SURVEILLANCE OF INFECTIOUS DISEASES IN ANIMALS AND HUMANS IN SWEDEN 2019

Chapter excerpt -
Salmonellosis

SVA NATIONAL VETERINARY INSTITUTE

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Folkhälsomyndigheten PUBLIC HEALTH AGENCY OF SWEDEN

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Reporting guidelines: Reporting guidelines were introduced in 2018 for those those chapters related to purely animal pathogens. The guidelines build on experiences from several EU projects, and have been validated by a team of international experts in animal health surveillance. The aim is to develop these guidelines further in collaboration within the global surveillance community and they have therefore been made available in the form of a wiki on the collaborative platform GitHub (https://github.com/SVA-SE/AHSURED/wiki). Feel free to contribute!

Layout: The production of this report continues to be accomplished using a primarily open-source toolset. The method allows the source text, produced by authors, to be edited independently of the template for the layout which can be modified and reused for future reports. Specifically, the chapter texts, tables and captions are authored in Microsoft Word and then converted using pandoc and R to the LaTeX typesetting language. Most figures and maps are produced using the R software for statistical computing. Development for 2019 has further improved the importing of content from Word to LaTeX. The method can now import text, tables and figure captions from Word, as well as the newly designed 'IN FOCUS' sections of some chapters. The tool is available as an R-package at GitHub (https://github.com/SVA-SE/mill/). This year the report was also built with a continuous integration pipeline on Microsoft's Azure DevOps platform, allowing every committed change to the content to be built and tested automatically. The report generation R-package and process was designed by Thomas Rosendal and Stefan Widgren. In 2019, figures and the final typsetting were done by Wiktor Gustafsson and Thomas Rosendal with contributions from the report authors.

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Salmonellosis

BACKGROUND

Salmonellosis is one of the most important bacterial zoonoses. The genus is divided into two species: *S. enterica* and *S. bongori*. Most *Salmonella* belong to *S. enterica* subspecies *enterica*. More than 2500 different serovars belonging to this subspecies have been described. *Salmonella* can infect reptiles, all warm-blooded animals, and humans. Humans are infected by contaminated food products of various types, through contact with infected animals, via person-to-person transmission or via a contaminated environment.

A severe domestic outbreak of *S.* Typhimurium in 1953 with more than 9000 cases prompted the need for a control programme for *Salmonella*. Since then, the strategy for control has been to prevent *Salmonella* in all parts of the production chain, from feed to food of animal origin. When Sweden joined the European Union in 1995, the Swedish *Salmonella* control programme was accepted. Sweden obtained additional guarantees for live animals, meat, and egg from countries with a non-equivalent *Salmonella* status to be tested for the presence of *Salmonella* before entering the Swedish market. The control programme constitutes an important safeguard to Swedish public health.

In recent years, a total of 2000–3000 human cases of salmonellosis have been annually reported to the Public Health Agency of Sweden. A majority (60–80%) of these cases were infected abroad. During the last decade, the number of cases infected abroad has decreased, whereas the domestic incidence has remained constant. The proportion of domestic infections in Sweden is low compared to many other countries. The source of the verified outbreaks is often imported food. The contribution to the human disease burden from domestic animals is low.

DISEASE

Animals

Infected animals are often asymptomatic. However, *Salmonella* can cause clinical illness with diarrhoea, abortions, and fever, and even lead to death. In Sweden, clinical signs are frequently seen in cattle, horses, and cats, whereas infected pigs and poultry are most commonly asymptomatic.

Humans

Salmonella infects the gastrointestinal tract and causes an acute gastrointestinal illness. The symptoms can range from asymptomatic and mild to severe. The incubation period is typically between 1 and 3 days but can vary from 6 hours to 10 days. Most patients recover from the illness spontaneously but sequelae such as reactive arthritis occur in approximately 1–15% of the patients. Excretion of the pathogen normally lasts for four to six weeks but prolonged asymptomatic excretion occurs.

LEGISLATION

Feed

Control of animal feed is an integrated and essential part of the control programme for *Salmonella* in primary production. The feed business operator is responsible for producing *Salmonella*-free feed. Poultry feed must be heat treated according to the legislation. A major part of cattle and pig feed is also heat-treated. The production of feed is supervised by the Swedish Board of Agriculture which carries out announced and unannounced inspections at feed mills and pet food producers. The control of *Salmonella* in feed is regulated in national legislation (SJVFS 2018:33) as well as in an EU regulation (Commission Regulation (EU) No142/2011).

Animals

Investigation is required upon clinical suspicion of salmonellosis and any finding of *Salmonella*, regardless of serovar, is notifiable. Action is taken to eliminate the infection or contamination except in cases of finding of *S. diarizonae* serovar 61:(k):1,5(7) in sheep. Vaccination is not used in Sweden. The *Salmonella* control programme is governed by the Swedish Act on Zoonoses (SFS 1999:658) and its regulations. The aim of the programme is that animals sent for slaughter and animal products should be free from *Salmonella*.

Food

Any finding of *Salmonella* in food is notifiable and a contaminated food product is considered unfit for human consumption. However, there is one exception, which is *S. diarizonae* serovar 61:(k):1,5(7) in sheep meat, as this serovar is not considered to be of public health importance (LIVFS 2005:20).

Laboratories analysing samples taken by authorities are obliged to send isolates of *Salmonella* from positive food samples to the National Reference Laboratory for serotyping (LIVFS 2005:21).

Humans

Salmonellosis in humans is notifiable according to the Communicable Disease Act (SFS 2004:168 with amendments, SFS 2013:634). A laboratory confirmed case can also include cases with samples that are only positive by PCR i.e. where no isolate has been obtained.

MEASURES IN CASE OF FINDINGS OF SALMONELLA

Isolates

All suspected isolates of *Salmonella* from non-human sources are sent to the National Veterinary Institute for confirmation, serotyping, resistance testing, and further typing. Index isolates from index cases in animals (first isolate of *Salmonella* in a holding of pig, cattle, goat, sheep, horse or a poultry flock, a companion animal or a wild animal) as

well as other index isolates (other serovars from the holding, findings of *Salmonella* at postmortem or in a lymph node but not confirmed in a holding, *S. diarizonae* serovar 61:(k):1,5(7) in sheep) are resistance tested. From cats and passerine birds, however, a subset of isolates is resistance tested and typed. In addition, one isolate per holding from holdings under restrictions are resistance tested. Isolates of *S.* Typhimurium and *S.* Enteritidis are further typed by MLVA.

All isolates of *Salmonella* from domestic human cases are sent to the Public Health Agency of Sweden for serotyping and further molecular typing. A subset of isolates from travel-associated cases are also typed. In 2013, phage typing of *S.* Typhimurium was replaced by MLVA. During 2016 MLVA was introduced also for *S.* Enteritidis.

Feed

Findings of *Salmonella* in intra-community traded or imported feed materials and compound feeds are reported in the Rapid Alert System for Food and Feed (RASFF) (https://ec.europa.eu/food/safety/rasff_en). Measures are always taken when *Salmonella* is detected in feed samples. *Salmonella* positive feed materials are usually treated with organic acids. After acid treatment the feed material must be re-tested negative before use in feed production. Finished feed containing *Salmonella* must be withdrawn from the market. Extended sampling and cleaning is done in the production line if *Salmonella* is detected in the weekly surveillance. If *Salmonella* is found before heat treatment, the contaminated part of the production line is thoroughly cleaned and disinfected, usually by dry cleaning, followed by disinfection. If *Salmonella* is found after heat treatment, the feed mill must be thoroughly cleaned and disinfected. Environmental sampling must show negative results before production is resumed.

Animals

If *Salmonella* is suspected in an animal, a veterinarian is obligated to take samples and implement measures to prevent further transmission. When *Salmonella* is detected, the laboratory must notify the Swedish Board of Agriculture and the County Administrative Board. When detected in a food-producing animal, the County Veterinary Officer informs the official veterinarian at the abattoir involved. When relevant, other persons are informed before confirmation.

When *Salmonella* is confirmed on a farm, the holding is put under restrictions except in cases of finding of *S. diarizonae* serovar 61:(k):1,5(7) in sheep, an epidemiological investigation is performed and a plan to eradicate *Salmonella* from the holding is defined. Animal movements to and from the holding are stopped.

All *Salmonella* positive poultry flocks are euthanised irrespective of serovar. The poultry house involved, and all possible contaminated areas are thoroughly cleaned and disinfected. Before introduction of new birds, all environmental samples must be negative for *Salmonella*.

IN FOCUS: MLVA - a typing technique that will soon be history

Genetic characterisation or 'typing' of bacterial isolates is done to find clusters of potentially related cases of infection, to match isolates from cases to those from suspected sources and to understand the population structure of a pathogen. *Salmonella* Typhimurium and its monophasic variants are together with *Salmonella* Enteritidis the most common causes of human salmonellosis in Sweden, together accounting for over 50% of the cases (data 2019). For these serovars, multi-locus variable number of tandem repeats analysis (MLVA) has been the cross-sectoral typing method of choice during the last decade. In MLVA the number of copies of "tandem repeats" in specific regions of the bacterial genome are determined by PCR and capillary gel electrophoresis. The analysed isolate can be described as a string of copy numbers for each repetitive region or "NA" if the region is missing. A patient isolate of *S.* Typhimurium can for instance be described as 2-13-3-NA-212, and this string can be matched to those of other potentially related isolates or suspected sources. In Sweden, MLVA data has also been used to investigate the spread of specific subtypes with e.g. certain birds, cats and hedgehogs having their own *Salmonella* MLVA variants.

MLVA has been an especially powerful tool for the investigation of international outbreaks and zoonotic transmission as data can easily be exchanged between public health and veterinary laboratories as well as between laboratories in different countries, facilitated by the establishment of shared EU-level protocols. Several foodborne outbreaks due to e.g. contaminated salami, dried herbs and eggs have been solved with the aid of MLVA typing results over the years. In recent years, whole genome sequencing (WGS) has become the gold standard for typing of essentially all bacterial pathogens. WGS is now rapidly replacing all other *Salmonella* typing methods including serotyping, the results of which can be inferred from WGS data. Unfortunately, MLVA profiles cannot currently be reliably extracted from WGS data and comparison with historical data is therefore problematic. In addition, new nomenclature for WGS profiles, clades or strains that would be an equivalent for communication purposes need to be developed.

In pigs and cattle, a combination of partial herd depopulation and hygienic measures controlled by repeated sampling is usually practiced. Cattle herds under restrictions for *Salmonella* are monitored by a combination of serological and bacteriological testing. Hygienic measures can include reducing the number of animals, control of animal feed and manure management on the farm and reduction of *Salmonella* contamination in the environment by cleaning and disinfection. Animals from restricted herds may be slaughtered after sampling with negative results. The restrictions are lifted when the cleaning and disinfection have been completed and *Salmonella* cannot be detected by culture from whole-herd sampling at two occasions performed four weeks apart.

If *Salmonella* is detected in companion animals, advice on hygienic measures to prevent further spread to other animals or humans is given to the owners. If *Salmonella* is detected in horses, the stables and/or the paddocks at risk are put under restrictions and follow up investigations are performed on the positive horse(s).

Food

Products released on the market will be withdrawn and contaminated products will be destroyed or sent for special treatment to eliminate the *Salmonella* bacteria, except for *Salmonella diarizonae* serovar 61:(k):1,5(7) in sheep meat.

Findings in imported consignments are reported in the RASFF system and the consignments will be returned to the country of origin, destroyed, or sent for special treatment as applicable. RASFF is also used for informing about contaminated Swedish food products released on the EU market or within Sweden.

In food enterprises where *Salmonella* has been detected, appropriate follow-up measures will be applied, such as careful cleaning and disinfection and environmental sampling.

SURVEILLANCE

Feed

In the control programme for feed, the emphasis is on control of feed raw materials, the heat treatment process, and preventive measures for preventing recontamination of heat-treated feed. Suspected feed-borne infections are also investigated (see infographic).

Surveillance of intra-community traded and imported compound feed and feed raw materials

Raw feed materials are the most important risk factor in feed production. In the domestic legislation, feed materials are classified according to the empirical risk of being contaminated, and high-risk feed materials must test negative for *Salmonella* contamination before being used in feed production. All consignments of intra-community traded or imported compound feed for cattle, pigs, poultry and reindeer and feed materials classified as a risk must be sampled and tested for *Salmonella*. The sampling plan is designed to detect a *Salmonella* contamination in 5% of the batch with 95% probability.

Surveillance of feed mills

The purpose of the surveillance is to ensure the absence of *Salmonella* in the production lines as well as in the feed mill environment. A safety management system is applied in the processing line according to HACCP (Hazard Analysis and Critical Control Points). The management system covers several specific GMP (Good Manufacturing Practices) requirements, according to the Swedish legislation. A minimum of five samples from feed mills that manufacture compound feedstuffs for poultry and a minimum of two samples from those manufacturing compound feedstuffs for other food-producing animals must be collected in the processing line on a weekly basis. These samples are analysed at the National Veterinary Institute (using MSRV, EN-ISO 6579-1: 2017) and any finding of *Salmonella* is reported to the Swedish Board of Agriculture. The feed manufacturers also take additional samples from the processing line and the feed mill environment as part of their own process quality control.

Pet food and dog chews

Sampling is performed by the feed business operators as part of their feed safety management system. Consignments of pet food and dog chews imported from third countries are sampled according to a sampling plan at the border inspection. The sampling plan is defined based on a risk assessment.

Animals

In all animal samples (poultry, cattle and pigs and other animals), except for those taken within the control programme at abattoirs, detection of *Salmonella* is performed using the MSRV (EN-ISO 6579-1: 2017) method or a method validated against it. Measurement of antibodies against *Salmonella* in blood or milk samples of cattle is performed using commercial ELISA tests PrioCHECK® Salmonella Ab bovine ELISA and PrioCHECK® Salmonella Ab bovine Dublin.

Poultry

The programme comprises a compulsory part and a voluntary part. The purpose of the compulsory programme is to ensure that poultry sent for slaughter and meat products should be free from *Salmonella*. All poultry species are included in the compulsory part, which sets the rules for mandatory sampling (Figure Infographic).

Compulsory programme

All breeding flocks with more than 250 birds are tested (Table 18). Grandparents of *Gallus gallus* broilers are imported as day-old chicks. Laying hens, turkeys, geese, and ducks are imported as parents. Samples consist of sock samples (free range systems) or faecal samples (cage systems) taken from all parts of the building or the department where the bird flock is kept. From rearing flocks, two pairs of sock samples are taken and pooled into one whereas five pairs pooled into two are taken from the breeding flocks in production.

Table 18: Sampling scheme of poultry.

Category of poultry	Sampling frequency	Sample type	Sampling before slaughter	Official veterinarian
Breeders in rearing	1 d, 4 weeks, 2 weeks prior to rearing or moving	2 pairs sock samples	14 d before slaughter	Once a year
Breeders in production	every 2nd week	5 pairs sock samples	14 d before slaughter	3 times under production
Layers in rearing	2 weeks prior to moving	2 pairs sock samples or 2 faecal samples of 75 g	14 d before slaughter	Once a year
Layers in production	every 15th week (start at 22–26 weeks)	2 pairs sock samples or 2 faecal samples of 75 g	14 d before slaughter	Once a year
Poultry for meat production (all species)		2 pairs sock samples or 2 faecal samples of 75 g	14 d before slaughter	Once a year

All holdings that sell eggs for consumption are sampled (Table 18). All poultry flocks that have more than 500 birds, irrespective of species, must be tested 1–2 weeks prior to slaughter. In practice, all poultry flocks are tested prior to slaughter and the results must be available before slaughter.

The poultry producers pay the costs for laboratory analyses and the visits to the farms. Only accredited laboratories are allowed to perform the analyses. County Veterinary Officers supervise the poultry control programme regionally. The laboratory sends the test results to the County Veterinary Officer on a quarterly basis. According to regulations, the County Veterinary Officer must send a report on the test results of all poultry holdings to the Swedish Board of Agriculture once a year.

Voluntary programme

The aims of the voluntary programmes are to prevent introduction of *Salmonella* into the poultry holding and minimise the risk of spread of the infection to animals and humans. The voluntary programmes have been in place for more than 40 years.

All broiler and turkey producers belonging to the Swedish Poultry Meat Association are affiliated to the voluntary programme which represents approximately 99% of the slaughtered broilers and 91% of turkeys. This voluntary preventive programme includes the use of all-in all-out production, hygiene measures and a high standard for poultry house construction, such as hygiene barriers between the clean and unclean parts. Purchases of animals may only occur from holdings affiliated to the voluntary programme and only heat-treated feed is allowed. The poultry houses must be cleaned and disinfected before introduction of a new flock. The poultry producer needs to make an application to be accepted into the voluntary programme and an official veterinarian inspects the holding at least once a year.

The organisation Swedish Eggs is responsible for the voluntary programme of the egg line (laying hens, pullets, breeders). The voluntary programme of the egg line resembles that of the meat line. However, a voluntary programme is also available for holdings with outdoor access. Producers affiliated to the voluntary programmes of egg line receive higher financial compensation in case of a finding of *Salmonella*.

Cattle and pig herds

This programme includes a compulsory and a voluntary component (Figure Infographic).

Compulsory programme

The aim of the programme is to ensure a low prevalence of *Salmonella* in cattle and pig herds. The compulsory part consists of annual faecal sampling from breeding pig herds and gilt-producing herds and biannual sampling from sow pools. In cattle, *Salmonella* testing is performed in all calves <12 months of age that are submitted for postmortem. *Salmonella* testing is also performed in conjunction with necropsies if an infection is suspected based on macroscopic findings. All imported animals are also tested and on clinical suspicion, any herd or single animal should be tested for *Salmonella*.

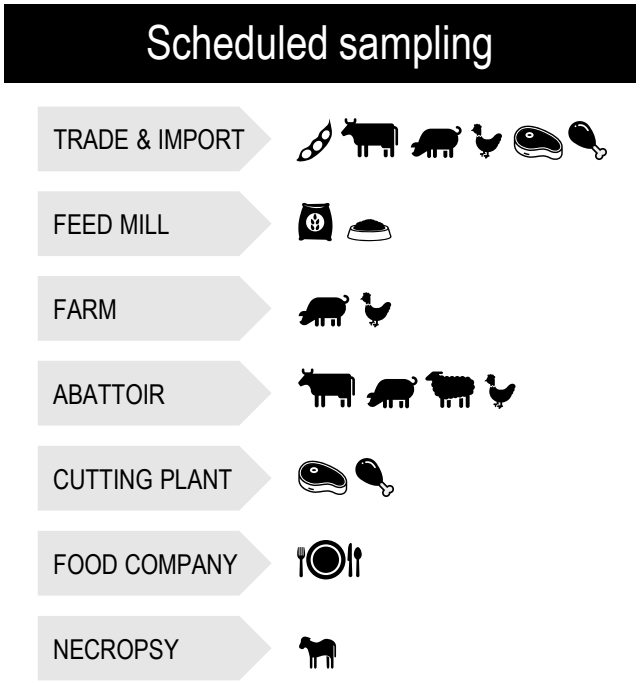
Voluntary programme

The voluntary programme is a preventive hygienic programme aiming at decreasing the risk of introduction of *Salmonella* and other infections. Holdings affiliated to the programme receive higher compensation in case of positive findings. In addition, affiliated holdings are entitled to apply for a commercial *Salmonella* insurance. Most breeding herds and many of the large dairy herds are affiliated to this programme.

In addition, there is a "Safe Trade" programme, including testing for *Salmonella* antibodies in bulk milk samples collected four times a year. All herds with test-positive results in this programme are offered veterinary consultations aiming at improved internal biosecurity to control and eradicate any *Salmonella* infection from the herd.

Salmonella screening in dairy herds

In October 2019, a national bulk milk screening was performed including all Swedish dairy herds. A total of 3282 samples were analysed with PrioCHECK® Salmonella Ab bovine ELISA (O antigens 1, 4, 5, 12 and 1, 9, 12). All samples with a PP-value higher than twenty (PP>20) in this first test were also analysed with PrioCHECK® Salmonella Ab bovine Dublin ELISA (JV dnr 6.2.18-14271/2018).



An illustration of the Swedish surveillance of *Salmonella* in feed, food, animals and humans. Infographic by Arianna Comin.

Other animals

Animals are tested for *Salmonella* on clinical suspicion or as part of trace-back investigations (Figure Infographic). Wild animals necropsied at the National Veterinary Institute are also tested for *Salmonella* on suspicion (see chapter on surveillance of wild animals).

Food

Control of *Salmonella* is an important part of in-house quality control programmes in many food enterprises in Sweden (Figure Infographic). All findings must be reported to the competent authority.

Approximately 1000 samples per year are tested as part of official sampling by local authorities at food enterprises, other than abattoirs and cutting plants. These samples are analysed mainly using NMKL (nr 71:1999) or a method validated against the standard method.

Isolates of *Salmonella* from samples of food taken by authorities are always sent for serotyping at the National Reference Laboratory for *Salmonella* (see Legislation). Although there are no legal requirements, laboratories most often also send isolates for confirmation from samples taken by food business operators. Serotyping of these isolates is funded by the Swedish Board of Agriculture, provided that the food business operator agrees that the results are made available to the national authorities. Data from 2007 and onwards are stored in a database at the National Veterinary Institute.

Surveillance at slaughterhouses and cutting plants

According to the Swedish *Salmonella* control programme, samples from intestinal lymph nodes and swabs from carcasses are taken from cattle and swine and neck skin samples are taken from slaughtered poultry. Sampling at each slaughterhouse is proportional to the annual slaughter volume. The total number of samples taken is calculated to detect a prevalence of 0.1% with 95% confidence level in cattle, pig, and poultry carcasses at a national level. Altogether, approximately 21 000 samples from cattle, adult pigs, fattening pigs, and poultry are collected at abattoirs annually.

At red meat cutting plants, approximately 5000 samples are taken annually from meat residues and approximately 1000 samples are taken in poultry meat cutting plants.

The samples within the control programme are analysed by commercial laboratories using the current edition of the NMKL (nr 71:1999) method, except for approximately 700 samples analysed by a method validated against the NMKL method.

Food business operators are obliged to take swab samples from carcasses of sheep, goats, and horses at slaughterhouses for analyses of *Salmonella,* according to the regulation (EG) 2073/2005 on microbiological criteria for foodstuffs. The results of these analyses are not collected by the competent authority. In Sweden, the corresponding requirements of swab sampling of carcasses of cattle and pigs and sampling of neck skins of poultry carcasses are replaced by the sampling within the *Salmonella* control programme.

Humans

Surveillance in humans is based on identification of the disease by a treating physician and/or by laboratory diagnosis (i.e. passive surveillance) (Figure Infographic). Both treating physicians and laboratories are obligated to report to the regional and national level to enable further analyses and adequate intervention measures. *Salmonella* spp. is part of the microbial surveillance programme at the Public Health Agency of Sweden and domestic isolates are whole genome sequenced for serovar determination, assessment of diversity and cluster detection. All isolates belonging to the serovars *S.* Enteritidis, *S.* Typhimurium and the monophasic variants of *S.* Typhimurium were subtyped using MLVA (multi-locus variable number tandem repeat analysis). The long-term goal is to use the data to evaluate efforts to lower the level of domestic incidence of *Salmonella* infection.

RESULTS

Feed

Fifteen major feed mills produce approximately 95% of the feed for food-producing animals. In the weekly surveillance of feed mills, 7394 samples were analysed for *Salmonella;* 33 of these samples (0.4%) were positive. Nine serovars were detected; *S.* Typhimurium was the most common (n=19) (Table 19).

In addition, *Salmonella* was detected in 16 out of 1654 analysed batches from feed materials of vegetable origin. The most common serovar was *S.* Mbandaka (n=4). *Salmonella* was detected in 4 out of 1417 batches from feed materials of animal origin and from pet food.

Sweden notified ten findings of *Salmonella* in feed materials and pet food during 2019. All of these concerned intra-community traded or imported feed materials. Seven of them had vegetable origin and the other three were of animal origin.

Animals

Poultry

Salmonella was detected in 2 (0.04%) of 4502 broiler flocks tested in routine sampling before slaughter (Table 20 and Figure 16). *Salmonella* was also detected in 4 of the 692 flocks of layers tested. *Salmonella* was not detected in any breeding flocks, neither in any samples of commercially raised turkeys, geese, ducks, quails, or ostriches. As the poultry registries maintained by the Swedish Board of Agriculture are not sufficiently updated, the figures on the number of flocks within the programme and the number of flocks not sufficiently sampled, can only be considered estimates. It is estimated that approximately 20% of the poultry holdings lack an annual official sampling.

Table 19: Serovars of *Salmonella* isolated within feed control in 2019.

Serotype	Feed material of animal origin[A]	Pet food	Feed material of oil seed origin[B]	Feed material of cereal grain origin	Other plants[C]	Process control feed mills	Process control rapeseed crushing plant
S. Derby	-	1	-	-	-	-	-
S. Dublin	-	1	-	-	-	-	-
S. Düsseldorf	-	-	-	-	-	1	-
S. Lexington	-	-	-	-	-	1	-
S. Mbandaka	-	-	4	-	-	2	-
S. Muenster	-	-	1	-	-	-	-
S. Saintpaul	-	-	-	-	-	1	-
S. Senftenberg	1	-	2	-	-	1	-
S. Tennessee	-	-	3	-	-	1	-
S. Typhimurium	-	1	3	-	-	19	-
S. Vejle	-	-	-	-	-	1	-
S. enterica sp. *diarizonae* (IIIb)	-	-	-	-	-	3	-
S. enterica sp. *enterica*	-	-	2	-	-	3	-
Not typed	-	-	1	-	-	-	-
Total	**1**	**3**	**16**	**0**	**0**	**33**	**0**
Number of samples	1222	195	1037	576	41	7394	822

[A]Meat and bone meal, animal fat, fish meal, greaves, protein meal, meat meal, milk products, egg products, poultry offal meal and animal by-products.
[B]Derived from palm kernel, rape seed, soya bean, linseed, and sunflower seed.
[C]Peas, algae, leaves (dried), beans, lignin, herbs (dried), and berries.

Table 20: Results from the *Salmonella* control programme in poultry flocks in 2019.

Animal species	Production type	Production stage	No. flocks tested	No. positives	Percentage	Serovar
Gallus gallus	Meat production	Adult Grand Parent	22	0	0.00%	-
Gallus gallus	Meat production	Adult Parent	148	0	0.00%	-
Gallus gallus	Meat production	Production	4502	2	0.04%	*S.* Bukavu, *S.* Reading
Turkeys	Meat production	Adult Parent	4	0	0.00%	-
Turkeys	Meat production	Production	151	0	0.00%	-
Gallus gallus	Egg production	Adult Parent	20	0	0.00%	-
Gallus gallus	Egg production	Production	692	4	0.58%	*S.* Düsseldorf, *S.* Kisii, *S.* Typhimurium (n=2)
Geese	Meat production	Production	5	0	0.00%	-
Ducks	Meat production	Production	10	0	0.00%	-

Cattle

In total, *Salmonella* was detected in 11 new herds in 2019 (Figure 17). *Salmonella* was isolated from six (0.18%) of 3308 mesenteric lymph nodes from cattle at slaughter (Table 21 and Figure 18).

In the bulk milk screening, 4.3% (n=140) of the samples were test-positive in the first ELISA. Of these 140 samples, 40 were also test-positive in the second test, primarily detecting antibodies against *S.* Dublin. There were regional variations in the prevalence of dairy herds with test-positive bulk milk samples ranging from 0% to 24%. The two regions with highest prevalence were Öland and Gotland. In Öland, 24% (33/136) of the herds were test-positive and 31 of these herds were also positive in the second test, indicating present or previous infection with *S.* Dublin, which is known from previous bulk milk screenings to be at this level in the region. In Gotland 22% (30/139) of the herds were test-positive in the first test, and only one of these were positive in the second test. This can be compared with results from the last bulk milk screening, performed in 2013 when 5% (12/218) of the herds in Gotland were test-positive. As a follow-up, a regional bulk milk screening is planned for spring 2020.

Pigs

Salmonella was detected in three pig herds (Figure 19) and from seven (0.24%) of 2922 lymph node samples taken from adult pigs and from five (0.16%) of 3091 lymph node samples from fattening pigs (Table 21, Figure 18).

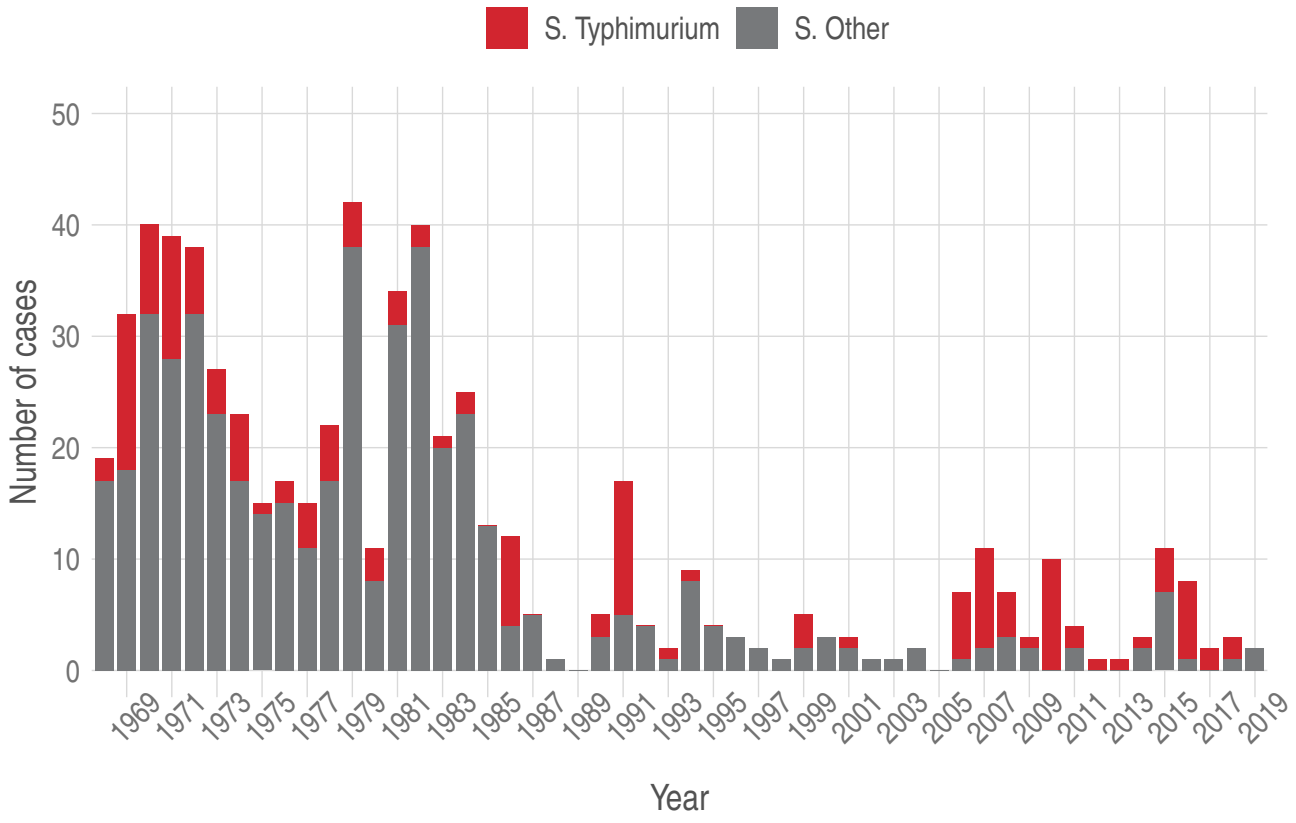


Figure 16: Annual notifications of *Salmonella* in broiler holdings during 1968–2019, breeding flocks included.

Other animals

Salmonella was detected in three stables with horses, in 1179 cats, in 9 dogs, in 21 wild birds (mainly passerine) and in one hedgehog (Table 22).

Food

Within the Swedish *Salmonella* control programme, swab samples were taken from 5935 pig carcasses and 3264 cattle carcasses. Neck skin samples were taken from 2904 poultry carcasses. *Salmonella* was detected in swab samples from one pig and one cattle carcass (Table 21). At cutting plants, *Salmonella* was not detected in any of the 5390 red meat or the 1244 poultry meat samples taken. (Table 21 and Figure 18).

In addition to the sampling performed within the control programme, 968 samples were taken by national and local authorities. *Salmonella* was detected in three samples. Two samples were taken from vegetables in an investigation of suspected food-borne outbreak, and one sample from pre-cooked crayfish taken in border control (Table 23).

Sweden notified seven findings of *Salmonella* in food during 2019. All these concerned intra-community traded or imported food batches within the food categories meat, crustaceans, and vegetables.

Table 21: Results from the *Salmonella* control programme at abattoirs and cutting plants in 2019.

Animal species	Sample type	No. samples	No. positive	Percentage	Serovar
Cattle	Lymph node	3308	6	0.18%	*S.* Düsseldorf (n=2), *S.* Typhimurium (n=4)
	Carcass swab	3264	1	0.03%	*S.* Dublin
Breeding swine	Lymph node	2922	7	0.24%	*S.* Agona (n=1), *S.* London (n=2), Typhimurium (n=4)
	Carcass swab	2878	0	0.00%	-
Slaughter swine	Lymph node	3091	5	0.16%	*S.* Typhimurium
	Carcass swab	3057	1	0.03%	*S.* Typhimurium
Cattle and swine	Meat trimmings	5390	0	0.00%	-
Poultry	Neck skin	2904	0	0.00%	-
	Meat trimmings	1244	0	0.00%	-

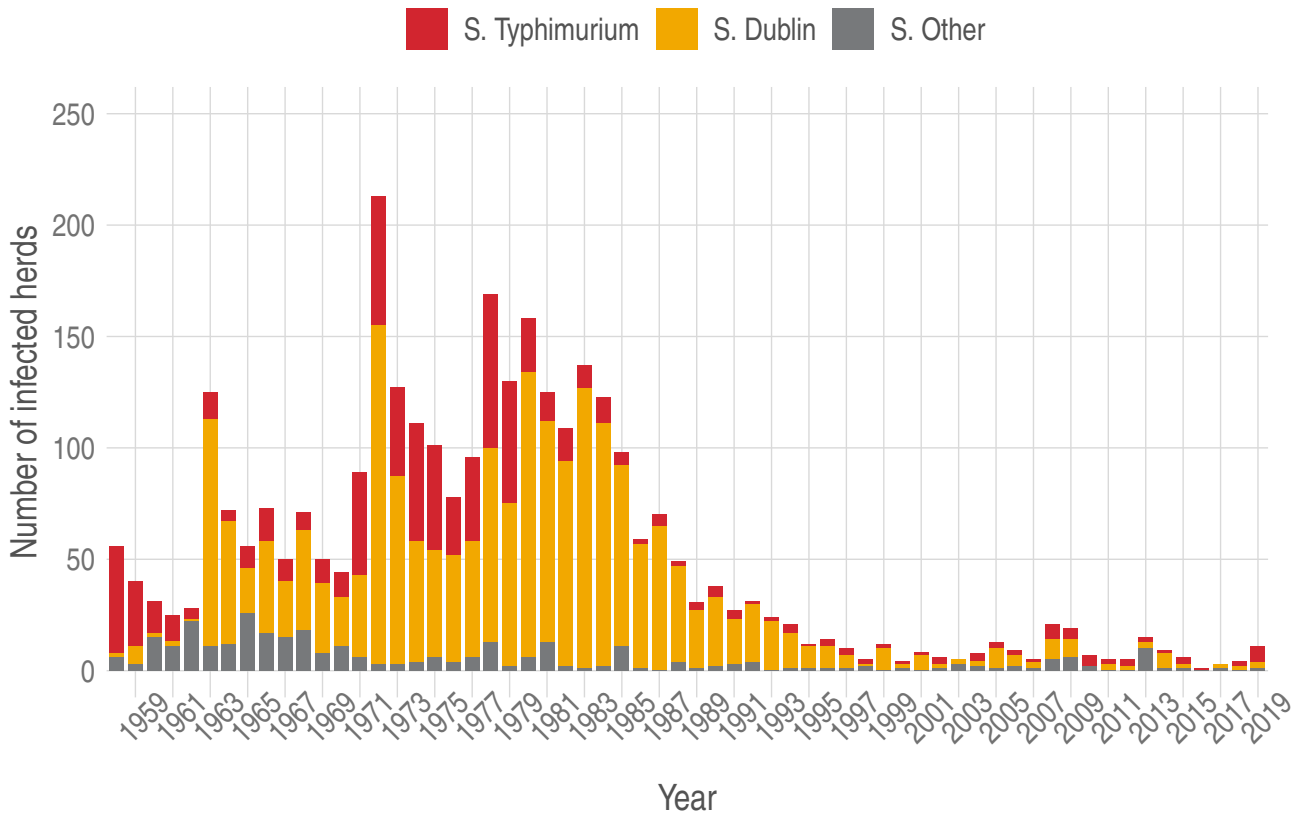


Figure 17: Annual notifications of *Salmonella* in Swedish cattle herds during 1957–2019. Data from 1957 through 1967 is extracted from a graph presented by J.Å. Robertsson (1985).

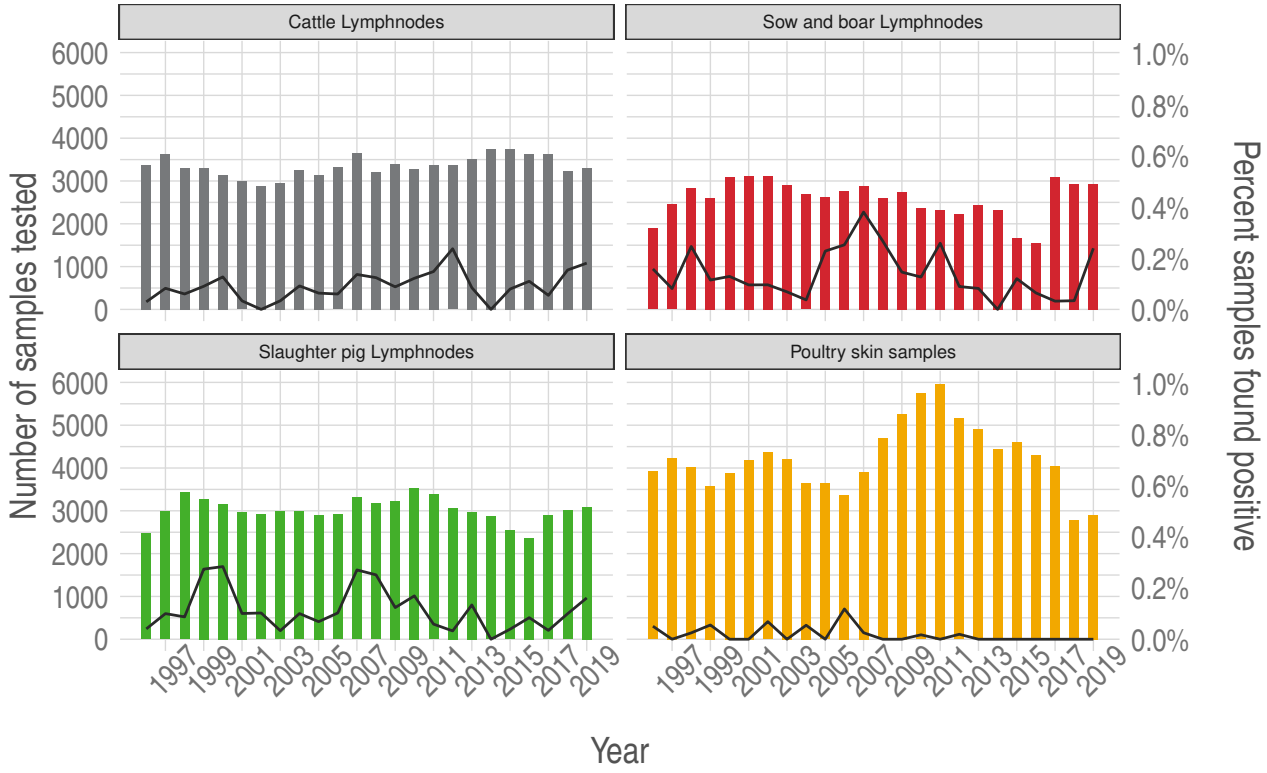


Figure 18: Samples tested (bars - left axis) and percentage of *Salmonella* found (line - right axis) in lymph node samples from cattle, sows and boars and fattening pigs sampled at major abattoirs as well as neck skin samples from poultry at all abattoirs. In 2014, a new laboratory was procured to perform *Salmonella* analyses of samples from abattoirs and cutting plants. The National Reference Laboratory for *Salmonella* and the National Food Agency of Sweden inspected the laboratory and found that the analytical methods and laboratory routines needed improvement. The laboratory results from 2014 and 2015 are therefore considered to be unreliable. Since 2016, another laboratory performs these analyses.

In total, data from serotyped isolates from 479 batches of food or carcasses sampled at retail, slaughterhouses, or other food enterprises between 2010 and 2019 is available. Of these, 283 were from imported food batches, 131 of domestic origin (24 food batches and 107 carcasses) and 65 from food batches of mixed or unknown origin. The distribution of serovars differ between the major food categories (Figure 20). *S.* Dublin was the most common serovar in beef meat whereas *S.* Typhimurium and *S.* Derby were most common in pork meat. The composition of serovars from poultry meat was quite variable, but *S.* Newport, *S.* Infantis and *S.* Enteritidis were most common. Isolates from lamb meat (mainly originating from swab samples of carcasses) were almost exclusively *S. diarizonae* serovar 61:(k):1,5(7), whereas the composition of isolates from vegetables varied a lot.

Humans

In 2019, a total of 1993 cases of salmonellosis were reported, compared to 2040 cases in 2018 (Figure 23). Domestic cases increased by 13% from 677 cases in 2018 to 763 cases in 2019, resulting in an incidence of 7.4 cases per 100 000 inhabitants. The domestic incidence varies from year to year but has been largely stable over a long period.

A total of 61% of the cases (n=1215) were considered to have been infected abroad. Since 2008, a steep decrease in the number of travel-associated cases has been noted, despite an increase in international travel.

Among the domestic cases, the median age was 45 years (0–94 years) and the incidence was highest for children younger than 5 years of age with 13.8 cases per 100 000 inhabitants followed by persons over 80 years of age with an incidence of 12.7 per 100 000 inhabitants.

Of the isolates from domestic cases, 90% were serotyped. The most common serovars from domestic cases were monophasic *S.* Typhimurium (24%), *S.* Enteritidis (18%) and *S.* Typhimurium (10%). Of the domestic isolates of monophasic *S.* Typhimurium, MLVA profile 3-14-8-NA-211 (17 cases) was the most common followed by 3-14-11-NA-211 (15 cases) and 3-12-10-NA-211 (14 cases). For *S.* Enteritidis, 3-9-5-4-1 (54 cases) was the most common MLVA profile followed by 3-10-5-4-1 (14 cases). None of the MLVA profiles of *S.* Typhimurium had over ten isolates. Around 70 additional serovars were identified in domestic cases during 2019. Of the cases infected in other countries, 14% were serotyped and *S.* Enteritidis was the most common serovar (46% of the isolates that were typed).

A clear seasonal variation of domestic salmonellosis is usually observed, with most cases occurring during the summer months. During 2019, most domestic cases were reported in early autumn due to several major outbreaks (Figure 22).

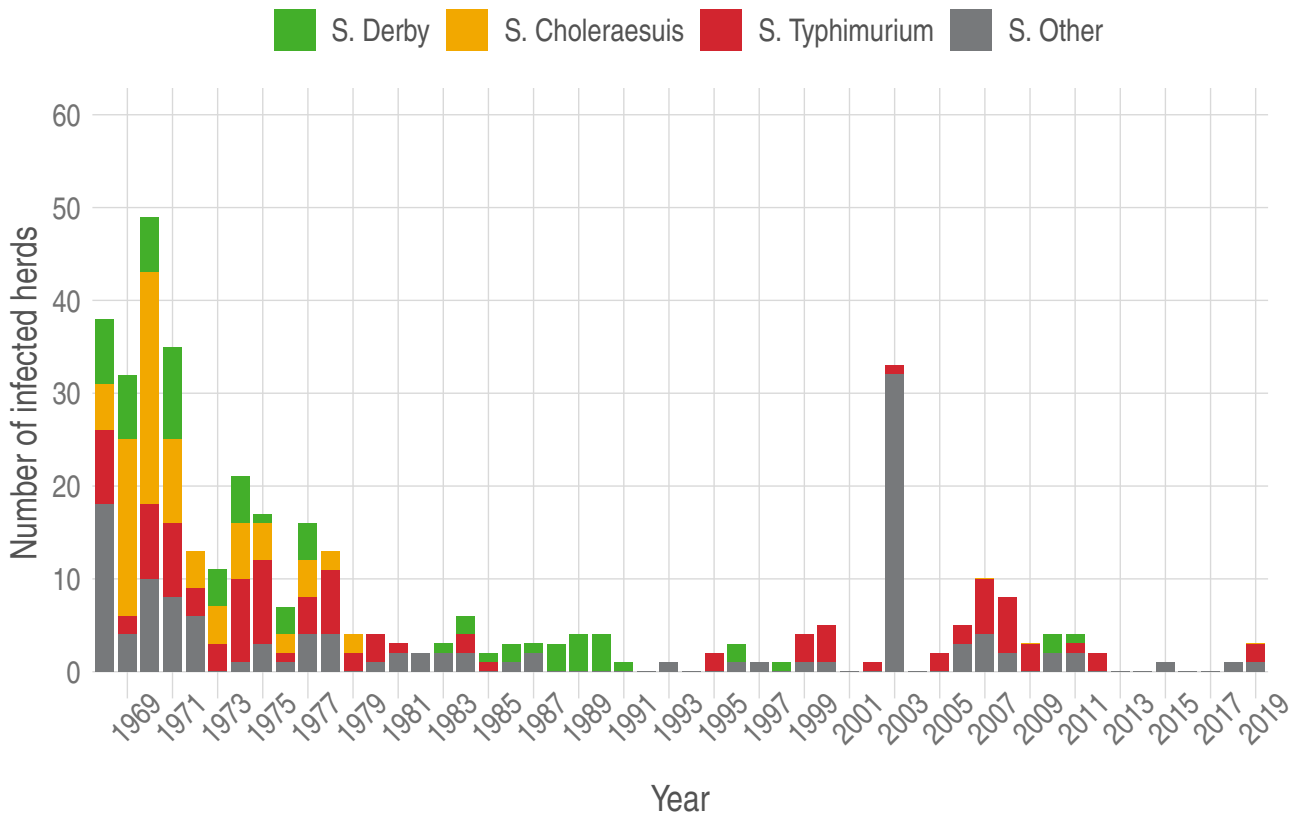


Figure 19: Annual notifications of *Salmonella* in swine herds during 1968–2019. In 2003, a feed borne outbreak of *S.* Cubana occurred in Sweden. In 2016 and 2017, *Salmonella* was not detected in any herd.

Table 22: Reported index cases of *Salmonella* in cats, dogs, horses, wild birds and wild mammals in 2019.

Serovar	Cats	Dogs	Horses	Wild birds	Other wild animals
S. Agona	0	1	0	0	0
S. Derby	0	1	0	0	0
S. Enteritidis	0	0	1	0	1[A]
S. Hessarek	1	0	0	1	0
S. Newport	1	0	0	0	0
S. Typhimurium	165	10	2	7	0
Salmonella enterica sp. *diarizonae*	1	1	0	0	0
Salmonella, O:4	1012	1	0	13	0
Total	**1179**	**17**	**1**	**21**	**1**
Number of samples	1836	152	57	44	24

[A]A hedgehog.

Table 23: Results of *Salmonella* analyses of food samples taken by the authorities in 2019.

Reason for sampling	Total no. of samples	No. of positive samples
Survey	178	0
Routine control	52	0
Suspected food poisoning or complaint	313	2[A]
Border control	228	1[B]
Unknown	197	0

[A]*S.* Enteritidis, vegetables contaminated at a restaurant.
[B]*S.* Newport, pre-cooked frozen crayfish

Outbreaks

The number of domestic infections in humans with *Salmonella* was comparatively low during the first half of 2019. However, from July onwards several major outbreaks occurred, which increased the number of cases for the whole year (Figure 22).

Outbreak of S. Typhimurium in wild birds, cats, dogs, horses, and humans

In the early months of 2019, a large outbreak of *Salmonella* Typhimurium (MLVA profiles 2-[11-15]-[3-4]-NA-212) occurred among cats in Sweden. In total, *Salmonella* was detected in 1179 (64.2%) cats of 1836 tested which was at the same level as in 2018 but more than previously observed. Of the 167 fully serotyped cat isolates, 165 belonged to the serovar Typhimurium. Infected cats were reported predominantly from the regions of Stockholm, Uppsala and Södermanland (65.7% of the cases). Simultaneously, *S.* Typhimurium with the same specific MLVA profiles were detected from 21 passerine birds, 10 dogs, 2 stables with horses as well as in 13 humans.

Outbreak of S. Enteritidis

In July 2019, the County of Dalarna informed the Public Health Agency of Sweden about fifteen people with salmonellosis all with an epidemiological link to a local pizzeria/kebab restaurant. All the dishes consumed by the cases contained vegetables, many of them both cucumber and tomato. Food analyses identified *Salmonella* in sliced cucumber and sliced tomatoes but not in other types of food tested or in whole vegetables. In addition, *Salmonella* was found on a worktop where food was prepared while the restaurant staff sampled were negative. Sequencing of the isolates from the samples of the worktop, sliced vegetables as well as in samples from a total of 50 people who had eaten at or picked up food from the restaurant in July 4–17 revealed an identical type of *Salmonella* Enteritidis ST11. Identical strains were also identified in nine Norwegian patients who had been in Sweden during this time, but it could not be confirmed if they had visited the specific restaurant. Continued source tracing could not reveal the origin of the bacterium.

Outbreak of S. Newport

During July through November, 33 persons from 12 counties were notified with *S.* Newport. A case-case study performed by the Public Health Agency of Sweden showed a strong association between being sick with the outbreak strain and eating crayfish. Most of the outbreak cases had eaten a certain brand of frozen pre-cooked Chinese crayfish, which was recalled by the retail company. Following the recall, *S.* Newport was detected in samples of crayfish taken by the retail company and in border control. Whole-genome sequencing showed that the isolates from food clustered with the isolates from the human cases, and the source of infection could thus be confirmed.

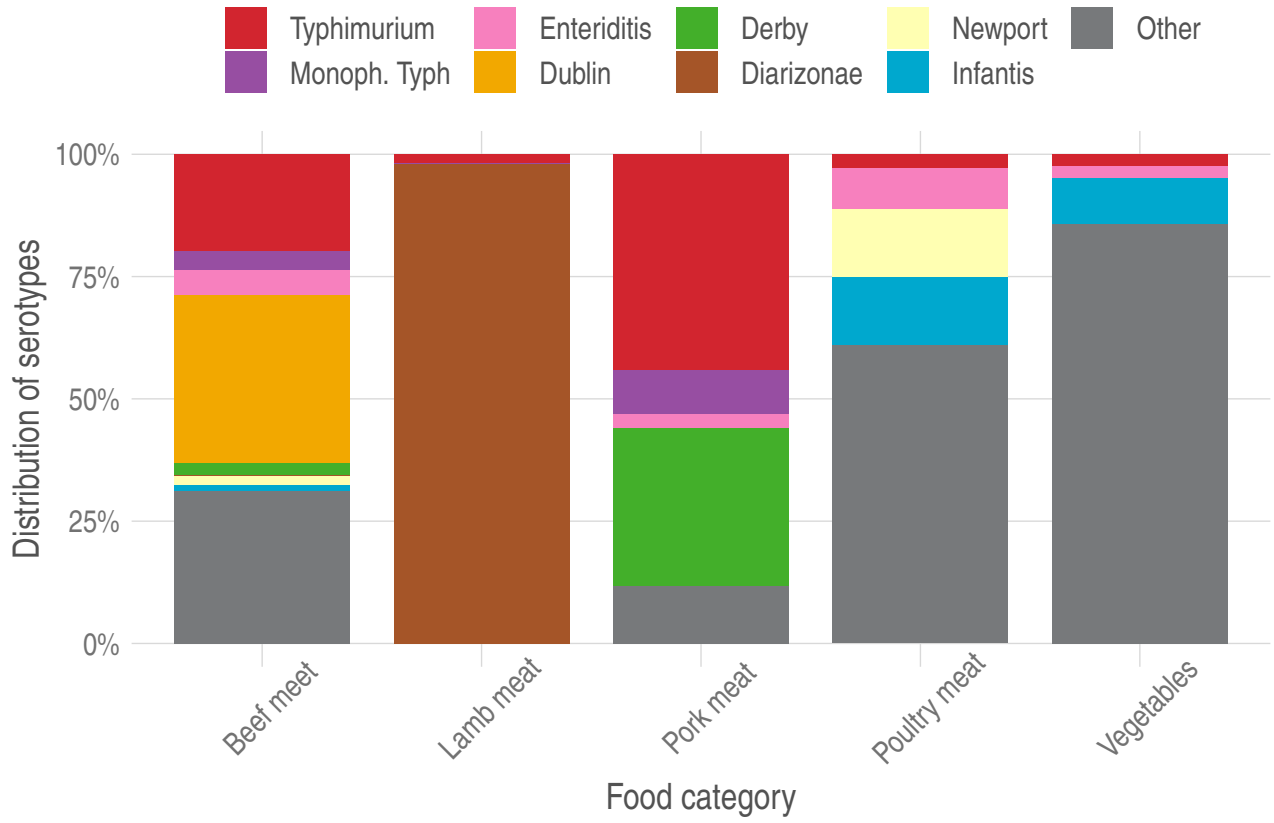


Figure 20: Distribution of *Salmonella* serovars in different food categories. Results of serotyping of isolates from samples taken at retail, slaughterhouses or other food enterprises by authorities or food business operators 2010 – 2019. In total, samples are from 379 batches of food or carcasses (beef meat 157, pork meat 34, poultry meat 36, lamb meat 110, vegetables 42). Food categories with isolates from samples of less than 20 batches of food are not included.

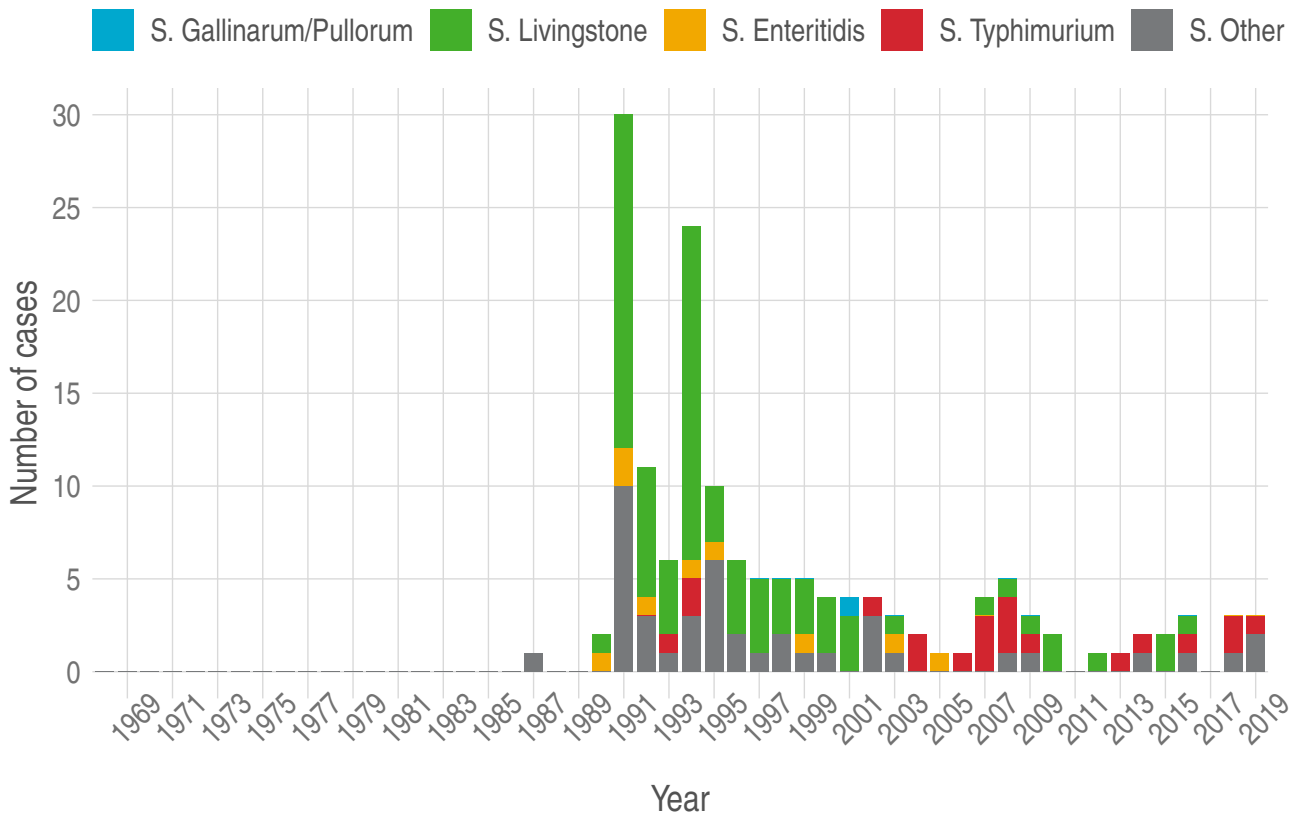


Figure 21: Annual notifications of *Salmonella* in layer holdings during 1987–2019.

Outbreak of monophasic S. *Typhimurium*

In the early autumn 2019, the county of Jönköping reported of an increase in salmonellosis cases to the Public Health Agency of Sweden. The regional clinical laboratory in the county informed that the *Salmonella* isolates all showed unusual phenotypic characteristics on XLD agar plates. They were lacking the traditional black pigmentation of colonies, i.e. they were dihydrogen sulphide negative. The outbreak spread nationally, and a case-control study was conducted. The analysis pointed towards small tomatoes being the likely source. The epidemiological typing also showed that the outbreak strain, a monophasic *S.* Typhimurium, belonged to an unusual sequence type (ST3478), closely related to the more common ST34. In total, 82 cases were identified, and this outbreak highlighted the importance of considering vegetables as a possible vector for transmission.

Outbreak of S. *Mikawasima*

In October 2019, the microbial surveillance programme at the Public Health Agency of Sweden identified a WGS cluster of *S.* Mikawasima. Simultaneously, an Urgent Inquiry was launched in EPIS (ECDC) by Public Health England (PHE) regarding a *S.* Mikawasima outbreak. PHE shared the outbreak sequence, and comparison showed that there was a match with the Swedish outbreak strain. In Sweden, a case-case study was conducted where the control group consisted of salmonellosis cases with differing serovars. In addition, the application SALUT (*Snabb Utredning av Livsmedelsburna Utbrott*) was used as a tool. This application has a database on food habits for the Swedish population that can be used as a reference for inquiries about food items consumed in the case group. The epidemiological studies did not identify any suspected food item. In total, 36 cases were identified in 12 counties. Internationally, almost 200 cases were reported. No suspected food item was identified as source. However, the spatial and temporal distribution of cases indicated a food source with a short expiry date that had been widely distributed in Europe. *S.* Mikawasima outbreaks have been repeatedly identified in the past in several European countries. This is the third European investigation where Sweden has had cases. None of the previous investigations have pinpointed a food source.

DISCUSSION

The low proportion of domestic *Salmonella* infections in humans is unique to Sweden, Norway and Finland when compared to most other European countries, where such data is collected. This reflects the low *Salmonella* burden in domestic animals and food. The reported travel related incidence in 2019, 11.8 cases per 100 000 inhabitants, is considerably higher than the domestic incidence of 7.4 cases per 100 000 inhabitants.

In the feed sector, in 2019 as in previous years, several different serovars were isolated in the weekly surveillance of feed mills where *S.* Typhimurium was the most common serovar (n=19). All findings were in the feed material intake area, in several different feed mills. This illustrates the importance of handling feed materials in a proper way even if the feed materials have been negatively tested for *Salmonella*.

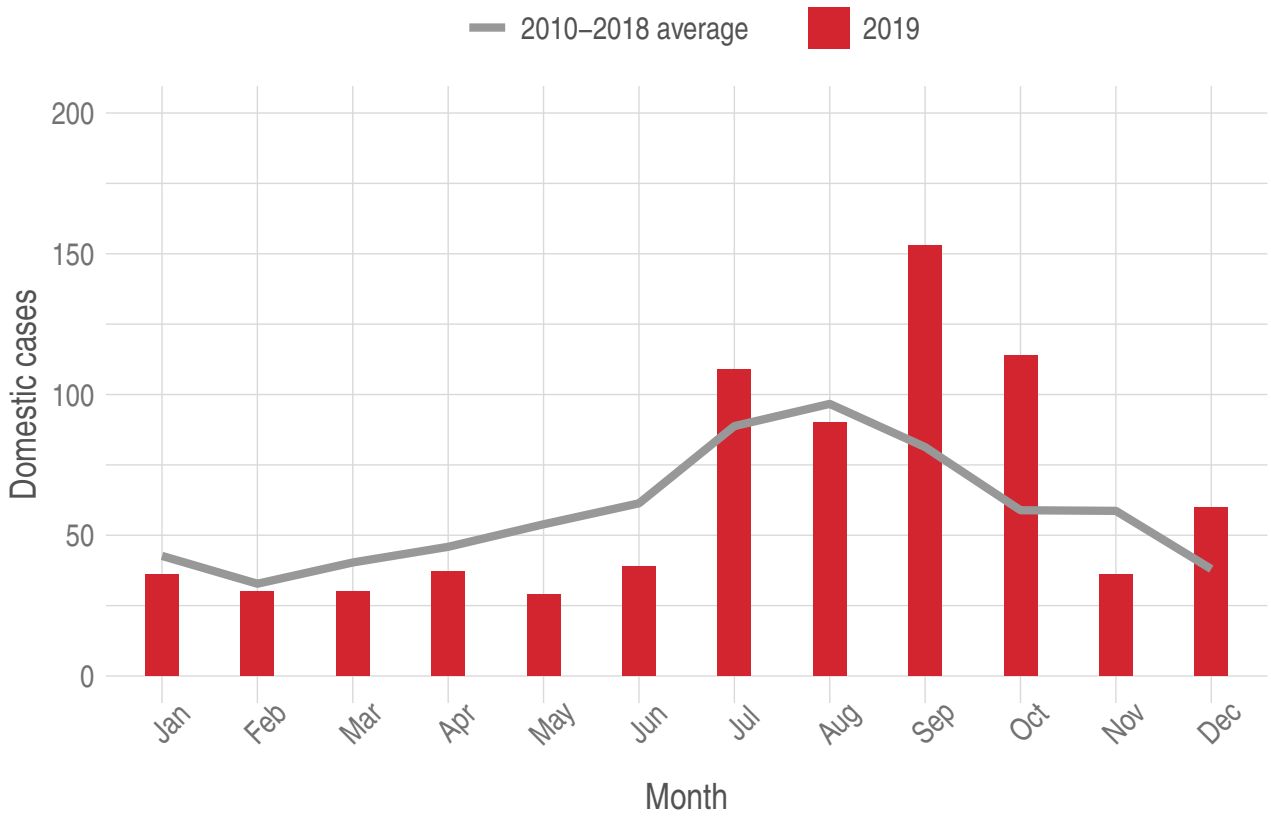


Figure 22: Monthly notifications of domestic human cases of salmonellosis in 2019 and a monthly average for notifications in 2010–2018.

Figure 23: Incidence (per 100 000) of notified human cases of salmonellosis in Sweden, 1997–2019. Travel-associated cases are those where the patient has reported travel to another country during the incubation period prior to clinical presentation. Domestic cases are patients that have not travelled outside Sweden.

In 2019, *Salmonella* was detected in a few flocks of broilers, laying hens and pig herds. As poultry and pig are important sources of salmonellosis in humans a continuous need for strict biosecurity routines are needed in poultry and pig holdings. In 2019, *Salmonella* was detected in 11 cattle herds, which was more than in the previous five years.

The Swedish *Salmonella* control programme has been in place for decades and resulted in a very low *Salmonella* burden in domestic animals (Figures 17, 19 and 21). However, the programme is costly and could be modernised.

Reported domestic human cases of salmonellosis vary from year to year depending on the number of outbreaks. The largest decrease over the past ten years was seen for the travel-associated cases, especially from European countries. This decrease in salmonellosis seems to be the result of the successful implementation of harmonised *Salmonella* control programmes in poultry across the union.

Thailand is the most common country for travel-associated salmonellosis, although the number of cases has decreased in the past years. It is still necessary to inform travellers about the risks of contracting *Salmonella* and other infectious diseases to further decrease the incidence. Also, information about how to prevent secondary transmission to other persons, to the environment and to animals when returning to Sweden is crucial.

Good co-operation between the public health, food control and food safety and veterinary sectors is crucial in outbreak investigations, in control, in surveillance as well as in the further developments of the surveillance programmes.

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