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Risk Factors for Sporadic Infection with *Salmonella* Enteritidis, Denmark, 1997–1999

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In a prospective case-control study of sporadic *Salmonella* Enteritidis infection in Denmark (1997–1999), foreign travel was reported by 25% of 455 case patients and 8% of 507 controls (odds ratio (OR) = 3.7, 95% confidence interval (CI): 2.4, 5.5). Among nontravelers, 80% of 335 cases and 81% of 467 controls had consumed eggs or dishes containing raw or undercooked eggs during the week before disease onset or interview, while 35% of cases and 19% of controls had incurred this exposure the day before onset or interview (OR = 2.2, 95% CI: 1.5, 3.1). Specific exposures included consumption of buttermilk dessert (OR = 11.7), homemade ice cream (OR = 4.3), raw eggs (OR = 3.4), and eggs fried "sunny side up" (OR = 2.5). Among persons who had used eggs in the week before disease onset or interview, eggs from battery laying hens were associated with disease (white eggs: OR = 2.4, brown eggs: OR = 1.9), whereas consumption of pasteurized eggs tended to be protective (OR = 0.3). The study confirmed that eggs are the principal source of *S.* Enteritidis in Denmark. This conclusion was reached through the use of an exposure time window that corresponds to the most relevant incubation period rather than the maximum incubation period. The authors recommend this method in studies that have the objective of determining risk associated with common exposures.

case-control studies; eggs; food poisoning; poultry; poultry products; risk factors; *Salmonella* Enteritidis

Abbreviations: CI, confidence interval; OR, odds ratio; PT, phage type.

Salmonella enterica serotype Enteritidis (*S.* Enteritidis) is the most common serotype associated with foodborne *Salmonella* infection worldwide. Eleven years ago, an international increase in the incidence of *S.* Enteritidis was described as a pandemic (1). Outbreak investigations (2–4), typing of bacteria (5, 6), and case-control studies of sporadic infections (7–12) have suggested that the emergence of *S.* Enteritidis was primarily due to contamination of the interiors of shell eggs. In Denmark, the incidence of *S.* Enteritidis infection among humans increased during the 1990s, and the epidemic peaked in 1997 with an incidence of 70 reported cases per 100,000 population (13). To address the hypothesis that consumption of raw or undercooked eggs was the primary risk factor for domestically acquired cases, we conducted a nationwide prospective case-control study. Additional objectives were to examine the role of specific dishes made with eggs, to examine the role of other food exposures, and to monitor the effect of a recently initiated *Salmonella* control program.

MATERIALS AND METHODS

The study was designed as a prospective, matched case-control study and was carried out from September 1997 to November 1999. Cases were patients with culture-confirmed *S.* Enteritidis, identified through examination of fecal specimens submitted to the Statens Serum Institut (Copenhagen, Denmark) by primary practitioners or hospitals. At the time of this study, the Statens Serum Institut undertook primary diagnostic analyses of gastrointestinal pathogens for approximately two thirds of the Danish population of 5.3 million. During the study period, a weekly number of 15–20 randomly selected patients with culture-confirmed *S.* Enteritidis were invited to participate by their own physicians. Individuals who

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TABLE 1. Distribution of *Salmonella* Enteritidis phage types and associations of specific phage types with foreign travel during the 2-week period before onset of *S.* Enteritidis infection, Denmark, 1997–1999

Phage type	Phage type distribution		Association with travel abroad			
	No.	%*	No.	%	Odds ratio†	95% confidence interval
8	142	35.5	14	9.9	1.2	0.6, 2.3
6	108	27.0	11	10.2	1.2	0.6, 2.4
4	74	18.5	48	64.9	27.1	14.4, 51.0
1	21	5.3	16	76.2	71.3	20.1, 252.6
21	7	1.8	3	42.9	16.6	2.8, 97.2
Other/nontypeable	48	12.0	12	25.0	4.4	2.0, 9.4
Not typed	55					

* Marginal percentage of all typed isolates (n = 400).
† Odds ratio from polytomous multivariable logistic regression comparing cases with 507 controls matched by time, gender, birthday, and county.

agreed to participate were mailed additional information about the study, a consent form, and a questionnaire. The patients were asked to sign and return the consent form by mail.

When a consent form was received, four potential controls were identified through the Danish Civil Register, which is a continuously updated population registry. Controls were matched by gender, date of birth, and municipality. A package including information about the study, a consent form, and a questionnaire was mailed to eligible controls, and they were asked to confirm their willingness to participate by returning the signed consent form. If none of the potential controls responded after 10 days, another set of individuals was invited to participate, according to the above procedure.

Patients and controls were asked to complete the questionnaire on food exposures as soon as possible after receipt of the information package. They were then contacted later by telephone, and while they were looking at the questionnaire, data were collected using a computer-assisted telephone interviewing system. This facilitated data collection and allowed standardized probing about relevant exposures. Data collected included information on symptoms, underlying illnesses, medications, foreign travel during the previous 2 weeks, consumption of eggs, poultry, and meat, and contact with animals, including pets. In total, 75 exposure variables were examined. We obtained food exposure data for a 7-day period prior to disease onset (cases) or interview (controls). However, the computer-assisted telephone interviewing system allowed categorization of food exposures into four groups: exposures incurred 1) on the same day, 2) on the previous day, 3) 2 days before disease onset/interview, or 4) 3–7 days before disease onset/interview. For individuals who had had several exposures during the previous 7 days, the most recent exposure was considered in the analyses.

Case patients who were part of a recognized outbreak, were unable to establish the date of disease onset, or had had a previous *Salmonella* infection were excluded from the study. Controls who had symptoms of gastroenteritis (diarrhea or fever plus abdominal pains) or who had had a previous *Salmonella* infection were also excluded. Finally, we excluded persons who were unable to complete the questionnaire because of language problems.

To increase precision, we pooled strata with identical values for the matching factors (14) and analyzed the data by conditional logistic regression. To address the hypothesis that certain *S.* Enteritidis phage types (15) were associated with foreign travel and others with egg-related food exposures, we quantified phage-type-specific risk factors by multivariable polytomous logistic regression analysis, adjusting for the matching variables (16). We used the PHREG and CATMOD procedures of the Statistical Analysis System, version 8.2 (SAS Institute, Inc., Cary, North Carolina), for the analyses.

RESULTS

The study included 455 patients; 275 (60.4 percent) were female. The median age was 43 years (interquartile range, 23–54), and 28 patients (6.2 percent) were under 5 years of age. Common symptoms included diarrhea (99.8 percent), abdominal pain (89.7 percent), fever (82.2 percent), joint pain (63.7 percent), headache (59.6 percent), nausea (59.5 percent), vomiting (42.7 percent), and blood in stools (22.7 percent). The median duration of sickness was 13 days (interquartile range, 8–17 days). A total of 63 patients (13.9 percent) had been admitted to a hospital. Among the 77 patients aged 60 years or above, 19 (24.7 percent) had been hospitalized. A total of 128 (28.1 percent) had had contact with other persons who had symptoms of gastroenteritis; 108 reported that these persons had onset of disease at the same time as or later than the onset of the respondent's illness. Most (66 percent) of these contacts belonged to the same household as the respondent, and 69 percent had shared a meal with the respondent.

One hundred and fifteen (25.3 percent) of the patients and 40 (7.9 percent) of 507 controls had been traveling outside of Denmark in the week before disease onset or interview (odds ratio (OR) = 3.7, 95 percent confidence interval (CI): 2.4, 5.5). Table 1 shows that two most common Danish *S.* Enteritidis phage types (PT), PT 8 and PT 6, were not associated

TABLE 2. Food-related risk factors for *Salmonella* Enteritidis infection acquired in Denmark, 1997–1999*

Food exposure	Exposure on the day before onset/interview						Exposure during the week before onset/interview					
	Cases		Controls		Odds ratio†	95% CI‡	Cases		Controls		Odds ratio†	95% CI
	No.	%	No.	No.			No.	%	No.	%		
Shell eggs	85	25.4	74	15.9	1.9	1.3, 2.7	234	69.9	354	75.8	0.7	0.5, 1.0
Dishes prepared with raw shell eggs	45	13.4	24	5.1	2.5	1.5, 4.4	115	34.2	130	27.8	1.4	1.0, 2.0
Eggs or dishes containing raw eggs	116	34.8	87	18.6	2.2	1.5, 3.1	269	80.3	379	81.1	0.8	0.6, 1.2
Chicken/hen bought whole	9	2.8	20	4.3	0.6	0.2, 1.4	36	11.4	124	27.1	0.4	0.3, 0.6
Chicken/hen bought in pieces	16	4.9	22	4.8	1.2	0.6, 2.3	59	18.5	120	26.2	0.7	0.5, 1.0
Ready-to-eat chicken products	4	1.2	6	1.3	1.1	0.3, 4.0	11	3.2	30	6.5	0.5	0.2, 1.1
Turkey	9	2.8	22	4.8	0.5	0.2, 1.3	69	21.5	123	26.7	0.7	0.5, 1.1
Ready-to-eat turkey products	4	1.2	4	0.9	1.4	0.3, 5.6	8	2.4	19	4.1	0.5	0.2, 1.3
Ground beef, any	38	11.6	58	12.6	1.0	0.6, 1.6	132	41.8	218	47.6	0.9	0.7, 1.2
Ground beef, raw	2	0.6	4	0.9	1.0	0.2, 6.1	11	3.3	19	4.1	0.8	0.3, 1.7
Beef, rare	12	3.6	9	2.0	1.6	0.6, 4.1	65	19.8	101	22.0	0.9	0.6, 1.3
Meatballs (ground pork and veal)	11	3.6	34	7.4	0.5	0.2, 1.0	136	44.3	228	49.6	0.8	0.6, 1.1
Other dishes made from ground meat	2	0.6	12	2.6	0.1	0.0, 1.1	31	9.1	69	15.0	0.6	0.4, 1.0

* The analyses included 340 cases and 467 controls matched by time, gender, birthday, and county. The percentage exposed was calculated after exclusion of individuals with missing information. Exposure windows included the day and the week before disease onset (cases) or interview (controls).

† Odds ratio from conditional logistic regression analyses after pooling of exchangeable strata.

‡ CI, confidence interval.

with foreign travel. However, travel outside of Denmark increased the risk of infection with PT 1, PT 4, PT 21, and other phage types. There was no significant interaction between travel and calendar time, age, or season.

Table 2 presents odds ratios for major food exposures calculated by applying both a 1-day exposure window and a 1-week exposure window. With the 1-week window, only eating dishes prepared with raw or undercooked eggs was found to be associated with increased risk of *S.* Enteritidis infection. When exposure was restricted to a 1-day window, consumption of eggs, consumption of dishes containing raw or undercooked eggs, and these two variables combined were all associated with increased risk. We also evaluated the data using a 3-day window (from 2 days before disease onset to same-day exposure). Out of 334 cases, 194 (58.1 percent) had eaten eggs or food prepared with raw or undercooked eggs, as compared with 203 (43.5 percent) of 467 controls (OR = 1.7, 95 percent CI: 1.2, 2.3). There was no

TABLE 3. Phage-type-specific associations of *Salmonella* Enteritidis infection with consumption of table eggs or dishes prepared with raw eggs, Denmark, 1997–1999*

Phage type	Exposed		Total	Odds ratio†	95% confidence interval
	No.	%			
8	48	38.7	124	2.8	1.8, 4.4
6	27	27.8	97	1.7	1.0, 2.9
4	6	24.0	25	1.3	0.5, 3.5
1	2	40.0	5	3.4	0.5, 24.0
Other/nontypeable	17	43.6	39	3.4	1.7, 6.8

* The exposure window was the day before disease onset (cases) or interview (controls).

† Odds ratio from polytomous multivariable logistic regression comparing cases with 467 matched controls.

TABLE 4. Specific egg-related risk factors for *Salmonella* Enteritidis infection acquired in Denmark, 1997–1999*

Egg-containing food item	Cases		Controls		Odds ratio†	95% confidence interval
	No.	%	No.	%		
Buttermilk dessert containing raw eggs	20	5.9	2	0.4	11.7	2.6, 52.2
Homemade ice cream	8	2.4	4	0.9	4.3	1.1, 16.6
Raw egg yolk, egg white, or egg nog	14	4.1	6	1.3	3.4	1.2, 9.9
Eggs fried "sunny side up"	34	10.2	25	5.4	2.5	1.4, 4.6
Omelette	9	2.7	7	1.5	1.7	0.6, 4.9
Mousse au chocolat or similar dessert	6	1.8	3	0.6	1.7	0.4, 7.3
Hard-boiled egg	45	13.4	58	12.4	1.0	0.7, 1.6
Soft-boiled egg	23	6.8	32	6.9	1.0	0.5, 1.7
Scrambled eggs	11	3.3	20	4.3	0.7	0.3, 1.5
Other	18	5.3	26	5.6	0.8	0.4, 1.6

* The analyses included 340 cases and 467 controls matched by time, gender, birthday, and county. The percentage exposed was calculated after exclusion of individuals with missing information. The exposure window was the day before disease onset (cases) or interview (controls).

† Odds ratio from conditional logistic regression analyses after pooling of exchangeable strata.

significant interaction between the overall egg variable (eggs or food prepared with raw or undercooked eggs) and time, age, or season. The overall egg variable was, by and large, associated with illness independently of phage type (table 3). None of the other food exposures, including consumption of broiler chickens and other poultry, were associated with increased risk of disease.

Table 4 shows specific egg-related risk factors. This analysis was based on the 1-day exposure window, and it showed that the highest risk was associated with consumption of homemade buttermilk dessert prepared with eggs (OR = 11.7). In the week before onset of disease/interview, 30 (8.9 percent) of 337 cases and 21 (4.5 percent) of 467 controls had eaten homemade buttermilk dessert (OR = 2.0, 95 percent CI: 1.1, 3.8). Other preparations associated with *S.* Enteritidis infection included homemade ice cream (OR = 4.3), raw eggs (OR = 3.4), and eggs fried "sunny side up" (OR = 2.5).

Two hundred and fifty-seven (79.8 percent) of 322 cases and 412 (88.6 percent) of 465 controls had used eggs in their household meals during the 1-week period before disease onset/interview (OR = 0.5, 95 percent CI: 0.3, 0.8). These persons were asked about the types of eggs they had used or handled; multiple answers were allowed. Table 5 shows that the use of eggs from battery flocks was associated with *S.* Enteritidis infection, that there was a modest risk associated with eggs obtained from hens reared in deep litter or a free-range production system, and that pasteurized eggs tended to be associated with a decreased risk of infection.

TABLE 5. Odds ratio for *Salmonella* Enteritidis infection according to the type of eggs used in household meals, Denmark, 1997–1999*

Type of eggs used	Cases		Controls		Odds ratio†	95% CI‡	Multivariate odds ratio†	95% CI
	No.	%	No.	%				
White table eggs from battery flocks	48	19.8	38	9.4	2.4	1.5, 3.8	2.4	1.3, 4.3
Brown table eggs from battery flocks	47	19.7	46	11.3	1.9	1.2, 3.0	1.9	1.1, 3.3
Eggs from deep litter or free-range production	125	51.0	195	47.8	1.1	0.8, 1.6	1.5	1.0, 2.4
Eggs from organic production	36	14.6	107	26.3	0.5	0.3, 0.8	0.7	0.4, 1.2
Eggs sold at barnyards	49	19.8	109	26.5	0.6	0.4, 0.9	0.8	0.5, 1.3
Pasteurized egg products	4	1.6	16	3.9	0.5	0.1, 1.4	0.3	0.1, 1.2

* The analyses included 251 cases and 412 controls who had used eggs in household meals during the 7-day period before disease onset (cases) or interview (controls). The percentage exposed was calculated after exclusion of individuals with missing information.

† Odds ratio from conditional logistic regression analyses after pooling of exchangeable strata.

Of 337 case patients, 158 (46.9 percent) reported that they followed procedures for the safe handling of eggs (OR = 0.6, 95 percent CI: 0.4, 0.8), as compared with 290 (62.5 percent) of 464 controls. Typical procedures reported included briefly scalding shell eggs prior to use, breaking eggs in a separate cup before pooling with other ingredients, and washing one's hands after handling eggs.

Host factors (such as use of various medications, including antibiotics) and chronic diseases (diabetes mellitus, chronic gastrointestinal or liver disease, cancer, and immunodeficiency) were not found to be associated with *Salmonella* infection in the present study. Furthermore, contact with pets or wildlife or animal husbandry was not associated with disease. Twenty-one (6.2 percent) of 340 patients and 35 (7.5 percent) of 465 controls had had contact with live poultry, mainly laying hens or other chickens (OR = 0.8, 95 percent CI: 0.4, 1.5).

DISCUSSION

Salmonella Enteritidis was one of the first of the recently emerging pathogens to be noted (17). Several years ago, its pandemic spread in the human populations of Europe and the Americas was suggested to be associated with modern intensive egg production (1). *S.* Enteritidis may colonize the ovaries and periovarian tissue of modern breeds of laying hens, and thus it has the potential for vertical transmission from breeders to layers and then to eggs sold for human consumption (17–19). Outbreak investigations and other studies (2–6) have indicated that a principal cause of *S.* Enteritidis infection is consumption of raw or undercooked eggs or dishes contaminated with raw eggs. This hypothesis has been corroborated by the results of case-control studies of risk factors for sporadic *S.* Enteritidis infection (7–12).

The incidence of *S.* Enteritidis increased several years later in Denmark than in the United States, the United Kingdom, and Central Europe; and unlike the case in the rest of Europe, PT 4 was not found to be the most prevalent strain in Denmark (1, 4, 17, 20). In 1997, when the epidemic peaked in Denmark, the overall incidence of reported infection with non-Typhoidal *Salmonella* serotypes was 95 cases per 100,000 population. As many as 73 percent of these infections were due to the Enteritidis serotype, with PT 6 (39 percent) and PT 8 (33 percent) being the two most common phage types (13). On the basis of systematic phage typing of isolates collected from humans and from the food chain, we previously estimated that 55–65 percent of all salmonellosis cases in Denmark could be attributed to eggs (13). Outbreaks of *S.* Enteritidis infection associated with eggs provided additional evidence suggesting that the increase in human infection was being caused by the spread of *Salmonella* among Danish laying hens. Importation of infected birds to the top of the breeding pyramid was probably the reason for the rapid spread of *Salmonella* in the egg production system (13, 21).

A national plan for controlling the problem was implemented in 1996–1998 (21). This plan was based on serologic and bacteriologic surveillance of all commercial egg-producing chicken flocks, as well as rearing stations and breeders. From March 1998 onward, eggs from *Salmonella*-positive flocks were heat-treated. The plan was accompanied by various measures to improve hygiene and to limit the spread of *Salmonella* in egg production systems (21).

We conducted the present case-control study to address the hypothesis that a major source of *S.* Enteritidis infection in Denmark was eggs, but also to identify other important vehicles and sources of *S.* Enteritidis. Furthermore, we wanted to examine changes in risk factors over time, possibly due to the effect of the national intervention plan described above.

As other investigators have found (11), foreign travel was a major risk factor for *Salmonella* infection in this study. We were unable to determine whether these infections were associated with eggs consumed abroad or other sources. Table 1 shows that infections with PT 4 (OR = 27.1) and PT 1 (OR = 71.3) were strongly associated with travel. PT 4 was the major egg strain emerging in the United Kingdom and other European countries in the early 1990s (1, 2, 7, 11, 22). PT 1 has previously been associated with travel to Southern Europe, and it has caused outbreaks traced back to eggs (22, 23). It is therefore conceivable that a large number of the travel-associated infections were acquired from eggs. Furthermore, it is striking that the two major Danish phage types, PT 6 and PT 8, were not associated with travel. These strains were the most common phage types found in Danish laying hens during the time period of the present study (13, 21, 23).

Our analyses of phage-type-specific risk factors were undertaken by polytomous logistic regression (16). This was a suitable approach, because the outcome of interest could be described by a fixed set of possible response values, depending on the phage type of the isolated *S.* Enteritidis strain. This method, which may be applied to responses of both nominal and ordinal scale, has several advantages compared with repeated subgroup analyses of specific outcomes. For example, some risk factors may be shared for all responses, whereas others may be specific to a certain outcome. This can be addressed in one model through the use of polytomous logistic regression. There is limited loss of statistical power in comparison with a standard logistic regression model. Furthermore, there is no "recycling" of control subjects in different subgroup analyses. One of the limitations of the approach is that the number of responses in each category must not be too low; otherwise the estimation and the goodness of fit become problematic.

Eggs are commonly used in Danish households, and as many as 80 percent of our cases and 81 percent of controls had consumed eggs or dishes prepared with raw eggs in a 7-day period. However, when we narrowed the exposure window from 1 week to 3 days and then to 1 day, we found an increasing strength of association. Thus, by applying a 3-day exposure window instead of a 7-day window, we found that the odds ratio increased from 0.8 to 1.6. When we focused on the day on which most patients had incurred the relevant exposure leading to infection—that is, the day before onset of disease—this odds ratio increased to 2.2. Particularly strong risks were associated with consumption of homemade buttermilk dessert, homemade ice cream, raw eggs, or eggs fried sunny side up; all of these dishes involve raw or undercooked eggs. The buttermilk dessert is a tradi-

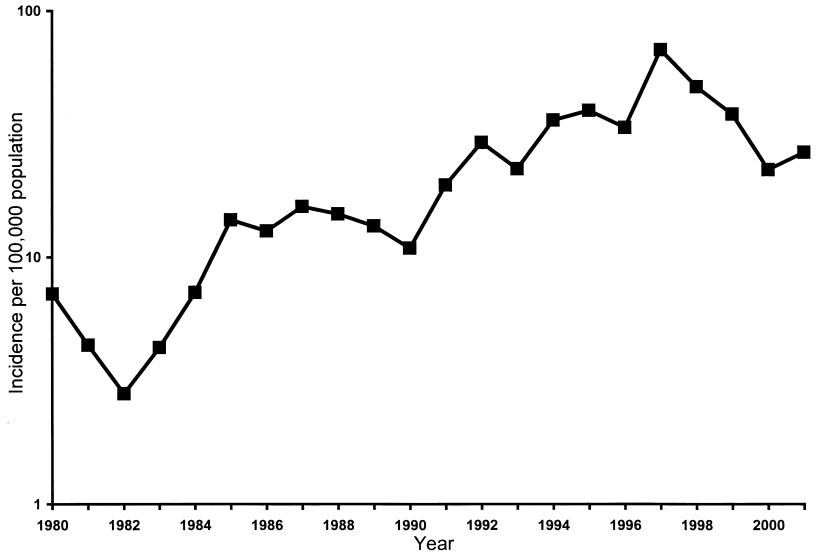

FIGURE 1. Incidence of *Salmonella* Enteritidis infection among humans in Denmark, 1980–2001.

tional and popular Danish summer dish, and it is available as a pasteurized commercial product. However, almost one out of 10 patients had eaten homemade buttermilk dessert made with raw eggs during the week before disease onset. We suggest that homemade buttermilk dessert may be a major risk factor for *S.* Enteritidis infection in Denmark.

At the beginning of 1998, there were considerable differences between the prevalences of *Salmonella* in the different systems of table egg production (battery, 35 percent positive; deep litter, 23 percent positive; free-range, 18 percent positive; organic, 9 percent positive). This difference was considered not to be due to the type of production but rather to depend on the hatchery, since many battery and deep litter producers were supplied by one particular hatchery that experienced *Salmonella* problems (24). In the present study, 257 case patients and 412 controls had used eggs in household meals, and among these individuals we found that illness was associated with eggs from battery, deep litter, and free-range production, whereas we were unable to demonstrate an association with organic eggs or eggs sold at barnyards. This observation is in line with the prevalences reported above. Consumption of pasteurized products tended to be protective.

Only about 50 percent of our case patients ate eggs or dishes containing undercooked eggs during the 3 days before disease onset. Unlike the results of studies from England (7) and France (11), no other food exposures, including consumption of broiler chickens, were found to be associated with *S.* Enteritidis infection. Why did the other half get sick?

Case-control studies of foodborne infection have limitations (25, 26). Estimates are often conservative because of recall bias. This issue is particularly important when the aim is to address the role of common exposures, such as consumption of eggs, meat, and poultry. Many factors, including the type of product as well as methods of storage, handling, and preparation, are critical in the chain of events leading to ingestion of infectious inoculums of bacteria. Cross-contamination from raw products to ready-to-eat food items is inherently difficult to investigate beyond the outbreak situation. Under these conditions, it may be hard to record precise information on the relevant exposure variables for all patients and controls.

It was interesting in our study that a higher proportion of controls than of cases claimed that they followed procedures for the safe handling of eggs. Our data did not allow for evaluation of specific procedures. Nevertheless, the finding suggests that behavioral factors may play an important role.

Finally, 28 percent of the cases had acquaintances or family members with gastroenteritis at the same time as the respondent. This high proportion mirrors the epidemic potential of *S.* Enteritidis in eggs and the fact that many household outbreaks are not noticed in current surveillance systems. However, some patients may have acquired the infection through person-to-person transmission, as suggested by other investigators (12, 27). For these patients, many of whom may be young children, the original source of infection is obscure.

Because of these methodological reservations, we suggest that the results of the present study be regarded as signals rather than precise measures of association that can be converted to population attributable fractions. However, we emphasize that these signals were strong, and they incriminated eggs from domestic commercial egg producers as a principal source of human infection. This was particularly true for PT 8 and PT 6.

Implementation of the Danish *Salmonella* control program, including the withdrawal of eggs from infected holdings, led rapidly to a decrease in the number of flocks infected (21, 24). This was mirrored by a decrease in the number of human cases of *S.* Enteritidis, as shown in figure 1. However, it is interesting that eggs continued to be a risk

factor for *S.* Enteritidis infection in Denmark during this period. The control program does not ensure freedom from *S.* Enteritidis in the egg supply, because some infected flocks may be missed by the monitoring system. Furthermore, there is a gap between the time a laying flock becomes infected and the time *Salmonella* is detected by surveillance. This gap is up to 9 weeks long in the Danish program. Infected eggs can reach the market during that time. Finally, the control program does not cover eggs imported from other countries. The proportion of *Salmonella* cases associated with foreign travel did not increase significantly in this period. The simultaneous decline in travel-associated cases probably reflected an overall decline in *S.* Enteritidis infection in Europe during the period (28). In addition, increased consumer awareness may have played a role.

The present case-control study confirmed the hypothesis that contaminated shell eggs are a primary source of human *S.* Enteritidis infection and that this risk is particularly associated with consumption of specific dishes containing raw or runny eggs. In Danish surveillance of the food supply, phage typing has played a pivotal role in quantifying sources of infection (13, 21, 24), and the present study provided analytical epidemiologic evidence to support this approach.

We recommend that other investigators who wish to address risk factors for foodborne infections design their study questionnaire in a way that allows modeling of different exposure windows, if possible. This method is particularly worth considering if the objective is to study common food exposures such as eggs, poultry, and meat. Stronger signals may be obtained by using an exposure classification that corresponds to the most common period of incubation rather than the maximum period.

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