

Ensuring safety of home-produced eggs to control salmonellosis in Poland: lessons from an outbreak in September 2011

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Implementation of control measures in line with European Commission regulations has led to a decrease in salmonellosis in the European Union since 2004. However, control programmes do not address laying hens whose eggs are produced for personal consumption or local sale. This article reports an investigation of a salmonellosis outbreak linked to home-produced eggs following a family event held in a farm in September 2011 near Warsaw, Poland. In the outbreak, 34 people developed gastroenteritis symptoms. Results from a cohort study indicated a cake, prepared from raw home-produced eggs, as the vehicle of the outbreak. Laboratory analysis identified *Salmonella enterica* serotype Enteritidis (*S. Enteritidis*) in stool samples or rectal swabs from 18 of 24 people and in two egg samples. As no food items remained, we used phage typing to link the source of the outbreak with the isolated strains. Seven *S. Enteritidis* strains analysed (five from attendees and two from eggs) were phage type 21c. Our findings resulted in culling of the infected laying hens and symptomatic pigeons housed next to the hens. *Salmonella* poses as a public health problem in Poland: control measures should not forget home-produced eggs, as there is a risk of infection from their consumption.

Introduction

In Europe, infection with *Salmonella* is a common cause of gastroenteritis [1]. *Salmonella enterica* serotype Enteritidis (*S. Enteritidis*) remains frequently reported, accounting in 2009 for 57% of all *Salmonella* serotypes [1]. Infection with *S. Enteritidis* is primarily linked to ingestion of contaminated meat or egg products [2]. Phage typing is a tool that is used to establish links between poultry flocks infected with *S. Enteritidis* and outbreaks among humans [3]. It can also be used to assess strains currently in circulation [4] and identify temporal trends [5]. It is not, however, routinely performed in many European countries, including Poland [4].

To prevent *Salmonella* infections, a number of control programmes have been implemented in the poultry industry within the European Union (EU) [1], including screening of laying hens, as recommended by the European Commission [6]. The introduction of programmes targeting laying hens has resulted in an overall decrease in the number of cases of *Salmonella* infection in the EU since 2004 [7]. However, under current regulations of the European Commission on the control of *Salmonella*, private farms producing table eggs (i.e. eggs produced or used for human consumption) for their own consumption or for sale to local retailers are exempt from current screening processes [8].

Despite the overall decrease in outbreaks of *Salmonella* infection in the EU, surveillance data since 1991 in Poland have shown that egg products play a pivotal role in the occurrence of salmonellosis outbreaks in humans, with 63% of the outbreaks between 2005 and 2010 being linked to this source [9]. The most striking increase has been in the proportion of outbreaks due to *S. Enteritidis* infection linked with the consumption of home-produced eggs: surveillance data show an increase from 76% of all *S. Enteritidis* outbreaks in 2004 to 82% in 2010 [9].

On 7 September 2011, a physician alerted the public health authority in Otwock, Poland, reporting that five people had fallen ill with gastroenteritis following a family event held three days earlier at a farm in the suburbs of Warsaw. The aim of our outbreak investigation was to stop the occurrence of cases, identify the source and explore ways to improve salmonellosis control in the long term at the household level.

Methods

Outbreak case definition

We defined a probable case of gastroenteritis as a person who took part in the family event on 4 September 2011 or who ate food that was brought home from the event and then developed diarrhoea, vomiting, stomach ache or temperature higher than 39 °C within 72 hours after consumption.

We defined a confirmed case of gastroenteritis as a probable case with laboratory confirmation of infection with *S. Enteritidis*.

Descriptive epidemiology

The hosts of the family event provided a list of addresses and contact numbers of all attendees of the family event. The public health authority collected information regarding demographics and health status of all the attendees and those identified during the outbreak investigation, in addition to a comprehensive list of all food and beverages consumed during lunch, dinner and dessert at the event. Initially, probable cases completed an open-ended, hypothesis-generating paper questionnaire: the majority were administered via telephone by the local authorities four days following the event. The questionnaire was a routine outbreak form, mainly focused on food consumption, with some additional questions regarding animal contact and travel within the previous two weeks. The National Institute of Public Health - National Institute of Hygiene then prepared a closed-ended questionnaire to be completed by all people on the list provided by the hosts and those identified during the investigation, to collect information on food/beverage items consumed during or after the family event and symptoms experienced. These close-ended questionnaires were administered, mainly via telephone, nine days after the event by each local health authority involved. Laboratory test results were added to the questionnaire results by the local health authorities or, in the case of phage typing, by the microbiology department at the National Institute in Warsaw.

Analytical epidemiology

We conducted a retrospective cohort study among attendees of the family event only. We calculated the risk of illness among people who had consumed food items and beverages, comparing this with the risk in people who had not consumed the same items. This yielded food/beverage-specific attack rates (ARs), relative risks (RRs) and 95% confidence intervals (CIs). We checked for effect modification and then established factors associated with becoming a case using multiple logistic regression. We included variables in the model if they had a p value of less than 0.2. We excluded attendees identified as asymptotically infected and those for whom basic information (e.g. age and items consumed at the event) was missing. Stata 10 was used for the statistical analysis [10].

Laboratory investigation

Human samples

Physicians collected stool specimens or rectal swabs from symptomatic and healthy people who consented (from 17 attendees and four people who ate food after the event). Local laboratories tested these samples for adenovirus, rotavirus and norovirus and cultured for *Salmonella*.

Antibiotic susceptibility profiles of *Salmonella* strains from four specimens were determined for treatment purposes [11,12]. These strains were from the first four cases, who lived in the farmhouse or surrounding houses on the premises

The laboratory at the National Institute of Public Health-National Institute of Hygiene phage typed these same *Salmonella* strains cultured from stool specimens of the first four cases [13]. We identified phage types (PTs) using reference phages provided by the Health Protection Agency, Colindale, United Kingdom.

In addition, the public health authority collected stool specimens from two attendees who had been involved in the preparation of food for the event who lived on the premises where the event had been held (one of whom was a professional food handler). The strain from the stool culture of this professional food handler was also phage typed and the antibiotic susceptibility profile was determined. The health authorities also collected a stool specimen from an additional food handler who attended the family event, but did not take part in the food preparation. The reason for collection of specimens from these persons was to identify any asymptomatic infections that could have constituted sources of secondary infections or clusters.

Extended laboratory and environmental investigations

The public health authority also requested information from the hosts regarding where the food had been prepared and stored, as well as details of the cold chain. In addition, the people involved in food preparation were asked about how the meals were served and the cutlery used during serving (e.g. knives).

Swabs were not taken from kitchen equipment at the event. As the event was held at a private residence, the taking of swabs in Poland is not currently required by law. In addition, the food safety authority visited the premises three days after the event, at which point the equipment had been cleaned. No left-over food items from the event were available for testing, thus phage typing of environmental and clinical isolates was used to identify the potential source of the outbreak. Raw eggs from the laying hens that resided on the farm had been used in food preparation for the event. As there were no samples available from the eggs used, fresh eggs from the flock were taken for laboratory analysis.

No samples were taken from pigeons that lived in an aviary situated next to the laying hens.

Once the public health authority had received initial notification of the outbreak, they informed the local veterinarian, a legal requirement in Poland.

Results

An overview of the inclusion/exclusion criteria for the cohort analysis and the results of the laboratory analysis are shown in Figure 1.

Descriptive epidemiology

The event, held on 4 September, took place on the hosts' farm, where two families plus tenants lived (n=11), in the farmhouse or surrounding houses on the premises. The hosts of the event kept 17 laying hens and 80 pigeons in adjacent aviaries.

A total of 57 people attended the event, of which 26 were symptomatic. Food taken home from the event was eaten later by eight people (all developed symptoms). Two attendees were involved in preparing food for the event (one of whom was a professional food handler). An additional food handler attended the

event but was not involved in food preparation. All of those living on the farm premises (n=11) attended the event.

In the open-ended (trawling) questionnaires administered to probable cases, we found that numerous names were used for the cakes at the event, making it hard for us to compare the answers. Thus there was an intentional overlap between the open-ended and closed-ended questionnaires, to clarify any ambiguity.

The closed-ended questionnaire was administered to 65 people linked with the outbreak: 57 attendees (including the two people who prepared the food for the event) plus eight who ate food from the event later. We obtained information on sex and health status (healthy vs symptomatic) from all 65 people: if the person did not complete the questionnaire, the information was provided by the hosts or family members. The 65 people resided in six districts located in two provinces: 33/65 were female.

Of the 65, 18 were probable and 16 were confirmed cases. Symptoms of the 34 cases included diarrhoea (n=32), temperature >39 °C (n=26), vomiting (n=22),

FIGURE 1

Inclusion/exclusion criteria for cohort analysis and results of laboratory analysis, *Salmonella* outbreak related to a family event, Warsaw, Poland, September 2011

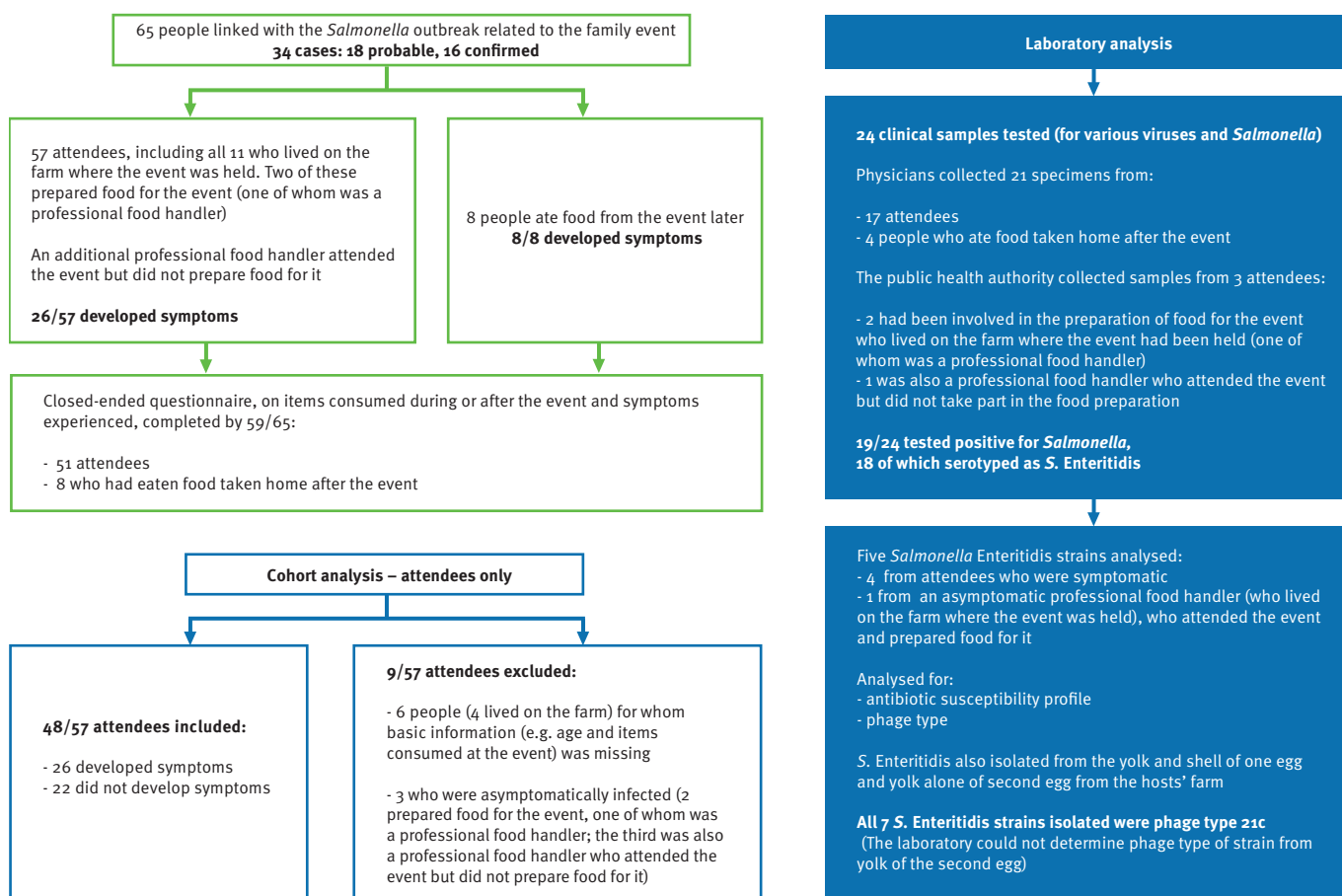


TABLE 1

Demographic details of people who attended^a or ate food from a family event later, Warsaw, Poland, September 2011 (n=65)

Demographic information	Cases ^b	Total	AR (%)
Age (years)			
<19	9	14	64
20–39	12	22	55
40–59	7	13	54
≥60	6	10	60
Unknown	0	6	0
Sex			
Female	17	33	52
Male	17	32	53

AR: attack rate.

^a Includes two attendees who prepared food for the event (one of whom was a professional food handler).

^b Probable (n=18) and confirmed (n=16).

stomach cramps (n=13) and nausea (n=2). Four of the 34 were hospitalised.

The overall attack rate was 52% (34/65); the rates were similar in all age groups and by sex (Table 1).

A total of 59 people completed the close-ended questionnaires: 51 attendees (including the two food handlers), eight who had eaten food brought home after the event. Information on age was missing for six people: of the 59 who provided the information, the median age was 36 years (range: 4–88).

The outbreak began on 4 September (the day of the event); the number of cases peaked between midnight and noon the following day and subsequently decreased (Figure). Time of symptom onset was provided by 29 cases: the remaining five could not recall the exact or approximate time. Of these 29 cases, 19 reported symptoms within 24 hours of the event (range: 3.5–69 hours).

Analytical epidemiology

The cohort study comprised 48 attendees; nine attendees were excluded, in accordance with the criteria: six did not provide information on food consumption (four of whom lived on the farm) and three were asymptotically infected with *S. Enteritidis* (two of whom lived on the farm). Of the 48 attendees, 26 developed symptoms (14 probable and 12 confirmed cases). People who ate angel cake (RR: 3.2; 95% CI: 1.7–6.2), cream cake (RR: 1.9; 95% CI: 1.4–2.6) and caramel cake (RR: 1.8; 95% CI: 1.4–2.4) were more likely to become ill (Table 2). Angel cake was eaten by most people in

the cohort: 19 out of the 26 people who became ill ate it. Furthermore, three of four people who ate cream cake and/or caramel cake and became ill also ate angel cake. The remaining seven people who became ill but did not eat angel cake ate the following cakes: éclairs and cream cake (n=1), éclairs only (n=5) and a cake not on the list of food items collected (n=1).

To explore whether cream cake or éclairs also acted as vehicles of infection, we examined the risk of developing symptoms for people who had eaten these cakes, according to whether they had eaten angel cake (Table 3). People who ate cream cake, but not angel cake, were four times more likely to become ill (RR: 4.00; 95% CI: 2.00–8.00). Consumption of éclairs was associated with a higher risk of illness, but this was not significant (RR: 4.71; 95% CI: 0.66–33.61). Stratification by caramel cake consumption was not possible because no one had been exposed to this cake alone.

Taking the results from our initial analysis into account, our multivariable model indicated consumption of angel cake as the only factor associated with illness (aOR: 192; 95% CI: 7–5,200) (Table 2). Cream cake was not included in the model as a result of colinearity.

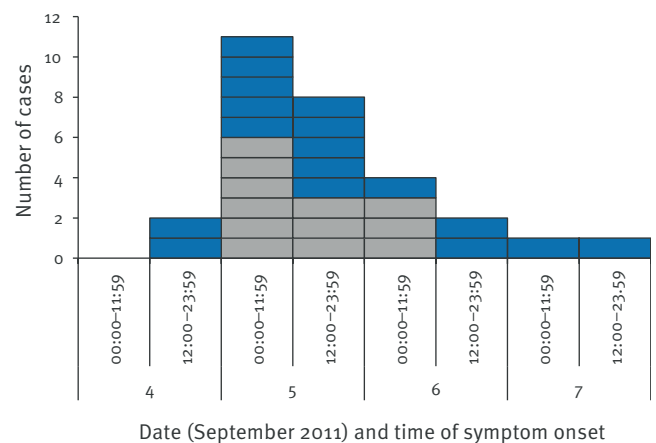
Laboratory investigation

Human samples

A total of 24 rectal swabs/stool specimens were collected: physicians collected samples from 21 people (17 attendees and four from people who ate food after the event) and the public health authority collected samples from the three food handlers/people involved

FIGURE 2

Cases of gastroenteritis by time of symptom onset, Warsaw, Poland, September 2011 (n=29)^a



Blue boxes represent probable cases (17 of 18 identified), grey boxes represent confirmed cases (12 of 16 identified).

^a Time of symptom onset was unknown for five of the 34 cases.

TABLE 2

Attack rate of gastroenteritis according to consumption of food items and beverages among attendees at a family event, Warsaw, Poland, September 2011 (n=48)

Type of meal/ beverage	Exposure ^a	Consumed			Did not consume			RR	95% CI	p value	aOR	95% CI
		Cases ^b	Total	AR (%)	Cases ^b	Total	AR (%)					
Lunch	Chicken soup	9	14	64	17	32	53	1.2	0.7–2.0	0.48	–	–
	Pork chop	9	15	60	17	31	55	1.1	0.7–1.8	0.74	–	–
	Tripe	16	32	50	10	14	71	0.7	0.4–1.1	0.18	0.1	0.01–1.7
	Cabbage salad	4	11	36	22	35	63	0.6	0.3–1.3	0.12	0.1	0.004–2.8
	Potatoes	8	21	38	18	25	72	0.5	0.3–0.9	0.02	0.1	0.01–1.3
Dinner	Chicken	2	2	100	24	44	55	1.8	1.4–2.4	0.21	–	–
	'Bigos' (meat stew)	5	6	83	21	40	53	1.6	1.0–2.5	0.16	82	0.7–10,290
Dessert	Angel cake	19	21	91	7	25	28	3.2	1.7–6.2	0.01	192	7–5,200
	Cream cake ^c	4	4	100	22	42	52	1.9	1.4–2.6	0.07	–	–
	Caramel cake	2	2	100	24	44	55	1.8	1.4–2.4	0.21	–	–
	Apples in jelly	5	7	71	21	39	54	1.3	0.8–2.3	0.39	–	–
	Eclairs	14	23	61	12	23	52	1.2	0.7–1.9	0.55	–	–
Alcohol	Vodka	4	9	44	3	12	25	1.8	0.5–6.0	0.35	–	–

aOR: adjusted odds ratio; AR: attack rate; CI: confidence interval; RR: relative risk.

The shaded rows represent items for which $p < 0.2$ and were therefore included in the multiple logistic regression model.

^a Food items and beverages provided by the hosts.

^b Probable (n=14) and confirmed (n=12).

^c Not included in the multiple logistic regression model due to colinearity.

in food preparation who also attended the events. Of the 24, 19 tested positive for *Salmonella*, 18 of which serotyped as *S. Enteritidis* (the 19th sample – from an attendee who did not live on the farm – was reported as *Salmonella* spp.). The laboratory did not identify any other pathogens in the samples, 17 of which were from attendees and four from people who ate food after the event.

Of the 18 serotyped strains, three were from attendees who did not have symptoms, two of whom were professional food handlers, one of whom was involved in food preparation for the event alongside the third asymptomatic individual. The public health authority exempted the two professional food handlers from work until they provided three consecutively negative samples.

Antimicrobial susceptibility profiles were determined for the same five strains that were phage typed. All were fully sensitive to ciprofloxacin, furazolidone, trimethoprim/sulfamethoxazole and had medium sensitivity to ampicillin and amoxicillin/clavulanic acid.

These same five strains of *S. Enteritidis* were phage typed as 21c. Apart from the strains isolated from the egg samples (described below), no other strains were phage typed due to financial constraints.

Extended laboratory and environmental investigations

S. Enteritidis was also isolated from the yolk and shell of one egg and the yolk alone of a second taken from the event hosts' laying hens. Two *Salmonella* strains isolated from the first egg were phage typed as 21c. The laboratory could not determine the phage type of the strain isolated from the yolk of the second egg.

The hosts used raw eggs, collected four days before the event from their laying hens, in the preparation of a quadruple cream-layered angel cake. During inspection by the public health authority, the hosts explained that all cakes had been stored at room temperature alongside other dishes on a warm autumn day. All cakes had been set out on the table on the same serving plate along with one knife.

During the outbreak investigation, the hosts informed the public health authority that half of their pigeons had fallen ill. The pigeons were then diagnosed as being infected with *Salmonella* by a veterinarian on the basis of their symptoms (the veterinarian did not conduct any laboratory tests on the pigeons). Due to the timing of the symptoms, it was assumed that the pigeons were also infected with *Salmonella*.

Given the laboratory results from the egg samples from the hosts laying hens and recommendation from the

TABLE 3

Cases of gastroenteritis among people who ate different types of cake at a family event, Warsaw, Poland, September 2011 (n=48)

Exposure to angel cake	By consumption of cake type	Cases ^a	Total	AR (%)	RR	95% CI
Yes	Cream cake	3	3	100	1.13	0.96–1.32
	No cream cake	16	18	89		
No	Cream cake	1	1	100	4.00	2.00–8.00
	No cream cake	6	24	25		
Yes	Caramel cake	2	2	100	1.12	0.96–1.30
	No caramel cake	17	19	89		
No	Caramel cake ^b	0	0	0	–	–
	No caramel cake ^b	7	25	28		
Yes	Eclairs	8	9	89	0.97	0.73–1.29
	No éclairs	11	12	92		
No	Eclairs	6	14	43	4.71	0.66–33.61
	No éclairs	1	11	9		

AR: attack rate; CI: confidence interval; RR: relative risk.

^a Probable (n=14) and confirmed (n=12).^b No RR yielded due to zeros present in this stratum.

veterinarian, the hosts took action: they agreed to cull the entire flock of 17 laying hens and the 40 ill pigeons assumed to be infected, remove their bodies from the premises and disinfect the entire area where the animals lived. The veterinarian provided treatment for the remaining 40 non-symptomatic pigeons.

Discussion

This gastroenteritis outbreak, which affected just under half (26 of 57) attendees of a family event, was linked to infected home-produced eggs from laying hens. Results from the outbreak investigation identified a number of factors that could have contributed towards its occurrence. These included the use of an unprocessed contaminated ingredient, inappropriate storage, cross-contamination and infection of food handlers [14].

The distribution of probable and confirmed cases suggested a point source food-borne outbreak. Epidemiological investigations pointed to angel cake as the vehicle of infection. *S. Enteritidis* is frequently isolated in products made using raw eggs [15–19]. The hosts used raw eggs knowing their hens had not been screened for *Salmonella*. The general public often consider organic [20] or free-range chickens more likely to be *Salmonella* free [21]. However, unless poultry are subject to checks, such assumptions cannot be made. The frequency with which such checks should be carried out and the methods that should be used are issues that raise a number of challenges. Any decision would have to take into account the following

points: whether the outcome would result in a recommendation or a regulation, whether the focus should be on villages or individual farms; the age of the laying hens; and whether ‘new’ hens had been introduced into existing flocks, as well as the presence of other animals on the premises. Recommendations on the frequency of testing should be carefully evaluated especially in terms of cost-effectiveness and acceptability. They should also consider who would pay for screening or regulation. The debate would benefit from a panel of experts being called together, including those from the European Food Safety Authority, European Centre for Disease Prevention and Control and others involved in work with poultry and *Salmonella*. Such discussions would be pertinent, as use of raw eggs from flocks that are regularly screened for *Salmonella* could potentially have prevented the outbreak. Infections with *Salmonella* traced back to unscreened home-produced eggs emphasise the importance of screening laying hens in private residences.

The high attack rate (52%, 34/65) in this outbreak could be attributed in part to the lack of refrigeration of dishes as they were stored at room temperature on a warm day. Lack of refrigeration allowed *S. Enteritidis* to grow, as previously documented in other outbreaks [18,22,23]. Had the dishes been refrigerated, the attack rate may have been reduced.

People who only ate cream cake from the desserts offered were four times more likely to develop symptoms (Table 3). This, along with the fact that the cakes

were placed together on the same serving platter with a single knife, supports the hypothesis of cross-contamination. Furthermore, the hosts left all the cakes out on the table throughout the course of a warm afternoon, where the cakes could soften and mix with others. Cross-contamination is frequently reported in *S. Enteritidis* outbreaks [23,24], particularly in places where large quantities of food are served [17,25]. We could not document a significant association between consumption of éclairs and illness; however, similar cross-contamination may explain why five cases who ate only éclairs for dessert also became ill.

Given the absence of left-over food specimens, we used phage typing to establish a link between consumption of angel cake and symptoms of *Salmonella* infection. *S. Enteritidis* PT21c was found, documenting its presence in Poland. This phage type is rare [22]. Phage typing is a key tool, used in outbreaks and as part of surveillance to assess the strains currently in circulation [4]. However, as this technique is not routinely performed in Poland, we cannot determine whether PT21c is in frequent circulation in the country. Phage typing needs to be encouraged, particularly during outbreak investigations, in countries where case reports of *Salmonella* infection remain high. Other tools for subtyping *S. Enteritidis* include pulsed field gel electrophoresis (PFGE) [26] and multiple-locus variable-number tandem-repeat analysis (MVLA) [27]. PFGE is considered to have low discriminatory power for *S. Enteritidis*, especially in outbreak settings [27]. MVLA has been shown to have better discriminatory power than phage typing or PFGE [28]; however, this technique for *S. Enteritidis* typing is not currently used at the National Institute of Public Health- National Institute of Hygiene in Warsaw.

Study limitations

Physicians did not take stool specimens from all people in the cohort. We therefore cannot rule out the possibility that other members of the cohort, particularly those who lived on the premises where the event was held, were asymptotically infected with *Salmonella*. If they had been infected with the same strain, they should have been excluded from the cohort, as consumption of cake would not have affected them. In our cohort, we excluded all known asymptomatic infected people who had been tested (as they were food handlers or involved in food preparation for the event). Lack of identification and exclusion of any additional asymptomatic infected people would result in an underestimation of the strength of association we calculated. Thus, this limitation does not prevent us from concluding that the angel cake was the vehicle in this outbreak.

The small numbers in this outbreak limited interpretation of results from the analytical study, due to lack of power. Its findings, however, were indirectly supported and strengthened by the microbiological results.

Conclusions

Salmonella control activities, such as screening of laying hens, have helped decrease the number of cases of *Salmonella* infection reported in Poland; however, this outbreak points to gaps that still exist. Identifying home-produced eggs as the source of the outbreak indicates that privately owned hens are not adequately covered by measures in place. Furthermore, the high attack rate observed demonstrates the impact use of unscreened home-produced eggs can have in the population. This – along with surveillance data suggesting that home-produced eggs remain a common cause of outbreaks of *Salmonella* infection among humans in Poland [9] – calls for action. On the basis of our results, we suggest areas where changes to everyday practices could be of benefit. To bridge this gap in salmonellosis control, we need to actively engage the general public. First, the general public should ensure safety of their food through the use of screened eggs in dishes that require raw ingredients. Second, food items containing raw products should be kept and served separately. Third, products requiring refrigeration should be kept at low temperatures prior to consumption. In the context of outbreaks, phage typing is one of the tools that can be used to establish links between cases and sources, for example, in the absence of food items.

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