Risk of Salmonella infection with exposure to reptiles in England, 2004-2007

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Non-typhoidal *Salmonella* infections are a common cause of gastroenteritis in England. Non-Enteritidis, non-Typhimurium *Salmonella* serotypes have gained in relative importance in recent years, but their modes of transmission are poorly understood. In a large case-case study in England between 2004 and 2007, the association between exposure to reptiles and *Salmonella* illness was investigated using multivariable logistic regression. Recent reptile exposure was associated with *Salmonella* illness with an odds ratio of 2.46 (95% confidence interval: 1.57-3.85, $p<0.001$), with much stronger effects among children under five years of age. The exposure was rare, and a population attributable fraction was estimated as 0.9%. Among the *Salmonella* serotypes found in people exposed to reptiles, several non-Enteritidis, non-Typhimurium serotypes were strongly associated with exposure. Reptile exposure is a rare but significant risk factor for *Salmonella* illness in England, with much higher risk in children.

Introduction

Non-typhoidal *Salmonella* is the second most common bacterial cause of gastrointestinal infection in England and Wales. It was estimated to account for 116,000 cases of illness, 3,400 hospitalisations and 268 deaths in 1995 [1]. In recent years, there has been a decline in notified infections in England and Wales of the most common *Salmonella* serotype, *S.* Enteriditis, due to improved control of *Salmonella* in chicken flocks [2], meaning that non-Enteritidis non-Typhimurium serotypes of *Salmonella* are becoming of greater relative importance in the United Kingdom (UK) – see Figure 1 [3].

Epidemiological associations of *Salmonella* infections are mainly inferred from investigation of outbreaks [3], although these account for only a small proportion of notified cases. Furthermore, it is thought that as little as one in six cases of gastrointestinal illness are notified to public health authorities in the UK [4]. Therefore, understanding of the causes of *Salmonella* illness outside of recognised outbreaks is limited. Food- [5] and travel-related exposures [3] are believed to be the dominant causal factors. The role of other rarer modes of transmission at a population level is less well understood.

Salmonella are among the flora naturally found in the gastrointestinal tract of many reptiles [6]. Human infection with *Salmonella* acquired from contact with reptiles is a well-recognised phenomenon and a recent review article summarised recent reports of reptile-associated salmonellosis in Europe [7]: Some European countries (Belgium, Finland, France, Germany, Ireland, Latvia) had reports of confirmed or likely reptile-associated *Salmonella* cases. In the Netherlands, serotype attribution techniques based on past identifications were used to estimate the fraction of human isolates that could be accounted for by exposure to reptiles. It was concluded that although less than 1% of *Salmonella* isolates were attributable to exposure to reptiles and amphibians between 2000 and 2007, this proportion was increasing in recent years [7]. Other European countries reported no known cases of *Salmonella* associated with reptiles, although information on this kind of exposure might not have been available in notification data. In the United States (US), reptile-associated salmonellosis is well known: there are documented outbreaks of salmonellosis related to pet reptiles [8,9] and two case-control studies [10,11] have described contact with reptiles or amphibians as important risk factors for salmonellosis in children. We are not aware of any previous studies describing the population-wide effect of reptile-associated salmonellosis in the UK.

Salmonella taxonomy and nomenclature is complex. This study employs the standard Kaufmann-White serology-based naming system for serotypes described here. Serotypes are referred to by abbreviated versions of the full name: the formal title of *Salmonella* enterica serotype Enteritidis as is here abbreviated to *S.* Enteritidis.

The Co-ordinated Local Authority Sentinel Surveillance of Pathogens (CLASSP) study was conducted by the Health Protection Agency (HPA) to investigate the effects of a wide variety of exposures on the acquisition of gastrointestinal illness in the general population in England. Among these exposures pet ownership in general and exposure to reptiles in particular were investigated. The CLASSP study used a case-case format [12] which is a variation of the standard case-control methodology where cases of another disease (here *Campylobacter* infections) are used as control cases for comparison with the disease cases under investigation (here *Salmonella*).

The main theoretical advantages of the case-case methodology are that it should be able to avoid introduction of notification bias and to minimise recall bias. The main disadvantages are that no apparent effect may be observed if the exposure under investigation is associated with both diseases, and that the control group will differ from the ideal study base (here the general population).

The most commonly described epidemiological associations of *Campylobacter* infection are with handling or consumption of inadequately cooked chicken meat and foreign travel, particularly to developing countries [13]. Consumption of some other foods has been described as a risk factor (RF) for *Campylobacter* illness [14,15]. *Campylobacter* is not among the commensal bacteria known to be carried by reptiles [6] and none of the many large epidemiological studies looking at RFs associated with *Campylobacter* (including those referenced above) have cited reptiles or amphibians as significant associations with this disease.

The aims of our study were to test the hypothesis that recent exposure to a reptile is associated with development of a *Salmonella* illness after accounting for all important confounding effects and to calculate a population attributable fraction (PAF) for reptile ownership on all *Salmonella* infections occurring in England.

Methods

Data collection

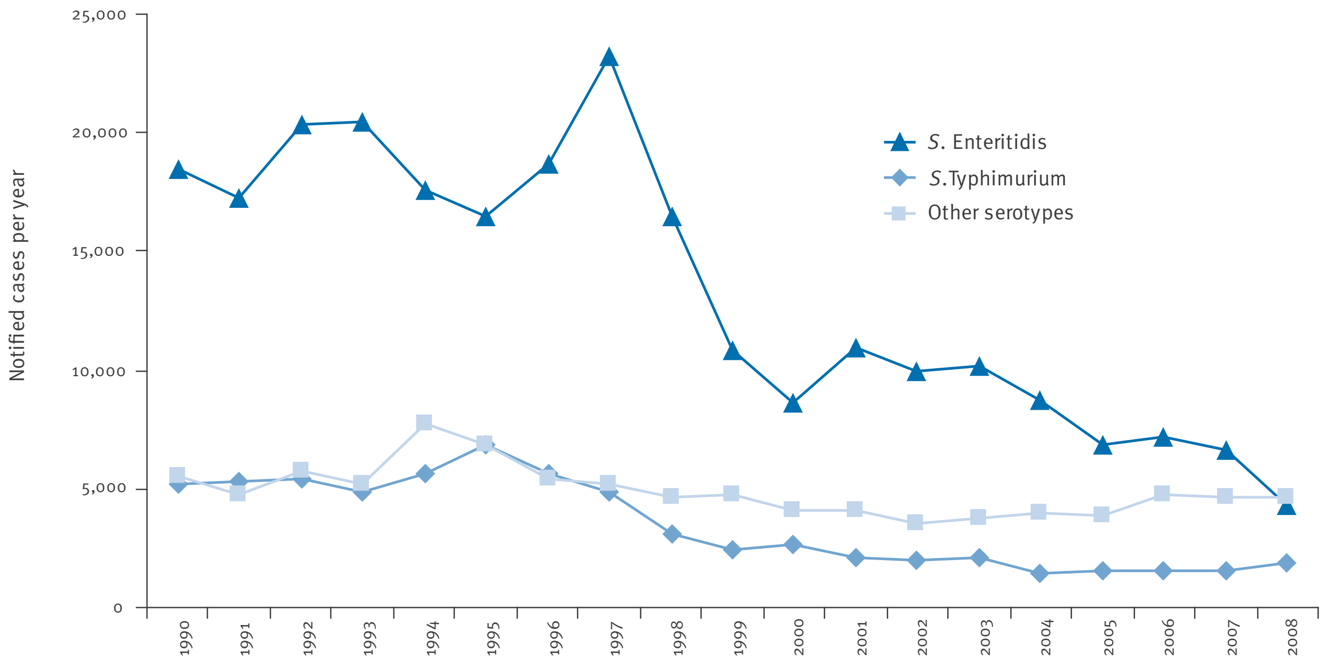
Health Protection Units of Local Authorities in England participated in the CLASSP study on a voluntary basis. Any individual resident in areas covered by these Local Authorities who had a microbiological isolate of either *Salmonella* or *Campylobacter* during the study period was eligible for inclusion. Information on exposures under investigation was collected using a standard study questionnaire covering a wide variety of plausible risk factors for acquisition of either *Salmonella* or *Campylobacter*. Questionnaires were filled in by Environmental Health Officers (who were unaware of the serotype of *Salmonella* isolates and to the hypothesis under investigation here) or were posted to the participants. Data entry and microbiological procedures were performed according to standard methods at HPA

Outcome and exposure variables

The outcome variable for this analysis was ‘type of infection’: either *Campylobacter* or *Salmonella*. Cases of *Campylobacter* were used as the control cases for this analysis with no matching of cases to controls. Questionnaires relating to infections with organisms other than non-typhoidal *Salmonella* or *Campylobacter* infections were excluded, as were records missing data for age, sex or cultural background.

Figure 1

Notified *Salmonella* infections in England and Wales, 1990-2008



Source: Health Protection Agency surveillance data.

A binary variable for the main exposure (ownership of reptiles) was derived by extraction of a variety of synonyms from the free text section of the CLASSP questionnaire relating to recent exposure to animals. The synonyms used for extraction were REPTILE, SNAKE, LIZARD, TORTOISE, TURTLE, TERRAPIN, DRAGON. Additionally, a manual search through all records was performed.

Other variables in the CLASSP questionnaire which represented potential RFs for acquisition of either *Salmonella* or *Campylobacter* infection were extracted from the study database These included variables relating to food and drink consumption, food handling, travel, pets (other than reptiles), visits to farms or zoos, recreational water activities, eating outside of the home. All of these study exposures were related to contact with the particular factor in the five days before development of illness. Age, sex and self-reported ethnicity were also included as study variables. Binary variables were created for each of these exposures, except for age and ethnicity which were categorical.

Missing data

For all binary exposures studied, we compared 'unexposed' individuals (those with no positive report of exposure) against 'exposed' individuals (reported exposure in questionnaire). Thus missing or unknown exposures were grouped into the 'no exposure reported' (baseline) group for each variable for the purposes of this analysis.

Statistical methods

All statistical analyses were performed using STATA v10.1.

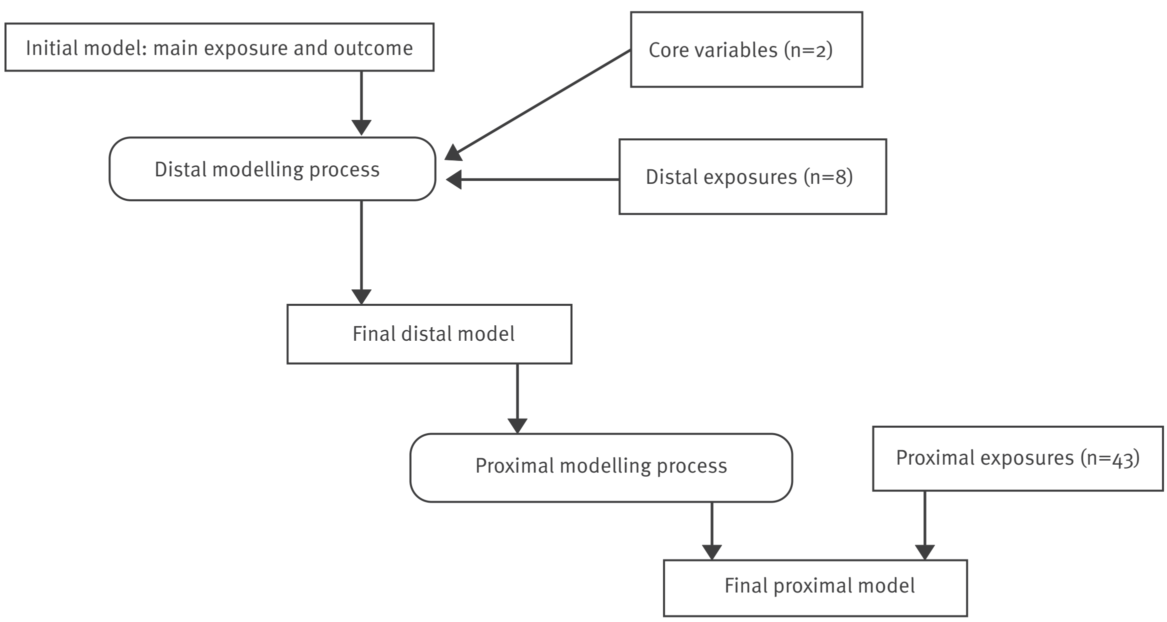
We described the demographic characteristics of study participants using Chi-square tests and Fisher's exact tests for association and Student's t-test for continuous variables. All exposure variables associated with the outcome with $p \leq 0.2$ in the bivariate analysis were included in the multivariable modelling process. Variables with $p > 0.2$ were considered not to have a direct effect on outcome, but were tested as potential confounders of the main exposure-outcome relationship.

We used a multivariable logistic regression model to determine the effect of reptile ownership on outcome and whether other exposure variables (i) provided an alternative explanation for outcome or (ii) confounded the main exposure-outcome relationship. We formulated a simple hierarchical framework to describe the causal relations of exposure variables [16]. We thus divided variables into a main exposure variable (ownership of a pet reptile), core variables (age and sex) and potential distal (n=8) and proximal (n=43) exposure variables. Distal exposure variables were those that might alter the likelihood of pathogen acquisition through a wide variety of end transmission vehicles, such as travel outside the UK or eating outside of the home. Proximal exposure variables were those relating to a specific method of pathogen acquisition, e.g. exposure to a particular foodstuff (e.g. eating or handling chicken) or type of animal (e.g. contact with a dog) or particular high-risk activities (e.g. watersports). Questions regarded a wide variety of exposures covering all known or suspected vehicles of transmission of these infections.

Variables were progressively added to the initial model as shown in Figure 2. First the distal exposure variables were introduced to the core model using a step-wise

Figure 2

Flow diagram of multivariable modelling process



process if they were significantly associated with the outcome ($p \leq 0.05$) based on evaluation of the p value in the likelihood ratio test. This generated the preliminary distal model. All excluded distal variables were then tested one by one to see if their inclusion resulted in significant confounding (>10% alteration) of the odds ratio (OR) for the main exposure-outcome relationship. This gave a final distal model.

Following this, proximal exposure variables were then introduced to the final distal model by the same process. The preliminary proximal model was examined to

TABLE 1

Descriptors of study participants, CLASSP study 2004-2007

	Salmonella (n=2,310)	*Campylobacter* (n=11,204)	Chi-square value	p value
Demographic variables				
Mean age (years)	35.1	44.0	-	<0.001 (t-test)
Sex			0.01	0.91
Male	1,113 (48.2%)	5,412 (48.3%)		
Female	1,197 (51.8%)	5,792 (51.7%)		
Ethnicity			23.6	<0.001
White	2,130 (92.2%)	10,600 (94.6%)		
Asian	105 (4.6%)	393 (3.5%)		
Other	75 (3.3%)	211 (1.9%)		
Data collection variables				
Questionnaire method			>1,000	<0.001
Personal interview	469 (20.3%)	397 (3.5%)		
Telephone interview	452 (19.6%)	941 (8.4%)		
Posted	318 (13.8%)	5,112 (45.6%)		
Unknown	1,071 (46.4%)	4,754 (42.4%)		

TABLE 2

Main multivariable results, CLASSP study, 2004-2007

	Distal model		Proximal model	
	OR (95% CI)	p value	OR (95% CI)	p value
Main exposure				
Reptile as pet	2.49 (1.61-3.83)	<0.001	2.46 (1.57-3.85)	<0.001
Distal exposure variables with OR>1.0				
Travel abroad	4.02 (3.63-4.45)	<0.001	–[1]	
Eating out at parties or buffets	1.18 (1.05-1.33)	0.005	–[2]	
Proximal exposure variables with OR>1.0				
Eggs eaten at home			1.19 (1.05-1.35)	0.006
Eggs eaten outside the home			1.60 (1.39-1.83)	<0.001
Bacon eaten at home			1.30 (1.15-1.48)	<0.001
Cold meats eaten outside the home			1.23 (1.07-1.42)	0.005
Poultry other than chicken eaten outside the home			1.41 (1.18-1.69)	<0.001
Contact with an ill person			1.15 (1.01-1.30)	0.037
Swimming			1.22 (1.07-1.39)	0.003
Fishing			1.59 (1.05-2.42)	0.029
Total N	13,514		13,514	
Degrees of freedom[2]	16		35	

CI: confidence interval; OR: odds ratio.
[1] Variables from the distal model are included in the proximal model, but are not shown in the proximal model column as their effects are intended to be analysed in the distal model.
[2] Age, sex, ethnicity and any variables with a modelled OR of <1.0 are not shown in this table.

see if inclusion of any of the excluded proximal variables had a confounding effect (>10% alteration of OR) on the effect of the main exposure. We tested for interaction between the main exposure variable and age category, sex and history of travel abroad in the final model.

Results

Participating subjects

The CLASSP study took place in England between November 2004 and October 2007. There were 66 participating Local Authorities (or County Councils), covering approximately 20% of the English population.

Cases with mixed infections (both *Salmonella* and *Campylobacter*, or involving other organisms) were excluded from this analysis (n=140, 0.9% of questionnaires). All individuals with missing data for age, sex or ethnicity were also excluded (n=777, 5.4%). The remaining 13,514 questionnaires formed the basis for this analysis. There were completed questionnaires from 2,310 individuals with non-typhoidal *Salmonella* isolates (17.1%) and 11,204 with *Campylobacter* isolates (82.9%).

Questionnaires were completed by personal interview, telephone interview or by postal questionnaire. The method of data collection was only known for 7,689 of the 13,514 questionnaires (56.9%). In general terms, data for *Campylobacter* cases were more frequently collected by postal questionnaire (overall 46% *Campylobacter* versus 14% *Salmonella*), whilst questionnaires for *Salmonella* infections were more often collected by personal or telephone interview

Table 3

Interaction of main exposure and age in final multivariable model, CLASSP Study, 2004-2007

Age group (years)	*Salmonella* cases in reptile owners	*Campylobacter* cases in reptile owners	Multivariable OR	95% CI	p value
0	9	3	17.3	4.50-66.25	<0.001
1-4	6	1	44.6	5.17-385	<0.001
5-19	8	4	12.1	3.52-41.7	<0.001
20-49	9	43	1.23	0.56-2.68	0.61
50+	2	23	0.65	0.15-2.85	0.57
Total	**34**	**74**			

CI: confidence interval; OR: odds ratio.

Table 4

Salmonella serotypes in subjects with and without exposure to reptiles, CLASSP study, 2004-2007

	Number of cases (% of *Salmonella* cases)			
	Reptile ownership		Univariate OR	
Organism/serotype	No	Yes	(95% CI)	p value[1]
Campylobacter	11,130	74	1.0 (baseline)	-
Salmonella Arizonae	1 (0)	2 (5.7)	300 (26-3,400)	<0.001
Salmonella Blockley	3 (0.1)	1 (2.9)	50 (5.1-490)	0.027
Salmonella Chester	6 (0.2)	1 (2.9)	25.1 (3.0-210)	0.046
Salmonella Ealing	0 (0)	1 (2.9)	infinite	0.007
Salmonella Enteritidis	1,211 (53.2)	5 (14.3)	0.62 (0.25-1.54)	0.3[b]
Salmonella Java	12 (0.5)	2 (5.7)	25.1 (5.5-114)	0.004
Salmonella Kentucky	22 (0.9)	1 (2.9)	6.8 (0.91-51)	0.14
Salmonella Muenchen	4 (0.1)	3 (8.6)	112 (24.5-520)	<0.001
Salmonella Oranienburg	4 (0.1)	3 (8.6)	112 (24.5-520)	<0.001
Salmonella Panama	4 (0.1)	1 (2.9)	37 (4.1-341)	0.033
Salmonella Senftenberg	14 (0.6)	1 (2.9)	10.7 (1.4-82.8)	0.096
Salmonella Stanley	33 (1.4)	1 (2.9)	4.56 (0.62-33.8)	0.204
Salmonella Tel-El-Kebir	0 (0)	2 (5.7)	infinite	<0.001
Salmonella Typhimurium	311 (13.6)	2 (5.7)	0.97 (0.24-3.96)	0.96[b]
Unnamed serotypes	136 (5.9)	8 (23.5)	8.85 (4.18-18.74)	<0.001
Other named serotypes	515 (22.6)	0(0)	0	-
Total (all *Salmonella*)	**2,276**	**34**	**2.24 (1.49-3.38)**	**<0.001[2]**

CI: confidence interval; OR: odds ratio.

[1] p value for Fisher's exact test unless otherwise specified.

[2] p value for Chi-square test.

(20% *Salmonella* versus 4% *Campylobacter*), see Table 1. The study questionnaire was administered (or sent by post) on the same day as the case notification was received. The interval between reported onset of illness and administration of questionnaire was thus generally short (median interval: 9 days, interquartile range (IQR): 6-13 days).

Key demographic characteristics of the study population are shown in Table 1. In both pathogen groups, infections occurred most frequently in children under the age of five years, with reduced frequency between the ages of five years and 20 years and a plateau among adults over 20 years. Of all 13,514 included participants, 49.1% were male (49.3% of the *Campylobacter* cases, 48.2% of the *Salmonella* cases, chi-square: 0.1, p=0.91).

Risk factors for disease

Main exposure

A total of 34 of the 2,310 individuals (1.5%) experiencing a *Salmonella* illness reported ownership of a pet reptile, compared with 74 of the 11,204 (0.66%) individuals experiencing *Campylobacter* illness. Using *Campylobacter* as control cases, we calculated a crude OR for exposure to a pet reptile as 2.25 (95% confidence interval (CI): 1.49-3.38, p<0.001).

Types of reptiles were tortoises (n=51), snakes (n=30, various types), lizards (n=31, various types), turtles or terrapins (n=5), with some participants reporting exposure to more than one of these.

Multivariable analysis

The results of the multivariable modelling process are presented in Table 2 below. All exposure variables with an OR>1.0 are shown here, whilst age, sex, ethnicity and variables with a modelled OR<1.0 are included in the model but not shown. The main exposure was associated with the outcome with an OR of 2.46 (95% CI: 1.57-3.85, p<0.001) in the final proximal model. We identified 10 other exposures with association with *Salmonella* infection independent of the main exposure. These were consistent with known risk factors for *Salmonella* [3,5]. None of the identified risk factors related to pets, although fishing was identified as weakly associated with *Salmonella* infections. None of the variables investigated as potential confounders were found have a major confounding effect (>10%) on the main exposure-outcome association.

In the final multivariable model, there was evidence of interaction between the effect of the main exposure and age category (likelihood ratio (LR) test p=0.03) and between the main exposure and sex (LR test p=0.01). Children under the age of five years were at much greater risk when exposed to reptiles than other age groups. For infants (under one year old) the OR was 17.3 (95% CI: 4.50-66.25) and for young children (between one and four years old) the OR was 44.6 (95% CI: 5.17-385). The age-stratified effects of the main exposure are shown in Table 3. Males appeared to be at higher risk of *Salmonella* infection when exposed to reptiles than females.

Salmonella serotypes

Numbers of cases of *Salmonella* serotypes with one or more isolates among people with reported reptile exposure are shown in Table 4. Odds ratios are calculated in comparison to *Campylobacter* control-cases. There was a clear indication that the overall pattern of serotypes of *Salmonella* seen among people with exposure to reptiles was different to that seen among people without this exposure (chi-square: 654, p<0.001, data not shown). *S.* Enteriditis and *S.* Typhimurium were no more common among reptile owners than would be expected by chance, whilst several other serotypes appeared to have some degree of association with exposure to reptiles.

Population attributable fraction

A PAF is defined as “the proportional reduction in average disease risk (...) that would be achieved by eliminating the exposure(s) of interest from the population” [17]. To estimate PAF for *Salmonella* disease caused by reptile exposure, we needed a proportion of the (general) population with this exposure (ppe). We used the proportion of *Campylobacter* cases reporting reptile ownership to estimate this: 74/11,204=0.66%. OR was used as an approximation of risk ratio as this was a rare exposure. Using the formula

$$PAF = \frac{ppe(OR-1)}{ppe(OR-1)+1}$$

and the OR from the final multivariable model, we obtained a PAF value of 0.95% for reptile exposure on *Salmonella* infections in England. If such a PAF were calculated for under five-year-olds only, it would be significantly larger than this: note the very high multivariable OR for these age groups in Table 3. However, we feel it is not appropriate to actually calculate such a figure as it would be unreliable due to the small numbers of individuals in these groups.

Discussion

Main findings

In this large case-case study of the exposures associated with *Salmonella* acquisition, we hypothesised that contact with reptiles was associated with development of illness after adjustment for alternative modes of acquisition and confounding factors. In our final multivariable model, there was a strong association of reported exposure to reptiles with *Salmonella* illness with an OR of 2.46 (95% CI: 1.57-3.85, p<0.001). The risk of exposure to reptiles was strongly influenced by age: children under the age of five years with this exposure were at much greater risk of developing *Salmonella* infection whilst individuals over the age of twenty years with this exposure did not experience significantly elevated risk.

These findings are unlikely to have occurred by chance, although the precise size of the effects could be subject to minor variation due to the small number of exposed individuals. None of the other variables of acquisition of infection in the multivariable model explained or negatively confounded this effect, and the effect of travel abroad acted as a positive confounder on the effect of reptile exposure. The effect of exposure to reptiles is unlikely to be confounded by unmeasured aspects of pet ownership in general as none of the seven other types of animal exposure examined in this analysis (dogs, cats, fish, poultry, other birds, other pets and farm animals) showed an independent association with *Salmonella* illness.

These findings are consistent with two case-control studies of risk factors associated with *Salmonella* infections in children in the United States (US) [10,11] where the odds of *Salmonella* illness in children were increased in association with recent contact with reptiles or amphibians.

There was clear indication from analysis of *Salmonella* serotypes that they were of different relative importance among people with and without exposure to reptiles. In those without recent reptile exposure, *S.* Enteritidis and *S.* Typhimurium predominated, in line with prevalent patterns of illness in the UK. Among those with exposure to reptiles, these two serotypes were much less common – they are known to be rare in poikilotherms [18] – and a variety of unusual *Salmonella* serotypes predominated. Many of these serotypes are known to be mainly found in reptiles (*S.* Arizonae [19]) or have previously been reported in cases or outbreaks of reptile-associated salmonellosis (*S.* Tel-el-Kebir [20], *S.* Java [21]). The analysis of serotypes was based on small numbers, so some of these associations may be chance effects.

We calculated a PAF for reptile exposure on all *Salmonella* infections in England during the study period as being 0.95%. We believe that this is the first such estimation made for such a PAF in England. This is consistent with an observation of 0.7% of *Salmonella* cases being of reptile-associated serotypes in the Netherlands [7], but less than a PAF estimate of 6% in a study specifically investigating reptile-associated salmonellosis in the US [10]. Although this PAF for reptile-associated salmonellosis in England is small, it represents a part of a sizeable disease burden – approximately 12,000 cases of salmonellosis were reported in England and Wales in 2007 [22], and this may underestimate the true community incidence by as much as threefold [4]. Furthermore, reptile-associated *Salmonella* appears to predominantly affect infants and children and could represent an amenable target for public health interventions [10].

Strengths and weaknesses

An important strength of the case-case format adopted for the CLASSP study was that it should have minimised bias due to case notification [23] as both cases and control cases came through the same notification process. The median interval from illness to interview was similar for *Salmonella* (11 days) and *Campylobacter* (nine days), indicating that a significant degree of recall bias was unlikely. As interviewers and participants were blind to the main hypothesis of this analysis, report of exposure to reptiles is unlikely to have been affected by interviewer bias or purposeful misreporting.

We are not aware of any association between *Campylobacter* illness and reptile ownership. Therefore whilst this case-case methodology may not have detected all exposures conferring risk for either *Salmonella* or *Campylobacter*, we are confident that it has accurately assessed the risk associated with the main exposure.

An important limitation of this analysis is the method of ascertainment of exposures, including the main exposure. Study participants were questioned on a wide variety of exposures and there were no objective validations of such exposure. Recall and report of pet ownership is likely to be more accurate than food recall, particularly as this concerned a period (on average) 9-14 days earlier. We felt that accuracy of exposure classification was likely to be adequate for the purposes of this analysis, and any resulting bias would be more likely to lead to underestimation than overestimation of the true effect size for the main exposure. The CLASSP study did not investigate RFs relating to susceptibility to disease (except age and sex) – factors such as recent antibiotic usage [24] may have had an effect on the development of illness.

Some element of bias may have been introduced to this study by use of different questionnaire methods between pathogen types: *Salmonella* cases were more likely to have a personal interview and *Campylobacter* cases were more likely to have a posted questionnaire. If there was differential accuracy in report of exposure by different interview methods this could have led to over or underestimation of effect sizes. We believe that such influences are unlikely to affect our main findings.

We analysed this study by comparing people with positive report of exposure against those with no reported exposure, such that people with unknown exposure status were included with the baseline group. This was done as a high proportion (>70%) of study participants had an unknown value for ≥1 exposure. The tick-box format of the questionnaire makes it likely that some participants omitted to tick for negative responses, which would lead to the data being Missing Not At Random (MNAR). The effects of bias introduced by this pragmatic compromise are limited: Other analyses of this dataset using different strategies (complete-case only and missing-indicator approaches) both suggested very similar sizes of effect for the main exposure-outcome relationship [25].

Some caution is required for the interpretation of the PAF estimate. The estimate of exposure to pet reptiles in the general population (0.66%) was obtained from the *Campylobacter* control cases in this study. The age distribution of *Campylobacter* cases did not match the general population – children were over-represented. Precise information on reptile ownership in the UK is difficult to obtain. A conference presentation in 2008 indicated there were approximately one million households in the UK with one or more pet reptiles, based on estimates from pet food sales [26], suggesting the calculated PAF may be an underestimate.

Conclusions

Reptile ownership is an important risk factor for *Salmonella* illness, with the effect being much stronger among infants and children. Although this exposure is rare in the general population, it may account for approximately 1% of *Salmonella* infections currently occurring in the UK. The calculated effect of exposure to reptiles is supported by the serological data on specific *Salmonella* serotypes seen among people self-reporting this exposure – these individuals are much more likely to be infected with unusual serotypes of *Salmonella* known to occur in conjunction with reptiles. Public health measures to minimise the risks of reptile-associated salmonellosis have been discussed elsewhere [10]. The HPA has published a leaflet outlining risks associated with reptiles [27]. Ownership of reptiles represents a serious risk to children.

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