An outbreak of Salmonella Typhimurium infections in Denmark, Norway and Sweden, 2008

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In November-December 2008, Norway and Denmark independently identified outbreaks of *Salmonella* Typhimurium infections characterised in the multiple-locus variable number of tandem repeats analysis (MLVA) by a distinct profile. Outbreak investigations were initiated independently in the two countries. In Denmark, a total of 37 cases were identified, and multiple findings of the outbreak strain in pork and pigs within the same supply chain led to the identification of pork in various forms as the source. In Norway, ten cases were identified, and the outbreak investigation quickly indicated meat bought in Sweden as the probable source and the Swedish authorities were alerted. Investigations in Sweden identified four human cases and two isolates from minced meat with the distinct profile. Subsequent trace-back of the meat showed that it most likely originated from Denmark. Through international alert from Norway on 19 December, it became clear that the Danish and Norwegian outbreak strains were identical and, later on, that the source of the outbreaks in all three countries could be traced back to Danish pork. MLVA was instrumental in linking the outbreaks in the different countries and tracing the source. This outbreak illustrates that good international communication channels, early alerting mechanisms, inter-sectoral collaboration between public health and food safety authorities and harmonised molecular typing tools are important for effective identification and management of cross-border outbreaks. Differences in legal requirements for food safety in neighbouring countries may be a challenge in terms of communication with consumers in areas where cross-border shopping is common.

Introduction

The endemic level of salmonellosis in three Nordic countries Norway, Sweden and Finland is low. The majority of cases are acquired during travel abroad, and among domestic cases, *Salmonella* Typhimurium is the most common serovar [1]. In Norway approximately 70-80% of notified cases of salmonellosis are acquired abroad, and among patients infected in Norway, S. Typhimurium is the most common serovar with generally 5-15 domestic cases reported monthly [2]. In Sweden the situation is similar, with the majority (70-80%) of human cases being travel-related and S. Typhimurium being the most common domestic serovar [3]. Norway, Sweden and Finland have special rules concerning trade of meat and meat-products within the European Union (EU), requiring that each consignment produced in another EU Member State and destined to be sold in these countries must be accompanied by a certificate stating that the product has been analysed for the presence of *Salmonella* according to a defined procedure [4]. In Denmark, both the epidemiological situation and legal requirements regarding *Salmonella* in meat is different. An estimated 40-50% of *Salmonella* cases are travel-related [5] and. S. Typhimurium is traditionally the second most frequent serotype after S. Enteritidis. However, a series of large S. Typhimurium outbreaks occurred in Denmark in 2008 [6], making S. Typhimurium the most frequent serotype in 2008 [7].

In order to rapidly identify possible outbreaks, Norway and Denmark routinely genotype all S. Typhimurium patient isolates with the multiple-locus variable number of tandem repeats analysis (MLVA) method [8]. The reference laboratory in Norway receives isolates from human cases as well as from animals, foods and feed. The database on MLVA-typed isolates currently comprises MLVA profiles from more than 3,000 isolates from both human and non-human sources, collected since 2004. In Denmark, human S. Typhimurium isolates are routinely MLVA-typed and phage-typed, while food and animal isolates are only phage-typed. In outbreak investigations food isolates with matching antibiograms and matching or related phage types are MLVA-typed. The Danish database currently comprises more than 4,000 human and non-human isolates collected since December 2004. If clusters of cases with a specific MLVA profile are detected, an investigation is initiated to verify and control the outbreak. In Sweden, isolates of S. Typhimurium from human, animals and feed are routinely phage-typed, and food isolates are phage-typed upon request. Until early

2009, MLVA-typing was only performed on clusters of various phage types of particular interest from an epidemiological point of view.

Outbreak detection

On 7 November 2008, the Danish Statens Serum Institut (SSI) registered a cluster of eight recent cases of *Salmonella* Typhimurium with the same new distinct MLVA profile. On the same day the Zoonosis Laboratory at the Danish National Food Institute identified two isolates from pork products with the same MLVA profile.

On 4 December 2008, the Norwegian Institute of Public Health (NIPH) also registered a cluster of six cases with S. Typhimurium-infection with a new, distinct MLVA profile, all submitted during the previous month.

In both countries independent outbreak investigations were initiated in order to identify the source of these infections and prevent further spread. Investigations in Sweden were undertaken later, following information from Norway on the possible source of infection in meat purchased in Sweden.

Methods

Case definition

For the purpose of outbreak investigation, a common case definition was used in all three countries. A case was defined as having a laboratory-confirmed *Salmonella* Typhimurium infection with the distinct MLVA-outbreak profile, and with illness onset after 1 September 2008. The MLVA profile was assigned as 3-12-4-13-2 (using allele numbers suggested by Lindstedt et al.); sizes of fragments were STTR9: 181 bp, STTR5: 275 bp, STTR6: 319 bp, STTR10: 370 bp, STTR3: 490 bp [8].

Patient interviews

In Denmark, seven among the initial cases were interviewed using a trawling questionnaire with focus on consumption of pork and pork products, and remaining cases were interviewed using a short standard questionnaire. In Norway, all cases were interviewed with a detailed standard trawling questionnaire for food-borne outbreaks. In Sweden, the cases were interviewed regarding general risk exposure for *Salmonella* with additional questions on supermarkets visited and travel history to either Norway or Denmark, as well as a focus on pork products consumption.

Microbiological investigation

In Denmark, due to a large ongoing outbreak of S. Typhimurium U292 [6], a temporarily intensified programme for surveillance of *Salmonella* isolates from food production facilities was set up in September 2008. As a result of this programme, a number of isolates were referred to the Danish National Food Institute for analysis. Isolates were phage-typed, and all isolates with phage types matching the human isolates were MLVA typed.

In Norway, food products from patients' homes, identified to be at risk, were sampled and tested. When preliminary results indicated presence of *Salmonella*, the isolates were sent from the local microbiological laboratories to the reference laboratory at NIPH for verification and MLVA-typing.

In Sweden, *Salmonella* Typhimurium RDNC and later also U302 isolates (due to relatedness with the phage type reactions in the Norwegian and Danish isolates) collected from patients and food products during late 2008 and early 2009 were typed with MLVA.

Environmental investigation

In all countries, detailed information regarding place and date of purchase of suspected products was collected from the patients in order to trace the contaminated consignment. In Denmark, the Food Safety Authority obtained detailed information regarding distribution of contaminated batches. In Sweden, the local environmental health authority visited the relevant shops, checked their hygiene routines, traced the origin of suspected meat products and checked the *Salmonella* certificates on imported meat consignments.

Results

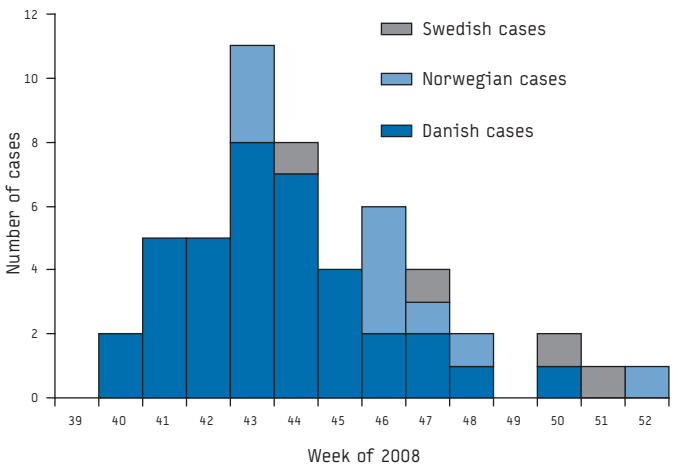
The investigation in Denmark

A total of 37 cases were confirmed. The outbreak strain was fully sensitive to all antibiotics tested and determined to be phage type U288 or RDNC. The majority of patients became ill in October and November (Figure 1). The median age of the cases was 54 years (range 1-86 years) and 15 were female. Four patients died, all were older than 75 years, and suffered from underlying illnesses. The precise causes of death could not be established, and it remains unclear to what degree the *Salmonella* infection contributed as a cause of death.

Within two weeks following the detection of the outbreak (on 7 November), the outbreak strain was identified among S. Typhimurium isolates from Danish pork meat (6 times) and pork products (4 times; raw pork sausage, raw pork roulade and twice in minced pork). The pork and pork products originated from 6 different companies. Of these, one company (in which most samples with the outbreak strain were found) was a cutting plant that supplied meat to the other five companies all of which were wholesalers. In addition, the outbreak strain was found in samples from a sow herd in December 2008. In the period during which the outbreak took place, pigs originating from the sow herd, but reared at other farms, were mainly slaughtered at two different slaughterhouses. Subsequently, it was also recognized that during 2008 there was an increased *Salmonella* seroprevalence in some of these slaughter pig herds. This was detected through the Danish serological *Salmonella* surveillance programme [5,9]. One of the slaughterhouses supplied meat to the incriminated cutting plant.

Figure 1

Cases of Salmonella Typhimurium in an international outbreak affecting Denmark (n=37), Norway (n=10) and Sweden (n=4), October-December 2008, by week of onset of illness (n= 51)



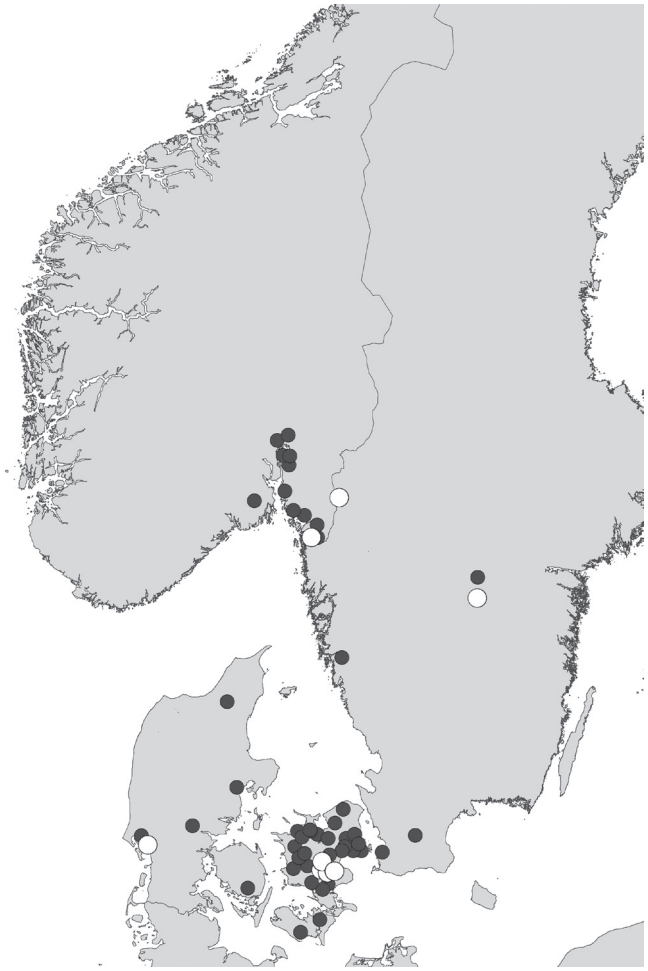
The majority of cases (30) were from Zealand (Figure 2); relatively many from the less densely populated south-western part of the island. The culture-positive meat processing plant, the culture-positive sow herd, the majority of related slaughter pig herds in addition to the two slaughterhouses, were also located in the same part of the country.

The results of the patient interviews were compatible with the hypothesis that fresh pork meat and different pork products originating from the two above mentioned slaughterhouses were the source of the outbreak. The particular MLVA-pattern was found for the first time in Denmark in three patients with onset dates in June and July, 2008. They were not counted among the outbreak cases, though it remains possible that their infections also originated from the same pig herds.

The incriminated cutting plant and one of the two slaughterhouses had been selling pork and beef to a number of Swedish establishments. No direct trade link between the Danish cutting plant and the slaughterhouse on one hand and the Swedish shops on the other was evident in the sales register from the Danish establishments. However intermediary establishments in Sweden were involved in distributing the meat. Links from Denmark to the Swedish shops were thereby established (Figure 3).

FIGURE 2

Place of residence of human cases of Salmonella Typhimurium (dark grey, n=51) and companies/ shops (white, n=8) where meat was bought by cases or found positive with the outbreak strain of Salmonella Typhimurium, Denmark, Norway, Sweden, 2008



The investigation in Norway

Ten cases were verified with the outbreak strain. The outbreak strain was fully sensitive to all antibiotics tested and determined to be phage type RDNC. The patients were all adults (21-80 years) living in the south-eastern part of Norway and their illness onset was between the end of October and the end of December (Figure 1 and 2). Eight patients reported that during the week before illness onset, they had consumed minced meat purchased at shopping centres located across the border in Sweden. Four of them remembered having eaten raw, rare or undercooked minced meat. Several had tasted raw minced meat while preparing food. The minced meat was either a mix of pork/beef or only beef, but most said they were not sure about this. The outbreak strain, with the rare MLVA profile, was isolated from samples of minced meat from the homes of two patients, but since the product had been repacked in patients' households, the original wrapping with product information was not available. However, one of the patients provided a bank printout that confirmed the exact place (retail outlet) and date of purchase, thereby facilitating further traceback along the food chain.

International alerts

On 15 December, after receiving completed questionnaires from five Norwegian patients, all of whom reported consumption of meat bought in Sweden the week before illness onset, NIPH notified the Swedish Institute of Infectious Disease Control (SMI) about the outbreak and asked if they had seen similar isolates of S. Typhimurium. In reply, SMI reported no findings of the specific RDNC phage pattern. On 19 December, an urgent inquiry was sent through the Food- and Waterborne Diseases network at the European Centre for Disease Prevention and Control (ECDC), and in response, Denmark reported the ongoing phage type U288 outbreak with identical MLVA-profile.

The investigation in Sweden

In Sweden four cases were confirmed with the outbreak MLVA profile. The patients were all adults, and three were in their 50s. They fell ill between October and December (Figure 1) and were from three different counties in the south of Sweden (Figure 2). One patient had been living and working in Copenhagen before disease onset and was most likely infected there. These cases were identified following MLVA-typing of recent patient-isolates belonging to phage type U302.

On 23 December, the Swedish National Food Administration found that the shops the Norwegian patients had visited, were selling pork from three Danish companies, one of which was the cutting plant incriminated during the investigations in Denmark. The two positive minced meat samples from the Norwegian patients contained only beef according to information from the shops. However, cross-contamination from other sources could have occurred during mincing in the shops. The Swedish environmental health authority could not identify any faults or breaches in the routines of the shops, and there was no meat from the relevant time period available for sampling. They could also confirm that the companies had thoroughly checked the *Salmonella* certificates of all consignments from other countries.

Sweden found two isolates with the outbreak strain from minced meat. The first minced meat sample was taken in November from a grocery store in the south of Sweden (Figure 2). A follow-up sample taken from the meat-grinder in the shop one week after the first, was also positive for S. Typhimurium, and both had the outbreak MLVA profile. This indicates that there was a persistent contamination of the grinder. This grocery store had been selling pork from the incriminated Danish cutting plant on some occasions during October and November. None of the four Swedish patients had been to this store nor to the shops visited by the Norwegian patients. However one of them had bought meat in another Swedish shop receiving meat from the above mentioned Danish slaughterhouse.

Product tracing

Product trace investigation revealed the trade route for meat from the Danish cutting plant to shops in Sweden, both to shops near the border where the Norwegian cases had bought meat and to another one where minced meat samples had tested positive for *Salmonella*, thus, confirming the link between Danish meat and positive findings of *Salmonella* in the environment and minced meat samples. Furthermore tracing of products from the second Danish slaughterhouse revealed a link to yet another Swedish shop indicating a possible second route of dissemination of contaminated meat to Sweden (Figure 3).

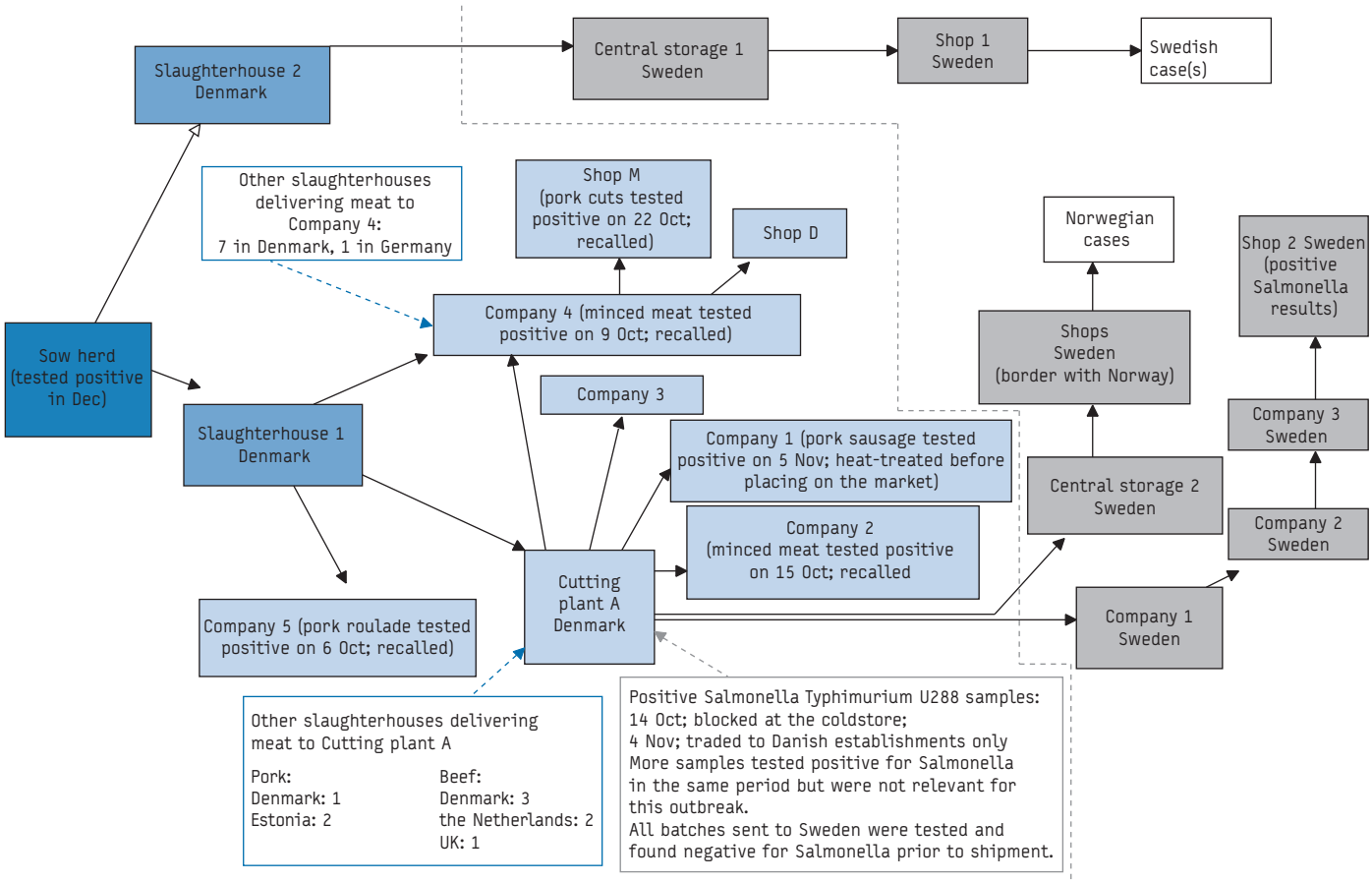
Control measures

In Denmark, following the multiple findings of the outbreak strain in food products, investigations were undertaken at the facility producing the raw pork sausage, as well as the cutting plant and the slaughterhouses that supplied meat to the cutting plant. Samples were taken for analysis from the cutting plant and the sausage-producing facility. The microbiological analysis did not identify *Salmonella*, which suggests that these facilities did not harbour persistent infections in their production environments. Furthermore, all analytical reports concerning batches of meat sent to Sweden from the cutting plant and one of the two slaughterhouses, were reviewed for sampling consistency according to the legal requirements. No known positive batches were put on the Swedish market, and the requirements concerning sampling and analyses were fulfilled.

In Norway, on 7 January, NIPH and Norwegian Food Safety Authority (NFSA) published an Internet update on the outbreak, in which the Norwegian public was informed that the *Salmonella* outbreak strain had been detected in minced meat bought in Sweden, and consumers were advised about safe handling of meat. This was followed by international alerts by the NFSA through the Rapid Alert System for Food and Feed (RASFF) [10] on 8 January, and by NIPH through the Early Warning and Response System (EWRS) on 9 January.

Figure 3

Trade route diagram for establishments involved in the outbreak of *Salmonella* Typhimurium in Denmark, Norway and Sweden, 2008



In Sweden, no further measures were taken, since the contaminated meat was not available in the shops anymore, and all environmental control samples from the shops were now negative.

Discussion

We report an outbreak of S. Typhimurium affecting three Nordic countries. The link between the outbreaks was established thanks to cross-border information exchange. Outbreaks that seem local may have international connections, and therefore early alerts are important for efficient investigation and management of such events. In the example described here, MLVA typing was instrumental in identifying and defining the outbreaks, in revealing the possible food/animal sources, and in establishing the link between the outbreaks in Denmark and Norway, and subsequently Sweden. We note with interest that the outbreak strain was communicated between the countries as belonging to three different phage type assignations: U288 in Denmark, RDNC in Norway and U302 in Sweden. Thus, in this outbreak, it would have been misleading if only phage type information had been exchanged between the countries. MLVA-typing has previously been successfully used in outbreak investigations in the Nordic countries [11-14]

In Sweden four human cases with the same MLVA profile were identified in addition to isolates from minced meat samples from a grocery store. No link between the cases and this grocery store or the shops identified by the Norwegian cases, could be established. However one of the Swedish patients reported buying meat in another Swedish shop, which was receiving meat from the incriminated Danish slaughterhouse. This shop belongs to a retail chain and is supplied from a central storage facility, and a possible connection to two more of the Swedish cases is likely. The fourth case was most probably infected during a stay in Denmark.

In Sweden, MLVA typing of human S. Typhimurium isolates had only been performed when epidemiologically relevant. However, as a result of this outbreak, as well as the Swedish experience with analysis of several clusters of other phage types of S. Typhimurium during 2008, it has now been decided to use MLVA to type all domestic human and other relevant S. Typhimurium isolates.

This outbreak also calls attention to some aspects concerning trade between countries with different endemic situation and regulations regarding *Salmonella*. Due to the endemic situation in Sweden and Norway (and also Finland) with a very low prevalence of *Salmonella* in domestic food, additional sampling for *Salmonella* is required on all fresh meat consignments sold to these countries from other EU/EEA countries [4].

The EC regulation on microbiological criteria for foodstuffs, says that when testing against set food safety criteria gives unsatisfactory results, the product or batch of foodstuffs shall be withdrawn or recalled [15]. However, products placed on the market, which are not yet at retail level and which do not fulfil the food safety criteria, may be submitted to further processing by a treatment eliminating the hazard in question provided that this use does not pose a risk for public or animal health and that this use has been authorised by the competent authority [16].

In Sweden, meat processing plants can get permission to heat-treat fresh meat contaminated with *Salmonella*, thereby eliminating the health hazard. However it is very uncommon that companies apply for this. Norway is due to implement EU harmonised legislation in this area, thus in near future the same option to sanitize contaminated meat applies.

In this outbreak, the source of the Norwegian cases could be traced back to shops located in Sweden close to the border with Norway, selling meat from Danish producers. These shops target Norwegian consumers. Information about the outbreak and the source was made public in Norway, since several of the cases in Norway reported consuming raw meat. This illustrates some of the challenges regarding food safety advice to consumers in areas where cross-border shopping is common, as the consumers may not be aware of information about or recalls of products in neighbouring countries.

In conclusion, this outbreak illustrates that good international communication channels, early alerting mechanisms, inter-sectoral collaboration between public health and food safety authorities and harmonised molecular typing tools, are important for effective identification and management of cross-border outbreaks.

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