salmonella* and *Staphylococcus aureus*. However, *Campylobacter jejuni* is a thermophilic and anaerobic bacterium requiring favorable temperature, oxygen and carbon dioxide scopes, which cannot be met during chicken preparation and processing. This reminds us that key efforts should be made to control the *Campylobacter jejuni* risk in farms and some key steps in preparation processes. Important interventions include preventing fecal contamination during transportation, increasing the scalding temperature, giving the scalding water a higher countercurrent flow rate, reducing contamination of feathers in the scalding tank to decrease *Campylobacter jejuni* in the scalding water, spraying water to reduce contamination at the plucking step, monitoring and maintaining the residual chlorine in the chill water.

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