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Outbreak of *Salmonella* Goldcoast infections linked to consumption of fermented sausage, Germany 2001

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SUMMARY

Salmonella Goldcoast (SGC), an uncommon serotype in Germany, was identified in 25 isolates between 1 April and 7 May 2001. To determine the cause of the outbreak, we conducted a matched case-control study including 24 cases and 51 controls. In a multivariable regression model, only consumption of a raw fermented sausage manufactured by a local company remained significant (adjusted odds ratio 20·0, 95% confidence interval 2·7–302·5). SGC isolated from case-patients shared an indistinguishable pulsed-field gel electrophoresis pattern. A part of the produced raw fermented sausage was sold after only 4 days of fermentation. Samples from the premises and products of the company were negative for SGC. However, short-time raw fermented sausage is more likely to contain pathogens. Irradiation of raw ingredients is not accepted by German consumers, thus strict adherence to good manufacturing practices, the use of HACCP programmes as well as on-farm programmes remain crucial to reduce *Salmonella*.

INTRODUCTION

Raw meat products are a popular element of German cuisine. In 1999, out of 31·3 kg sausages consumed annually per person, 5 kg were raw sausages. Raw fermented sausages have a long tradition in Germany. As many as 400 different kinds of fermented sausages, each with a slightly different mixture of ingredients or with a modified processing, are estimated to exist in Germany. Curing, smoking, fermentation and drying are crucial steps in the processing of these sausages, creating an environment with a low pH and low moisture which is hostile to pathogens. It is believed that these steps in the processing, together with a high level of hygiene, render these ready-to-eat products safe. However, apart from traditionally produced, raw fermented sausages (mainly products with long shelf-lives) production of short-time fermented, less dried, and partly smoked sausages has increased during the past years. These products are intended for

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quick consumption and their shelf-life is very limited. Particularly, short-time fermented, spreadable 'frische Mettwurst' (a special kind of raw fermented sausage) is a critical product. In a national study from 1996, investigations on *Salmonella* spp. in spreadable, raw fermented sausages composed of pork and/or beef resulted in 3·8% positive samples [1]. A certain protection against pathogens, especially salmonellae, is only possible if ingredients including raw meat are carefully selected, degradation of pH and a_w (water activity) are monitored and a continuous refrigeration of the products is maintained.

An outbreak in the past could be linked to fermented sausages of the short-time fermentation type, and there was evidence that the processing was insufficient for elimination of microbial pathogens [2].

Since the reunification of Germany in 1990, only one outbreak with a sound epidemiological investigation has been linked with the consumption of raw meat in Germany: an outbreak of sorbitol-fermenting *E. coli* O157:H$^-$ in Bavaria in 1996 [3].

Salmonella enterica serotype Goldcoast (SGC) belongs to serogroup C. It was first isolated in Ghana in 1953 [4]. SGC was identified as the agent responsible for outbreaks in the United Kingdom involving 250, 31 and 24 cases respectively following the consumption of French pâté, cress and cheddar cheese [4, 5–7].

During the 5 weeks between 1 April and 7 May 2001, the German National Reference Laboratory for Salmonella (NRLS) received 25 isolates of SGC. Against a semi-annual median of 13 isolates between 1993 and 2001, this number seemed unusually high. Furthermore, most of the patients were clustered in one county in Thuringia, one of the 16 federal states in Germany. The sudden rise in cases of SGC raised suspicion of an outbreak and an epidemiological investigation by the Robert Koch-Institut in cooperation with the local and state health authorities was initiated to identify a possible common source of SGC.

METHODS

From 7 May 2001, we ascertained cases of SGC by searching the databases of the NRLS and the national surveillance system for infectious diseases as well as by contacting private and state laboratories in Thuringia and other states. A hypothesis-generating questionnaire including a broad food history was developed for exploratory interviews which were conducted between 11 and 21 May. Six out of 15 interviewed patients with SGC reported having eaten products from company A. Three of those were close relatives who all lived in different households, but met for an Easter (15 April) picnic. This was their only common exposure in the assumed incubation period of 7 days prior to onset of illness. During this picnic they ate three types of sausage. (i) A sausage made of cooked blood that was stuffed in pork bladder (blood sausage), (ii) a sausage made of cooked meat in aspic stuffed in pork bladder (aspic sausage), and (iii) a fermented sausage made of raw meat (raw fermented sausage), all produced by company A.

To test the hypothesis that one or more of these products of company A were responsible for the outbreak we decided to conduct a matched case-control study. The study commenced on 29 May 2001, immediately after having received an invitation from Thuringia to collaborate in the investigation of the outbreak. A case-patient was defined as an adult person (18 years or older) with diarrhoea between 1 April and 31 May 2001, and laboratory-confirmed SGC in the stool, who was the first case in the household. Patients who travelled abroad during the week prior to onset of illness were excluded from the study. Patients examined in exploratory interviews were also excluded. Control subjects were adult persons without diarrhoea between 1 April and 31 May who did not travel abroad prior to onset of illness of their corresponding case-patient. Between 29 May and 6 June, we identified control subjects through random digit dialling or by choosing them randomly from the telephone directory and matched 2–4 control subjects to cases on the basis of their residence using the telephone area code as a proxy.

A standardized questionnaire contained questions about the consumption of blood sausage, aspic sausage, raw fermented sausage, raw ground pork meat, 'Mettwurst', eggs, cheddar, French pâté, chicken, pork or beef products as well as the location of the purchase of blood sausage, aspic sausage, raw fermented sausage, raw ground pork meat and Mettwurst. Case-patients were asked about exposure to food items in the week before onset of illness; control subjects were asked about exposure to all food items for the entire time period from 1 April, until 31 May 2001.

We calculated matched odds ratios (mOR) and exact 95% confidence intervals (95% CI) to assess associations between food items and disease using SAS 8.2 statistical software (SAS Institute Inc., Cary, NC, USA). Variables with a P value of less than 0·05 were

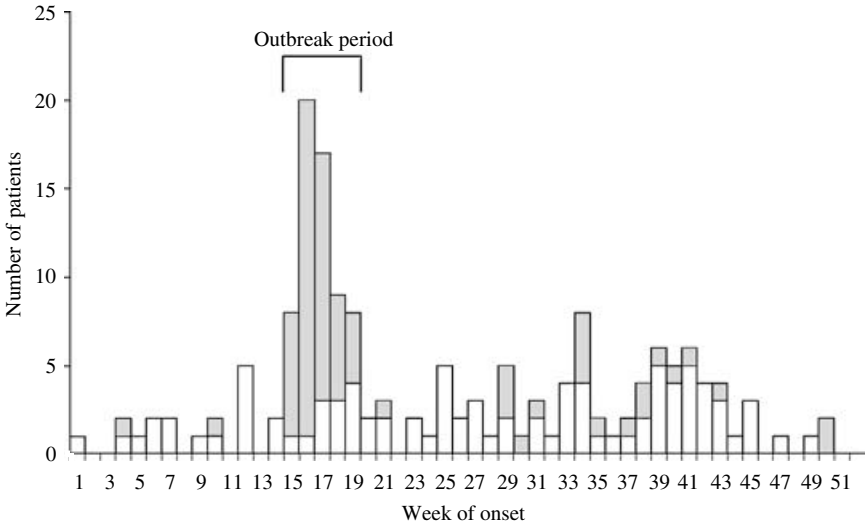

Fig. Number of case-patients ($n = 163$) with *Salmonella* Goldcoast without travel history in the week before disease by week of disease onset, in Thuringia (▨) and other federal states (□) in Germany, 2001.

considered statistically significant and were included in an exact conditional logistic regression model using SAS as well as LogXact-4 for Windows (Cytel Software Corporation, MA, USA) to calculate adjusted odds ratios (aOR).

Subtyping of SGC isolates using pulsed-field gel electrophoresis (PFGE) was performed at the NRLS. To increase specificity three restriction enzymes were used [*Xba*I (Roche Molecular Biochem, Mannheim, Germany), *Bln*I (New England Biolabs), *Spe*I (New England Biolabs, Frankfurt am Main, Germany)]. SGC isolates from patients with onset of illness in the first 6 months in 2001 were compared with SGC isolates of the previous years. The predominant pattern of isolates during the outbreak period (1 April until 31 May 2001) was defined as the outbreak pattern.

We inspected company A on 25 and 30 May and collected swabs from floors, knives and machines in the company as well as from the abattoir and the company-owned breeding (farrower to weanling) farm. We observed the production process in the plant. Food samples of the products that were produced in the relevant time period (before week 15 in 2001) were no longer available. However, samples were taken from products manufactured at the time of the inspection. Furthermore, we obtained a list of retailers supplied directly by company A.

RESULTS

In 2001, 192 patients with SGC without a known travel history before onset of illness were identified in Germany. The number of patients with SGC rose sharply in calendar week 15 (9–15 April) and fell until week 19 (7–13 May) to a median weekly number of two patients (Fig.). Fifty (80·6%) of the patients between weeks 15 and 19 were residents of Thuringia.

A total of 44 patients with SGC met the case definition. Of these, 42 were known to us at the time of the case-control study. We were able to contact 25 case-patients, but one person refused to participate. Thus, 24 case-patients remained in the study.

Case-patients lived in the following states: 22 (92%) in Thuringia, one in Saxony-Anhalt, and one in Saxony. Eleven (50%) of the 22 case-patients from Thuringia lived in the county where company A is located. The median age of the case-patients was 54 years (range 30–69 years); 11 (46%) case-patients were women. For the 24 case-patients we matched 51 control subjects.

In univariate analysis, no statistically significant association was found between case-patients with SGC and the consumption of sausages in general, beef products in general, pork products in general, poultry in general, pâté or cheddar. Having eaten blood sausage, aspic sausage, raw fermented sausage, raw ground pork meat or Mettwurst as such was not significantly associated with illness. The consumption of eggs (mOR 0·2; 95% CI 0·03–0·7) was inversely associated with illness. Six (29%) out of 21 case-patients and 1 (2%) out of 51 control subjects who answered the question reported having eaten blood sausage from company A (mOR 13·1, 95% CI 1·6–602·6; Table 1). A total of 21 case-patients and 48 control

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Table 1. *Consumption of products by case-patients (n=24) and control subjects (n=51) in an outbreak of* Salmonella *Goldcoast, Thuringia, Germany, April/May 2001*

	Case-patients		Control subjects				
Exposition	*n*	Total*	*n*	Total*	Matched odds ratio	95% CI	*P* value
Blood sausage†	6	21	1	51	13·1	1·6–602·6	0·01
Aspic sausage†	1	23	3	51	0·7	0·01–8·5	1
Raw fermented sausage†	9	21	2	48	9·6	1·9–93·7	0·002
Raw ground meat†	4	20	3	47	3·7	0·5–34·8	0·29
Mettwurst†	0	21	0	49	—	—	—
Eggs	13	22	46	51	0·2	0·03–0·7	0·009
Any product from company A	12	20	3	44	12·0	2·6–85·7	0·0002

* Number of case-patients or control subjects who remembered having eaten the product.
† Product from company A.

Table 2. *Results of the final exact conditional logistic regression model in an outbreak of* Salmonella *Goldcoast, Thuringia, April/May 2001*

	Case-patients		Control subjects				
Exposition	*n*	%	*n*	%	Adjusted odds ratio	95% CI	*P* value
Raw fermented sausage*	9	43	2	4	20·0	2·7–302·5	0·0009
Eggs	13	59	46	90	0·06	0·005–0·4	0·0016

* Product from company A.

subjects remembered whether they ate raw fermented sausage. Nine (43%) case-patients and 2 (4%) control subjects reported having eaten raw fermented sausage from company A (mOR 9·6, 95% CI 1·9–93·7). In addition, consumption of any product from company A was significantly associated with disease (mOR 12·0, 95% CI 2·6–85·7). In the exact conditional logistic regression model, the results were similar for raw fermented sausage (aOR 20·0, 95% CI 2·7–302·5) and eggs (aOR 0·06, 95% CI 0·005–0·4) (Table 2). Case-patients reported having purchased the products from company A in seven different shops.

During the first 6 months of 2001, 31 SGC isolates were sent to the NRLS. Of these isolates, 22 were subtyped using PFGE and compared with isolates of previous years. Eighteen (90%) out of 20 SGC isolates from patients with onset of illness during the outbreak period were found to be indistinguishable by PFGE using restriction enzymes *Xba*I, *Bln*I and *Spe*I ('outbreak profile'). Of these 18 isolates that shared a PFGE profile, 14 were from patients that corresponded to the case definition and were included in the case-control study. The remaining four isolates were either from children or secondary cases. All case-patients with an identical PFGE pattern resided in Thuringia. The outbreak profile was also found in four patients in 2000 who resided in Thuringia. Isolates of the two patients with onset of illness before the outbreak period showed a different PFGE pattern when compared with the outbreak profile.

Company A is a middle-sized meat-processing company, which produces approximately 100 different kinds of sausages and meat products, mainly from pork. Because company A is not registered as a company with European Union authorization, it is not permitted to deliver its products to other European member states. The fermentation and smoking process of raw fermented sausage lasts between 4 days and 8 weeks before this product is distributed to shops for sale. A part of each produced batch of raw fermented sausage was sold soon after appearing on the shelf after only 4 days of fermentation. We did not detect any obvious faults in the production process of raw fermented sausage, but hazard analysis of critical control points (HACCP) procedures were not in place. For example, microbiological tests of the products were not taken after the different production steps. None of the employees reported to have

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had diarrhoea in the month before the outbreak occurred. No stool samples were available from the employees.

Microbiological samples taken from the premises of company A, the abattoir and the company-owned breeding farm were negative for *Salmonella* spp. However, among samples from products from company A, ground pork meat and a frying sausage tested positive for *Salmonella* Group B.

DISCUSSION

Since the reunification of Germany in 1990, this is the first publication from an observational study that has implicated raw fermented sausage as the likely source of a *Salmonella* outbreak in Germany.

This is particularly important because raw products are extremely popular in Germany, and there is a lack of awareness about the possibly inherent risks.

Ideally, investigations of foodborne outbreaks should implicate a vehicle epidemiologically, as well as identify indistinguishable organisms in case-patients and in the implicated vehicle(s). In this outbreak investigation, our case-control study, supported by information from exploratory interviews, enabled us to strongly implicate a fermented sausage as the vehicle of infection. This product has a short fermentation time (4 days) and is immediately marketed (and purchased) thereafter due to the inherent short shelf life of these products. We deem it the rule rather than the exception in outbreak investigations that microbiological examinations of food products with a short shelf life cannot be performed because of the timespan between onset of symptoms and outbreak detection and investigation. Thus, the only way to obtain information on the vehicle is by conducting observational studies. Therefore, we emphasize the importance of recommendations made previously [8], that public health officials should not require confirmation of microbial contamination of a product before taking action when sufficient epidemiological evidence is available.

The outbreak investigation was prompted immediately after consensus between the affected states and the Robert Koch-Institut was achieved. However, this was 3 weeks after initial detection of the outbreak. Increased awareness is necessary among all involved authorities in Germany of the need for timely communication and collaboration in infectious foodborne disease outbreaks.

This case-control study was challenging because case-patients and control subjects did not significantly differ in their general habit of eating sausage products, e.g. raw fermented sausage. Only the inclusion of a question on the point of purchase of the relevant meat products allowed the implication of raw fermented sausage from company A as the likely responsible vehicle.

Only 9 out of the 24 case-patients remembered having eaten the raw fermented sausage of company A. Thus, 15 of the case-patients were 'unexplained' in our study. However, there were three factors that affected the identification of the responsible exposure. (1) Interviews were conducted 6 weeks after the peak of the epidemic curve in week 22 which probably weakened recollection considerably. (2) Interviewees had to remember not only what they had eaten but where they had bought it. Also, households often did not buy their food at just one shop. (3) Possible cross-contamination is possible both at the shop as well as at home so that exposure to raw fermented sausage might have occurred inadvertently [9].

Why the consumption of eggs was inversely associated with disease is not clear to us; we suppose that people who do not eat raw fermented sausage are less likely to eat any sausage and more likely to eat eggs.

We could not identify the point of contamination. The fact that the case-patients bought raw fermented sausage from at least seven different supermarkets or retail shops renders a contamination at the retail level unlikely.

On inspection, we were unable to detect obvious faults in the manufacturing process for raw fermented sausage, although this does not rule out contamination at this level [10]. The raw meat itself could have become contaminated before processing as the pigs themselves may have become infected or contaminated at the farrower farm or carcass cross-contamination may have occurred at the abattoir [11, 12]. In this case, routine samples from the abattoir and the company-owned farrower farm were taken after the end of the outbreak, thus the negative results do not rule out that possibility. The fact that SGC isolates from Thuringia from the previous year were indistinguishable from the outbreak strain may suggest that they are derived from the same source.

The fermentation step during processing in conjunction with holding them at dry conditions ideally reduces the number of pathogens, but probably fails to do so at times [1, 13]. Short-time raw fermented sausage, such as the one implicated in this outbreak,

should be more likely to still contain pathogens, such as *Salmonella* spp. [14]. Previous studies have shown that contamination of raw pork sausages with these pathogens is not a rare event [1, 10, 15] and that outbreaks are more likely to occur following insufficient processing of meat products [16]. Retailers usually sell short-time raw fermented sausage soon after distribution from the company. The sharp rise of the epidemiological curve would be in line with the release of contaminated, short-time raw fermented sausage, perhaps from only one batch, that was on the shelf for only a short time.

In conclusion, we believe that this outbreak of SGC was probably associated with short-time raw fermented sausage distributed by company A. We cannot decide whether processing was unsuccessful in eliminating salmonella that were present before processing or that organisms were introduced during processing. We believe, therefore, that strict adherence to good manufacturing practices and HACCP are crucial to achieve an acceptable level of safety [17].

Nevertheless, this can only be successful to a certain extent. Irradiation of raw ingredients, albeit a useful method, is not accepted by German consumers. We must, therefore, also communicate to the public that certain meat products are made of raw meat and that the consumption of those products, especially raw meat and short-time raw fermented sausage, may always bear a residual risk of contamination with human pathogens.

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