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Annual Report on Zoonoses in Denmark 2022

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Annual Report on Zoonoses in Denmark 2022

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Contents

Introduction

Campylobacter continues to be the most common cause of bacterial foodborne illness in humans, with 5,142 cases in 2022 in Denmark. The number of *Salmonella* infections continued to increase for the second year in a row, to 899 cases in 2022. For both infections, the number of cases seems to move towards the same levels as observed before the COVID-19-pandemic in 2020-2021.

Foodborne outbreaks

In total, 63 foodborne outbreaks with 1,284 patients were reported in 2022. Similarly in 2021, 63 outbreaks were reported, with 1,257 patients involved.

Norovirus (NoV) was the leading cause of foodborne outbreaks in Denmark, causing 14 outbreaks and affecting a total of 614 persons. The most common way of acquiring NoV infection was through exposure to symptomatic or asymptomatic healthy carriers among kitchen staff.

Salmonella spp. caused 11 outbreaks in Denmark in 2022, with three of them being part of international outbreaks. The largest outbreak was with *Salmonella* Enteritidis sequence type (ST) 11, where 24 cases were reported between March and September. The source of the outbreak could not be identified, but imported chicken products were suspected. A multi-country outbreak of monophasic *Salmonella* Typhimurium was linked to chocolate products, particularly Kinder eggs, affecting 369 cases in 16 countries.

The number of reported *Campylobacter* outbreaks increased from three outbreaks in 2021 to 11 outbreaks in 2022. This increase was primarily due to a change in the threshold for investigating genetic clusters. Six outbreaks of listeriosis were also reported in Denmark in 2022, with the source being identified for two of the larger outbreaks.

Listeria monocytogenes

Listeriosis is a foodborne disease caused by *Listeria monocytogenes*, and its clinical presentation ranges from mild to invasive disease. In Denmark, whole-genome sequencing (WGS) are routinely used to characterise all *L. monocytogenes* isolates to carry out surveillance and to conduct targeted outbreak investigations. The number of listeriosis cases reported in 2022 was high, with three outbreaks accounting for a third of all cases.

The likely sources of two of the large outbreaks were identified as ready-to-eat (RTE) spiced and sliced meat roll ('rullepølse') and fish patties, while the source of the third larger outbreak could not be identified, despite massive efforts.

The investigations highlighted the importance of collaboration with producers, the usefulness of using consumer purchase information for targeted traceback investigations, and the value of WGS in identifying the source of outbreaks. Additionally, investigations on the presence and persistence of *L. monocytogenes* in the production environment of the Danish RTE food processing companies showed that the overall prevalence of *L. monocytogenes* in high risk RTE food processing companies was largely unchanged between 2016 and 2020, despite the Danish Veterinary and Food Administration (DVFA) *Listeria* awareness campaign launched in 2015. The outbreaks of listeriosis in 2022 highlight the need for continued risk management strategies, including real-time comparison of sequenced *L. monocytogenes* from human cases and the food industry, and revised risk communication strategies to decrease the number of cases.

Impact of changes in diagnostic methods on STEC and *Cryptosporidium* in Denmark

Over the past decade, the clinical microbiological departments (CMDs) in Denmark have shifted towards DNA-based diagnostic methods for detecting gastrointestinal pathogens, leading to increased sensitivity for the detection of Shiga toxin-producing *Escherichia coli* (STEC) and *Cryptosporidium*. While all cases of STEC are reported by the CMDs to Statens Serum Institut (SSI), cryptosporidiosis cases are assessed by SSI through MiBa (The Danish National Microbiology Database). Between 2013 and 2022, there was a notable increase in STEC and *Cryptosporidium* cases reported due to changes in diagnostic methods. With the new method up to 24 diarrheagenic bacterial, viral and parasitic

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The Annual Report on Zoonoses presents a summary of the trends and sources of zoonotic infections in humans and animals, as well as the occurrence of zoonotic agents in food and feeding stuffs in Denmark in 2022. Greenland and the Faroe Islands are not represented. The report is based on data collected according to the Zoonoses Directive 2003/99/EC, supplemented by data obtained from national surveillance and control programmes as well as data from relevant research projects. Corrections to the data may occur after publication resulting in minor changes in the presentation of historical data in the following year's report. The report is also available at www.food.dtu.dk.

infections are tested at the same time. These methods have enabled a dramatic increase in the diagnostic sensitivity, which, together with a significant increase in the number of individuals tested, has led to an increase in the detection of particularly two pathogens: STEC and *Cryptosporidium*. However, the proportion of cultures or samples sent to SSI for further characterization is below a third of the samples taken, reducing the ability to detect clusters, emerging species, and subtypes. In 2022, approximately a quarter of *Cryptosporidium*-positive samples were submitted to SSI for typing, revealing a diverse range of zoonotic species and subtypes involved in human cryptosporidiosis in Denmark.

Vectorborne zoonoses

The 2022 vector season was normal in regard to the number of all five mosquito genera present in Denmark. However, the West Nile fever mosquito *Culex modestus,* which bites both birds and mammals, was detected recently in Denmark and has the potential to spread the virus from wild birds to humans and horses. No exotic mosquitoes were found in 2022, but three exotic ticks were positive on PCR tests conducted for a wide range of pathogens.

Denmark has an ongoing programme for identifying and ranking emerging zoonotic disease risks including vector-borne infections, and a beta version of a new deterministic risk ranking tool was developed in 2022. The tool includes the impact on animal welfare in the risk score and allows the user to allocate subjective weights to each of eight different ranking criteria depending on the specific purpose of the ranking.

A One Health status on surveillance, outbreak investigation and action plans for *Campylobacter* in Denmark

The annual number of *Campylobacter* cases reported in Denmark has been between 3,740 and 5,389 over the past five years. Since 2019, a subset of human samples has been sent for whole genome sequencing to detect clusters and outbreaks. In 2022, 19 genetic clusters with five or more cases were detected, comprising 26% of the sequenced cases, of which 25% were matched to a source, mostly chicken meat produced in Denmark.

Chicken is a staple food in Denmark and is often eaten without the consumer noticing the brand or type, which makes it difficult to obtain specific exposure information from patients with campylobacteriosis. Denmark has had national Action Plans against *Campylobacter* in chicken since 2008, and the fourth plan was started in 2022 and will run until 2026. *Campylobacter* status of broiler flocks is monitored through cloacal swab samples obtained at the slaughterhouses where all flocks are sampled. Flocks raised outdoors have a much higher prevalence of *Campylobacter* than those raised indoors. Targets for reduction

on farm level has been set for each production type in the Action Plan. Surveillance of *Campylobacter* in fresh chicken meat is performed at slaughterhouse-level, where leg skin samples are collected from chilled carcasses ready for human consumption. In the new Action Plan the reduction targets in fresh meat is set for each of the medium/major sized slaughterhouses. Furthermore, it was decided to set different goals for the maximum level of concentration of *Campylobacter* in the meat, for the summer- and winter period, in consideration of the seasonal changes in *Campylobacter* prevalence.

Future perspectives for One Health collaborations

The health of humans, animals and our shared environment are interconnected. Protection of animal health and public health from zoonotic threats requires a One Health approach and collaborations across sectors and country borders. Cross-sectoral One Health collaboration is increasingly emphasised and applied in Denmark, in Europe and globally and societal, political and environmental changes call for continuous evolution of the One Health approach.

The One Health European Joint Programme (One Health EJP) is an ongoing European initiative for One Health collaborations that has gathered 44 partners across Europe to address foodborne zoonoses, Antimicrobial Resistance (AMR), and emerging threats. The recently published Strategic Research and Innovation Agenda (SRIA) highlights the importance of international, cross-sectoral, multidisciplinary collaborations and the need for harmonization of methods and approaches across sectors for comparable data. Examples of activities of the One Health EJP are briefly described in the chapter. In Denmark, OHEJP SimEx conduction took place on May 2022. SSI, DTU-FOOD and DVFA - the three organisations that constitute in the Central Outbreak Management Group (COMG) - participated in the outbreak exercise.

Two new initiatives, OH4Surveillance and UNITED4Surveillance, funded under EU4Health programme, strengthen surveillance using a One Health approach. Several large projects under EU4Health programme apply One Health approaches to strengthen collaborations and preparedness for emerging threats.

Another One Health related Partnership is the PSFS FutureFoodS. The ambition of the PSFS FutureFoodS is to collectively develop and implement an EU-wide committed research and innovation (R&I) partnership which accelerates the transition towards diets that are healthy, safe and sustainably produced and consumed in resilient EU and global food systems.

1. Food- and waterborne outbreaks

By the Central Outbreak Management Group

Food- and waterborne outbreaks in Denmark are registered in the Food- and waterborne Outbreak Database (FUD). Appendix Table A3 lists the outbreaks that occurred in 2022. Household outbreaks and clusters not verified as common source foodborne outbreaks are excluded. Outbreak investigation procedures in Denmark are described in Chapter 6.

In 2022, 63 foodborne outbreaks were registered in FUD (Figure 1.1, Table A3) and the total number of persons affected by foodborne outbreaks was 1,284 with an average of 20 persons per outbreak (range 2-125). Of the 63 outbreaks, 31 were local/regional and 32 were national outbreaks, of which three were part of international outbreaks. The number of foodborne outbreaks in 2022 is on the same level as in 2021, where 63 outbreaks also were registered. The number of foodborne outbreaks reported in Denmark by pathogen in the last five years from 2018 to 2022 is illustrated in Figure 1.2. The number of foodborne outbreaks registered in 2021 and 2022 has increased again after an exceptional COVID-19 pandemic year of 2020. The pandemic in 2020 led to general restrictions on gatherings,

closed restaurants, and increased hygiene focus, which are considered to have resulted in a lower number of local point-source outbreaks, whereas it does not seem to have affected the number of national outbreaks to the same degree.

1.1 Norovirus outbreaks
Norovirus (NoV) was the most frequent cause of foodborne outbreaks in 2022 (14 outbreaks), and in total 614 persons were affected. The transmission routes for NoV causing foodborne outbreaks were multiple. The most common way of infection with NoV in 2022 was contamination from symptomatic or healthy carriers among kitchen staff (eight outbreaks and 367 persons affected). Moreover, four outbreaks were related to the intake of oysters, while the route of transmission remained unknown in two other outbreaks. The most common settings (six outbreaks and 211 persons affected) were restaurants, cafes or catering services, while three outbreaks (110 persons affected) were related to canteen or workplace catering. The remaining five outbreaks were related to either take-away or multiple places.

Figure 1.1. Aetiology of the 63 foodborne disease outbreaks reported with a causative agent in the Food- and waterborne Outbreak Database (FUD), 2022. Percentage of total outbreaks indicated in brackets
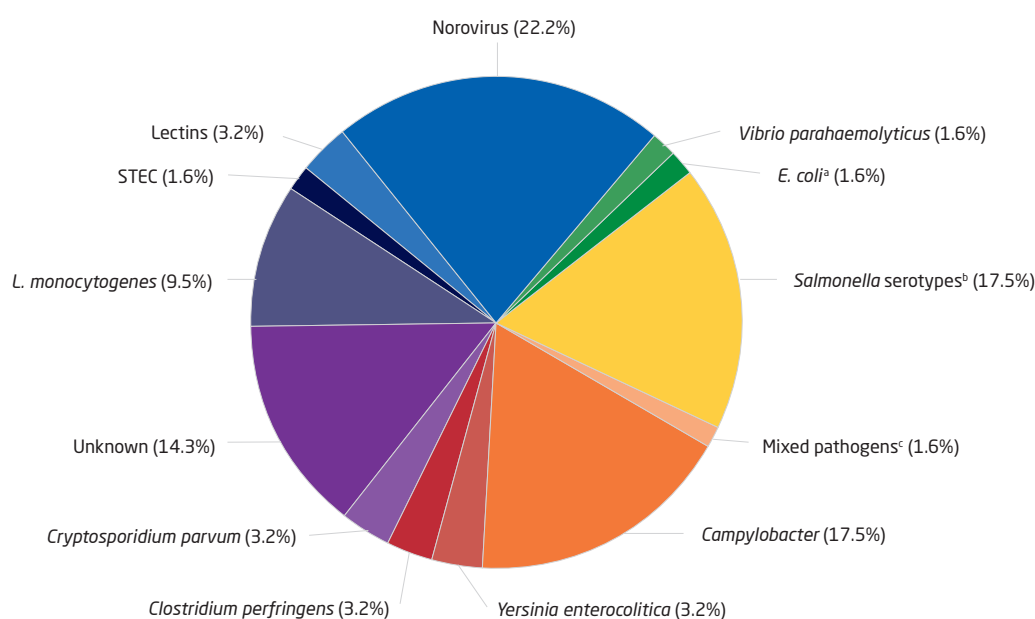
a) One outbreak with *Campylobacter jejuni* and STEC   b) Including the monophasic strains S. 1,4,[5],12:i:-

Source: Food- and waterborne Outbreak Database (FUD)

1.2 *Salmonella* outbreaks

In 2022, 11 *Salmonella* outbreaks were identified as genetically closely related by whole genome sequencing (WGS). This is on the same level as previous years, in 2021, 12 outbreaks of *Salmonella* were registered. Three of the *Salmonella* outbreaks registered in 2022 were part of international outbreaks. One international outbreak of monophasic *Salmonella* Typhimurium was linked to different chocolate products (FUD2067) (see text box). The largest outbreak of *Salmonella* in 2022 was due to *Salmonella* Enteritidis sequence type (ST) 11 (FUD2084), where 24 cases were registered between March and September. The cases were primarily from the capital area. The source of the outbreak could not be identified. However, a probable source of infection for this outbreak were chicken products from Poland. In June and July, an outbreak of monophasic *Salmonella* Typhimurium with six cases were registered and the cases were spread geographically throughout the country (FUD2086). All six cases had eaten beef meat. There was a match between cases and two isolates from minced beef from two different companies, where the raw material was from the Netherlands and Denmark, respectively. Immediately before the production of the minced meat both companies had minced meat where the raw material came from the same Danish supplier. It is likely that the source of infection came from this supplier.

1.3 *Campylobacter* outbreaks

The number of registered *Campylobacter* outbreaks increased from three outbreaks in 2021 to 11 outbreaks in 2022. This increase was primarily due to a change in the threshold for investigating genetic clusters. From 2022, genetic clusters of human cases down to five cases were registered. This is further described in chapter 5. All outbreaks were national outbreaks caused by *Campylobacter jejuni*. For six outbreaks the source was identified as chicken meat, primarily based on WGS match between human samples and food isolates – one of which was from imported chicken. A long-lasting outbreak described in 2021 caused by two different sequence types of *Campylobacter jejuni*; ST52 (FUD1974) further continued with 44 cases in 2022. Multiple preventive efforts have been put in place in both chicken farms and slaughter houses to reduce transmission of *Campylobacter*.

1.4 Other outbreaks of interest

In 2022, six outbreaks of listeriosis were registered. For two larger outbreaks the source was identified; one outbreak of *Listeria* ST8 with nine cases was due to cold-cut meat (FUD2074). The other outbreak was *Listeria* ST7 comprising 10 cases and turned out to be due to fish patties (FUD2127). The outbreaks are described in detail in chapter 2.

Table 1.1. Norovirus outbreaks per route of transmission based on number of cases or number of outbreaks, 2020-2022

Transmission route/source	2022		2021		2020	
	No. of outbreaks	No. of persons ill	No. of outbreaks	No. of persons ill	No. of outbreaks	No. of persons ill
Ill kitchen staff or healthy carrier of virus among kitchen staff	8	367	9	307	2	109
Kitchen staff tending to ill persons at home before entering the kitchen	0	0	3	116	2	158
Ill persons/guests attending a buffet	0	0	0	0	0	0
Seafood (oysters)	4	126	0	0	2	122[a]
Unknown route of transmission	2	121	2	70	0	0
Total	14	614	14	493	6	267

a) One of the two outbreaks in 2020 (FUD1838) consisted of 286 cases of which 271 cases were additionally registered in 2019.

Source: Food- and waterborne Outbreak Database (FUD)

Figure 1.2. Number of foodborne outbreaks by pathogen reported in Denmark, 2018-2022
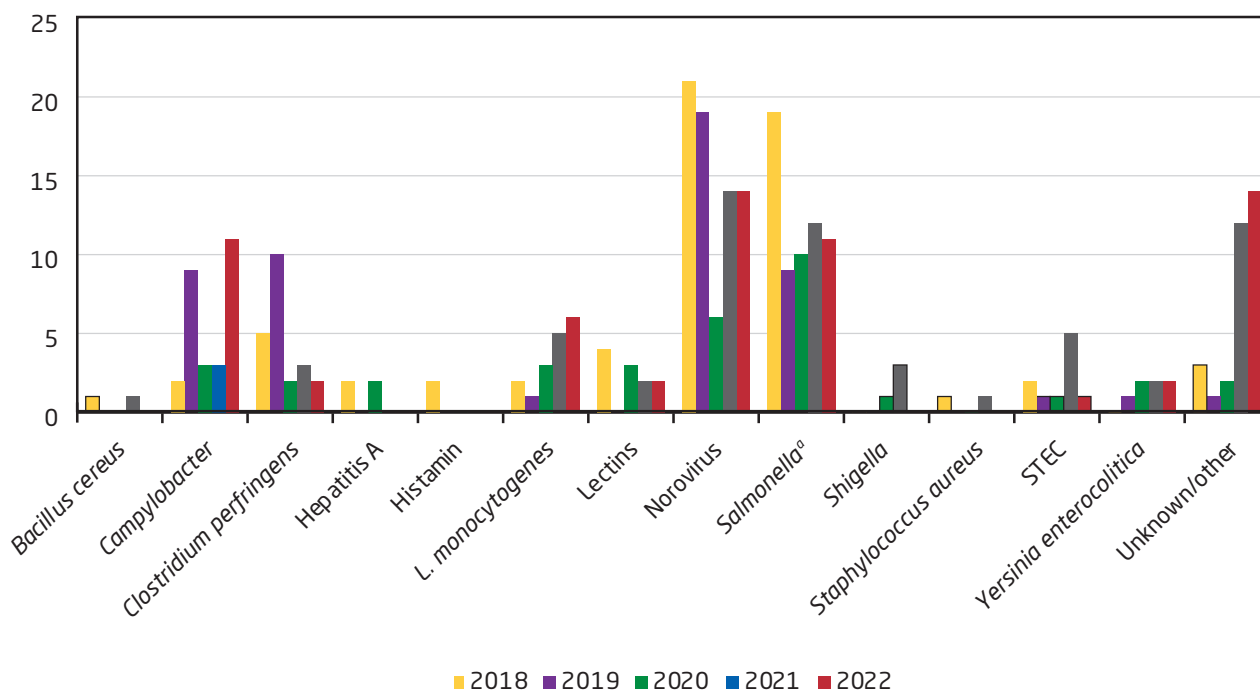
a) Note for *Salmonella* that travel-related outbreaks were not included from 2019 and onwards. .

Source: Food- and waterborne Outbreak Database (FUD)

1.5 References

1. European Centre for Disease Prevention and Control, European Food Safety Authority, 2022. Multi-country outbreak of monophasic Salmonella Typhimurium sequence type 34 infections linked to chocolate products, first update – 18 May 2022
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By the Central Outbreak Management Group

On 17 February 2022, a cluster of cases with monophasic *Salmonella* Typhimurium ST 34 infection (1,2) was reported to the European Centre for Disease Prevention and Control's surveillance portal for infectious diseases by the United Kingdom (UK). By 18 May 2022, 369 cases had been identified in 16 countries. Most cases were below ten years of age and many of those ill had been hospitalised. People fell sick between December 2021 and June 2022.

Initial patient interviews in the United Kingdom suggested that the likely vehicle of infection was Kinder eggs. A case-control study, descriptive epidemiology and food chain investigations supported this. Chocolate products tested positive for *Salmonella* and whole genome sequencing analysis indicated matches with outbreak cases. The Salmonella type matching the human cases was also found in own-check samples in a factory in Belgium.

In Denmark, products from the producer of chocolate including Kinder eggs were recalled from the market on April 6 just prior to Easter holidays. Only four cases were subsequently identified in Denmark – two children and two adults from different parts of the country.

2. Listeria monocytogenes

By Laura Espenhain (laes@ssi.dk), Nao Takeuchi-Storm, Pernille Kold Munch, Lisbeth Truelstrup Hansen, Niels Ladefoged Nielsen, Jens Kirk Andersen, and Susanne Schjørring

2.1 *Listeria monocytogenes* in humans in Denmark in 2022

Listeriosis is a foodborne infection caused by *Listeria monocytogenes.* The clinical spectrum of listeriosis ranges from mild to invasive disease including bacteraemia or meningitis. *Listeria monocytogenes* can also be transmitted from mother to fetus in utero or to the neonate during birth. Risk factors for invasive disease include immunosuppression, advanced age, and pregnancy. The incubation is longer than for most foodborne pathogens, usually a few weeks. In Denmark, invasive forms of listerioses in humans are monitored in the Danish surveillance system. The 30-day mortality of registered cases of listeriosis is about 25% [1].

As part of the national surveillance, whole genome sequencing (WGS) is routinely used at Statens Serum Institut to characterise all *L. monocytogenes.* A genetic related cluster is defined based on the population structure in the relevant sequence type (ST), usually ≤7 allelic differences applying single linkage. All patients are interviewed using a hypothesis-generating questionnaire in regards to their consumption of risk food products (e.g. ready-to-eat (RTE) products including sliced cold-cut meat, smoked fish, and salad) in the four week period before falling ill. The introduction of WGS increased the discrimination of isolates, allowing for more targeted outbreak investigations as well as direct comparison between *L. monocytogenes* isolates from human and food or the production environment [2].

Following a large *Listeria* outbreak in 2014 [3], there has been reported about 40-60 cases annually in Denmark. Approximately 60% of all the reported cases with listeriosis between 2014 and 2022 were part of genetic clusters (two or more cases with the same type). Of these 37% were part of larger genetic clusters (outbreaks) involving eight or more cases (Figure 2.1).

Figure 2.1. Number of listeriosis cases in Denmark (N=532) per year, categorised into three groups according to the number of times the types of Listeria monocygenes *have been reported in human cases during the period from 2014-2022*
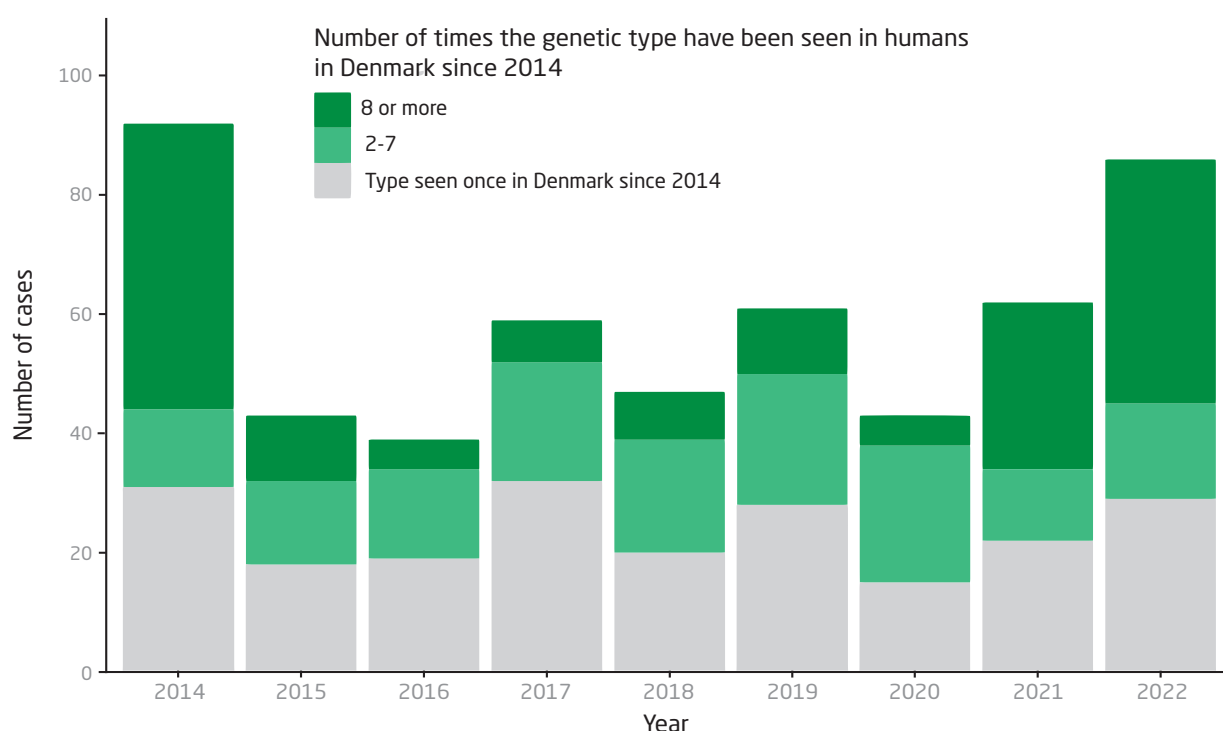
In 2022, a marked increase was seen, with three large outbreaks that accounted for a third of all registered cases in 2022: sequence type (ST) 8 (FUD2074), ST37 (FUD2080), and ST7 (FUD2127). Below we describe these three major outbreaks.

Following a rise in the number of listeriosis cases in the spring of 2022 (Figure 2.2), communication to the public and to food processing companies was intensified. The food business operators were encouraged to intensify their own-checks of the production lines. Relevant international authorities were informed about the rise through the Rapid Alert System for Food and Feed News run by the European Food Safety Authority (EFSA) and the European Centre for Disease Prevention and Control's (ECDC) surveillance portal for infectious diseases. No other countries reported having seen cases with the same genetic types.

Based on information from the interviews of cases belonging to the FUD2074 cluster, it was noted that all (nine) interviewed cases reported consumption of RTE cold-cut meat products. All the nine cases reported eating spiced sliced meat roll ('rullepølse') and eight of the nine reported that they had eaten sliced ham ('hamburgerryg'). Moreover eight reported shopping in the same supermarket chain. A general traceback on cold-cut meat identified four suppliers with production on six locations in two countries. Sampling was done on the three production sites in Denmark and no *L. monocytogenes* matching the ST seen in patients was identified. The traceback for 'rullepølse' identified one common production site outside of Denmark. On this site, *L. monocytogenes* was identified in the production environment and in a 'rullepølse' sample from the own-check. The company recalled multiple brands of 'rullepølse' on the 5 and 10 July and voluntarily shared the isolates with the Danish Veterinary and Food Administration (DVFA) for analysis by WGS. The WGS of *L. monocytogenes* from the `rullepølse´ matched the *L. monocytogenes* identified in patients. After the recall, two additional cases were reported. This was not unexpected due to the long incubation period often seen for *L. monocytogenes*. This investigation underlines the importance and value of involvement of the food processing companies at an early stage during an outbreak investigation and the power of using WGS for surveillance. Even though interviews showed a strong indication of a cold-cut product, more specifically 'rullepølse', the microbiological evidence could not easily have been established without collaboration from the company and the outbreak would likely have continued.

Also, in the spring of 2022, a second large outbreak of listeriosis was investigated (FUD2080). The first cases were diagnosed mid-May and during the following four weeks, a total of nine cases were identified of which four died within 30 days from testing positive. Most cases were from the Capital region. In the attempt to identify the source of the outbreak, 43 companies were contacted and samples were taken if deemed relevant. In total, 16 types of *L. monocytogenes* were identified in nine companies, 14 in environmental samples. None matched the type identified in patients belonging to the outbreak, and only three types were genetically related to types seen in few Danish none-recent patients since the introduction of WGS in 2014. Despite massive efforts, the source of the outbreak remains unidentified. The abrupt peak with cases falling ill within a short time window, points towards a heavily contaminated product or batch as opposed to inappropriate handling by the consumer.

The third large outbreak occurred in the autumn and was caused by *L. monocytogenes* ST7 (FUD2127). In total, 10 Danish cases and one tourist were identified as being part of the outbreak. The first case occurred in August, week 33. Cases were living in all parts of Denmark. No other countries reported having identified cases belonging to the same cluster. Three patients died within 30 days after testing positive. Based on the first four interviews and investigation of receipts from grocery shopping, it was noted that all cases had eaten and/or bought fish products such as fish patties ('fiskefrikadelle') and smoked salmon. The fish products identified on the receipts obtained from patients were investigated further by the DVFA. No *L. monocytogenes* isolates were identified in the production environment samples from the salmon manufacturer. However, *L. monocytogenes* was identified both in the production environment and in products from the fish patty manufacturer. Whole genome sequencing showed that the *L. monocytogenes* from the fish patties were identical to the type identified in the patients. As a consequence, the fish patty manufacturer was sanctioned on the handling of food, risk of contamination and cleaning by the DVFA. The link between the fish patties and the patients were supported by epidemiological findings, as seven patients in seven completed interviews reported eating or buying fish patties. On the 8 November 2022, the company recalled a batch of fish patties. The following day, the company decided to extend the recall to include all products produced until the 9 November 2022. After the recall only one additional case was identified.

The three major outbreaks in 2022 were unusual in the sense that they accumulated many cases in a relatively short period of time. Outbreaks caused by *L. monocytogenes* typically span over a long period of time, even years, since the bacteria can persist in production facilities as described in the following section. In Figure 2.3, the number of listeriosis cases by year are shown for the six outbreaks for which two or more cases were identified in 2022. Three outbreaks caused by *L. monocytogenes* ST11, ST1607 and ST37, additional to those described in

Figure 2.2. Number of listeriosis cases in Denmark per month in 2022 (N=86). Cases belonging to the three major outbreaks are marked.
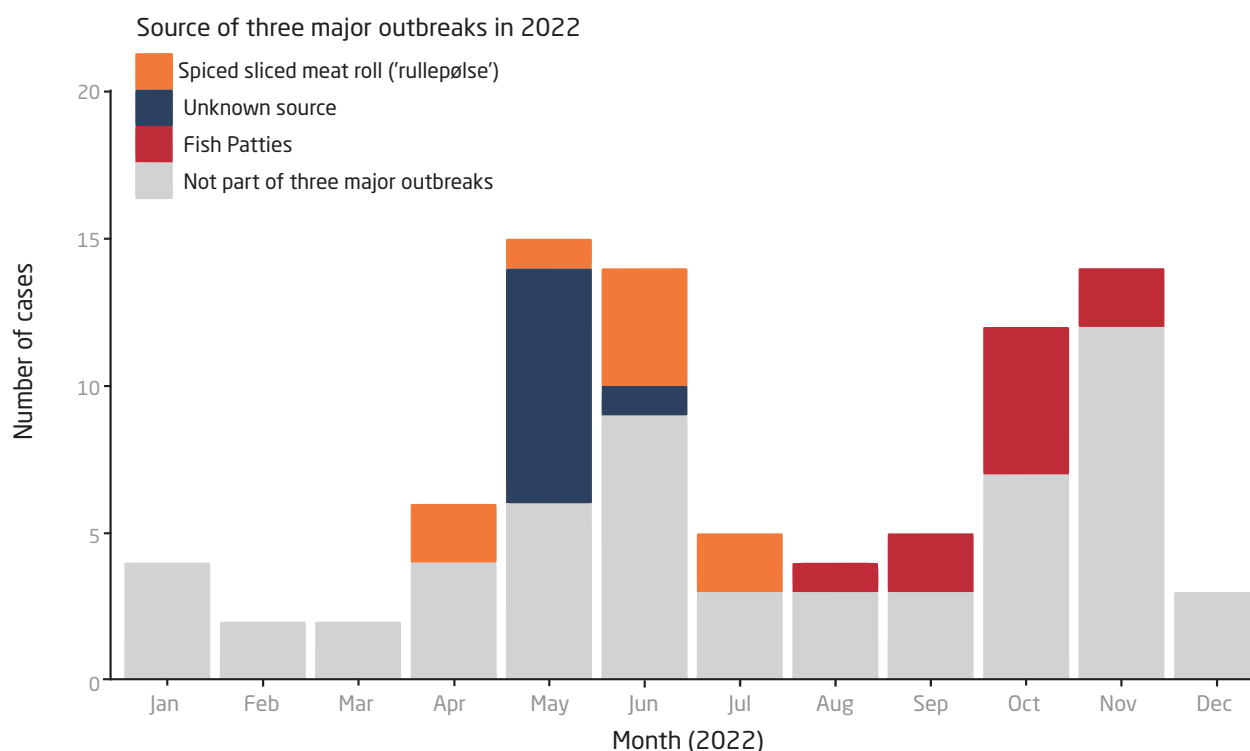
detail above, are seen with 8-14 cases accumulating over the last 3-5 years. Despite that many of these cases were interviewed, and several signals were followed up by the DVFA, the sources of these outbreaks remain unknown.

2.2 *Listeria monocytogenes* in food production environment

Following a large outbreak of *L. monocytogenes* infection in 2014, DVFA, together with the industry, initiated a series of control activities and research projects to improve the control and management of *Listeria* in the food production [4]. Two projects were conducted to obtain a deeper knowledge of the presence and persistence of *L. monocytogenes* in the production environment of RTE food processing companies. Here we describe the summary of results of the projects, which are also published as a scientific article [5].

Food processing companies producing Ready-to-eat (RTE) fish and meat products known as risk products with regard to *L. monocytogenes* were selected and visited in 2016 and 2020. A total of 20 food processing companies, nine producing RTE meat and 11 producing RTE fish products, were sampled both in 2016 and 2020. Additionally, 33 companies were sampled only in one of the years. Swab samples were collected in the production environment and

cultured for the presence of *L. monocytogenes. Listeria monocytogenes* was found in 6.7% of the total 777 swab samples. Moreover, one positive sample was found in 17/39 (43.5%) of the companies in 2016 and 11/34 (32.4%) in 2020. Four companies had at least one positive sample in both years. The prevalence was slightly lower in 2020 but *L. monocytogenes* was still found in one third of the participating RTE food processing facilities.

Fifty *L. monocytogenes* isolates (30 from 2016 and 20 from 2020) from 24 companies from the abovementioned projects were used for further WGS analyses. In addition, *L. monocytogenes* isolates from samples taken at the 53 sampled companies between 2016 and 2020 through the DVFA's routine surveillance programme for environment and food were identified. This resulted in additional 35 *L. monocytogenes* positive samples. Hence, a total of 85 *L. monocytogenes* isolates were analysed by WGS to assess the strain diversities and persistence of genetically similar strains over the years.

The results of the WGS revealed that there were 16 different STs of either lineage I or II. Sequence types, ST8 and ST121, were the most common. Moreover, ST7, ST8, ST121, ST399 and ST451 were isolated over two or more years from the same company, while the other ST's were

Figure 2.3. Annual number of listeriosis cases belonging to large genetic clusters (outbreaks) consisting of eight or more cases and with at least two cases in 2022
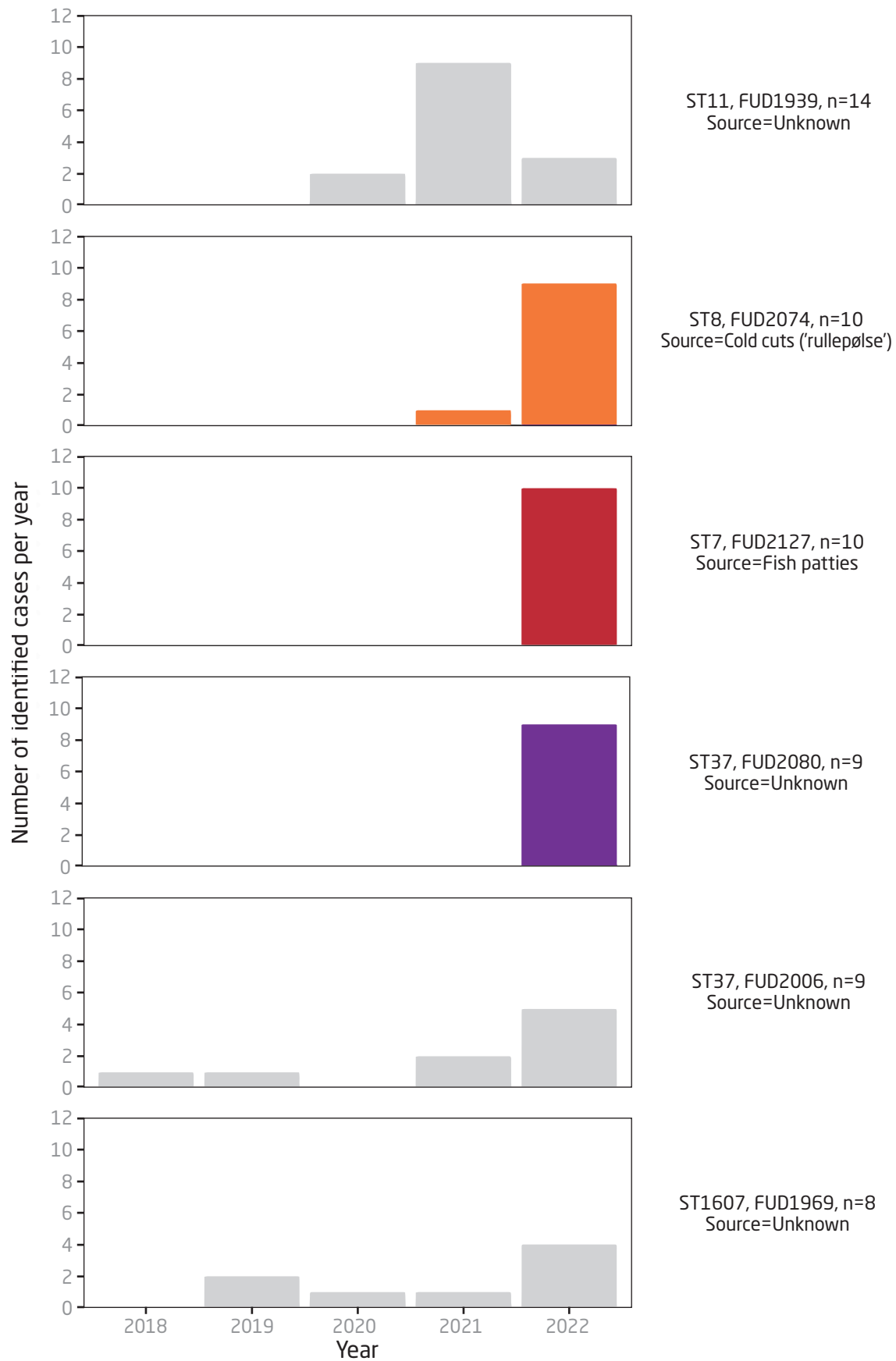
found only on one occasion within a company. Out of 27 companies where *L. monocytogenes* was found in either the production environment (n= 24) or in the products between 2016 and 2020, 10 companies had isolates belonging to more than one ST between 2016 and 2020. There were only a small genetic difference among isolates from the same ST, if they were collected within the same company, regardless of the sampling years and source (environment vs. product). On the other hand, greater genetic differences existed, if isolates belonging to the same ST came from different companies.

Genetic links between isolates from humans and production site/food products are frequently identified during outbreak investigations, which was also observed in 2022. Our results showed a similar link. Here *L. monocytogenes* ST451 isolates from humans from the period 2014-2020 and productions sites (2016-2020) could be linked genetically. This suggests that this strain has persisted in the production environment over many years.

2.3 Conclusion

Findings from the two projects on listeriosis in food production environment confirm that L. monocytogenes strains are able to colonise the production environment in food processing companies making RTE products, and that some of the strains can persist for many years. The study has also shown that the overall prevalence of L. monocytogenes in high risk RTE food processing companies was largely unchanged between 2016 and 2020, despite the DVFA's Listeria awareness campaign launched in 2015. This is also reflected in the fact that the incidence of listeriosis in Denmark has not decreased.

These continuing challenges with *L. monocytogenes* in the production environment, and the two outbreaks described above, also underline the need for increased focus on combining different risk management strategies in the companies including e.g. reassessment of product shelf life, a change in product recipes, and intensified focus on cleaning and disinfection procedures. The large outbreaks in 2022 were, however, caused by *Listeria* types which had not been seen previously. Nevertheless, since *L. monocytogenes* can persist in the food production environment, real time comparison of genetic sequences of *L. monocytogenes* from human cases and from the food industry is valuable for investigating and preventing outbreaks. Also, current risk communication strategies may need to be revised and improved to better reach all target groups to decrease the number of listeriosis cases.

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3. The impact of changes in diagnostic methods of Shiga toxin-producing *Escherichia coli* (STEC) and *Cryptosporidium* in Denmark, 2013-2022

By Mia Torpdahl (mtd@ssi.dk), Christen Rune Stensvold, Anne Line Engsbro, Flemming Scheutz and Tine Graakjær Larsen

Over the past 10 years, the majority of clinical microbiological departments (CMDs) in Denmark have to a large extent changed their diagnostic methods for detecting gastrointestinal pathogens from culturing to DNA-based diagnostic methods. These methods were introduced either as in-house PCR or commercially available gastrointestinal panels (QiaStat, Seegene, BDMax, etc.), using genomic DNA extracted directly from stool samples. The panels allows a multiplex PCR-based approach that enables fast, cost-effective, and flexible syndromic testing. Up to 24 diarrheagenic bacterial, viral and parasitic targets are included, and these methods have enabled a dramatic increase in diagnostic sensitivity, which, together with a significant increase in the number of individuals tested, has led to a remarkable increase in the detection of particularly two pathogens: Shiga toxin-producing *Escherichia coli* (STEC) and *Cryptosporidium*.

All cases of Shiga toxin-producing *Escherichia coli* (STEC) are reported by the CMDs to Statens Serum Institut (SSI). At SSI, cases are recorded as cases; i.e. each patient is only recorded once over any six-month period. Furthermore, all culturable STEC are sent by the CMDs to the reference laboratory for gastrointestinal infections at SSI for further characterization. Isolates are included in the national surveillance for the detection of outbreaks, in order to follow trends of serotypes, subtypes of Shiga toxin, and other virulence markers. In some instances, DNAs from non-culturable specimens are sent to SSI for direct subtyping.

Human cryptosporidiosis is not yet a laboratory notifiable disease in Denmark. However, through MiBa (The Danish National Microbiology Database, see also chapter 6. Surveillance and control programmes), the number of positive samples over time can be assessed. At the moment, cryptosporidiosis episodes are recorded once in a 60-day period. The CMDs are encouraged to submit samples positive for *Cryptosporidium* to the reference laboratory of parasitology at SSI for species identification and subtyping, which involves molecular characterization of small subunit ribosomal RNA and glycoprotein 60 genes, respectively.

Between 2013 and 2022, a notable increase in cases was seen for both STEC and *Cryptosporidium*, reflecting the introduction of DNA-based diagnostics at several CMDs (Figure 1). The number of cases dropped in 2020, and then increased again in 2021, with the increasing trend continuing in 2022 (Figure 1). This is likely explained by the travel restrictions imposed during the COVID-19 pandemic (see also chapter 3, Annual report on zoonoses in Denmark 2020 [1]), clearly having a more obvious effect on the total number of *Cryptosporidium*-positive samples (Figure 1). The increases seen for STEC and *Cryptosporidium* are not directly comparable, since the impact of introducing DNA-based methods will vary between the CMDs. These differences reflects i) whether the DNA-based method is a commercial method or developed as in-house PCR, ii) what changes there have been in the selection criteria of individuals tested and iii) finally the geographical populations covered by the CMDs.

From 2013 to 2022, the number of STEC-positive specimens increased from 214 to 1330 (Figure 1); however, in the same period, the number of culture-positive samples (STEC isolated) only doubled (from 186 to 381). Hence, the proportion of culture-positive samples decreased from 86.9% in 2013 to 28.6% in 2022. There was no significant annual change in the number of severe STEC cases observed, specifically involving hemolytic uremic syndrome (HUS), indicating that HUS-associated subtypes did not cause the increase in STEC.

In 2022, approximately a quarter of *Cryptosporidium*-positive samples were voluntarily submitted to SSI for typing. These samples showed that a wide range of zoonotic species and subtypes are involved in human cryptosporidiosis in Denmark, including some that have not previously been identified in Denmark, and at least one that has never been found anywhere in the world. The implementation of these new diagnostic tools and work flows highlights that *Cryptosporidium* is a diverse and important pathogen in Denmark, which has likely been largely neglected previously.

Figure 3.1. Number of cases of Shiga toxin-producing Escherichia coli (STEC) *and* Cryptosporidium *infection in Denmark, 2013-2022*
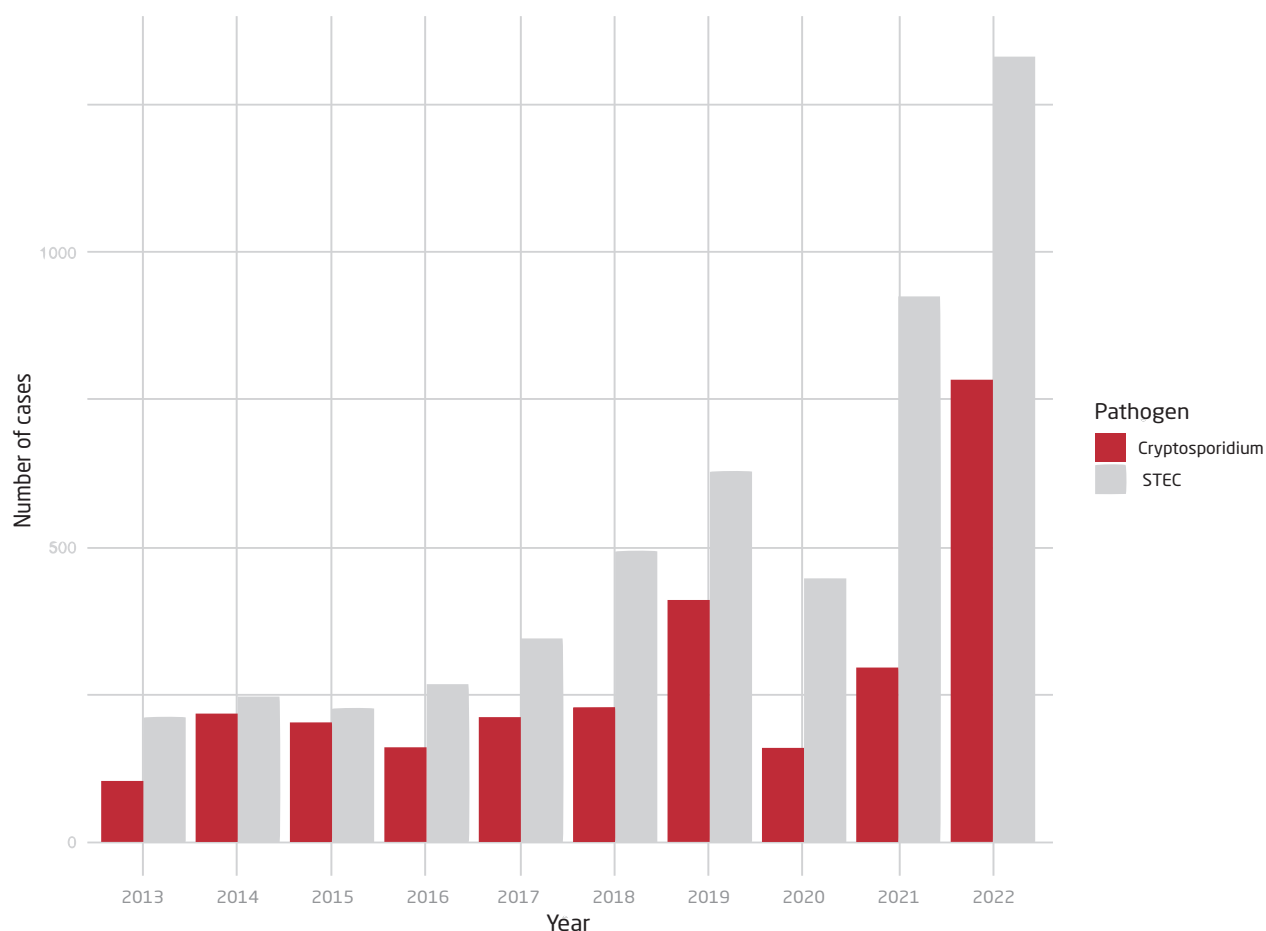
In conclusion, the increase in annual cases for both STEC and *Cryptosporidium* reflects i) a change from traditional diagnostic methods to DNA-based methods, ii) changes in the tested population, and iii) increased testing, all of which would be masking any factual increase in the incidence. The proportion of cultures or samples from patients sent to SSI for further characterization is only below a third of the total for both species and the ability to follow trends, detect outbreaks and discover emerging species and sub-types is thereby reduced.

3.1 References

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4. Vectorborne zoonoses

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The Danish Veterinary Consortium monitors vectors at the University of Copenhagen on behalf of the Danish Veterinary and Food Administration and contributes to surveillances of and vector-borne diseases in Denmark. The vector surveillance has taken place since 2011 and data are continuously updated at www.myggetal.dk.

4.1 Monitoring of endemic vectors
The number of of mosquito genera present in Denmark is still five.

The West Nile fever mosquito *Culex modestus*, only recently discovered in Denmark, bites both birds and mammals, and may therefore effectively spread the virus from wild birds to humans and horses [1]. This mosquito species is adapted to warmer parts of Europe and has a short season in Denmark (Figure 4.1).

The abundance of Culex modestus in Denmark varies significantly from year to year. In 2022 the species was abundant near the water holes on the beach meadows at West Amager near Copenhagen Airport, with attack rates of more than 1 bite per minute on warm sunny afternoons (Figure 4.1). In total 372 specimens were collected by human landing catch in the Køge Bay area and subsequently screened for West Nile virus and Usutu virus (Figure 4.2). All mosquitoes tested negative for the viruses by PCR, although both viruses have been circulating in the Netherlands and Northern Germany since the warm summer of 2018, and despite Usutu virus being identified in a Black bird (Turdus merula) in Sweden in 2019.

4.2 Passive surveillance of exotic vectors
No exotic mosquitoes were recorded in 2022. Three exotic ticks previously submitted by veterinarians were PCR tested for a wide range of European pathogens during 2022. The samples tested on PCR were a Hyalomma tick found on a healthy Danish horse without travel history, one Rhipicephalus sanguineus tick (brown dog tick) from a Danish dog recently returned from Spain, and one Dermacentor

Figure 4.1. Estimated number of bites from Culex *modestus per hour based on observed landing rates on a human volunteer*

Hourly number of *Culex modestus* attacking per human host during midafternoo at Vestamager meadows
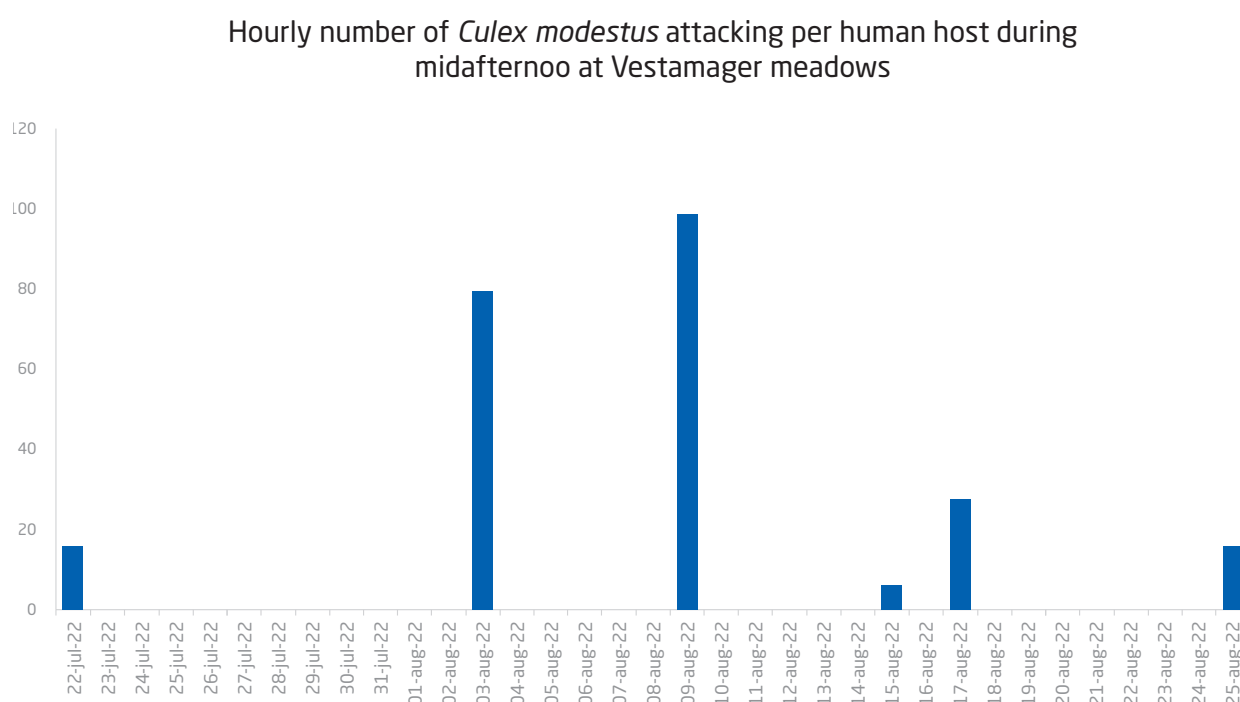
reticulatus tick (meadow tick) from a clinically ill Danish dog without travel history. No pathogens were identified in the Hyalomma or the Rhipicephalus tick, while the Dermacentor tick tested positive for Babesia canis, a parasite highly pathogenic for dogs, but without zoonotic potential [2]. The number of reports of Dermacentor ticks and the associated Babesia canis infection have been increasing in Denmark, but it remains unknown if this tick species is repeatedly introduced or is now breeding in low numbers in the country. Dermacentor reticulatus has been expanding in Germany and is now common as far north as Hamburg. This species is vector for exotic zoonotic pathogens e.g., Rickettsia raoultii, previously identified in Dermacentor ticks introduced to Denmark [3]. The exotic Hyalomma tick was first reported in large numbers in Northern Europe shortly after the warm summer in 2018.

Additionally, a white tick removed from a Danish dog without travel history was submitted by a veterinary clinic. This tick was identified as Ixodes hexogonus also known as the hedgehog tick. The tick is only very rarely collected by flagging (the usual method for collecting questing ticks in nature). It is however endemic and widespread in Denmark and can occur in very large numbers on Danish dogs after dogs have been exploring hedgehog nests where the ticks wait for a host. This hedgehog tick tested negative for all target pathogens by PCR.

4.3 Identifying emerging vectorborne threats in Denmark

Denmark has an ongoing programme for identifying and ranking emerging zoonotic disease risks including vectorborne threats. In 2022, a beta version of a new deterministic risk ranking tool was developed for future ranking of emerging risks in Denmark (Figure 4.3). The tool is based on the previously developed Dutch EZIPs-ranking model (Emerging Zoonoses Information and Priority systems) [4] but with some significant modifications. The most important modifications are that the Danish tool also includes the impact on animal welfare in the risk score and that the tool does not operate with fixed weights of the ranking parameters and therefore does not produce one fixed ranking. Instead, the Danish tool assumes that ranking depends on a defined purpose of the desired ranking. It therefore allows the user to allocate subjective weights to each of

Figure 4.2. Culex *modestus biting at West Amager in August, 2022*

Figure 4.3. Risk ranking tool for emerging zoonotic diseases including vector-borne infections in Denmark
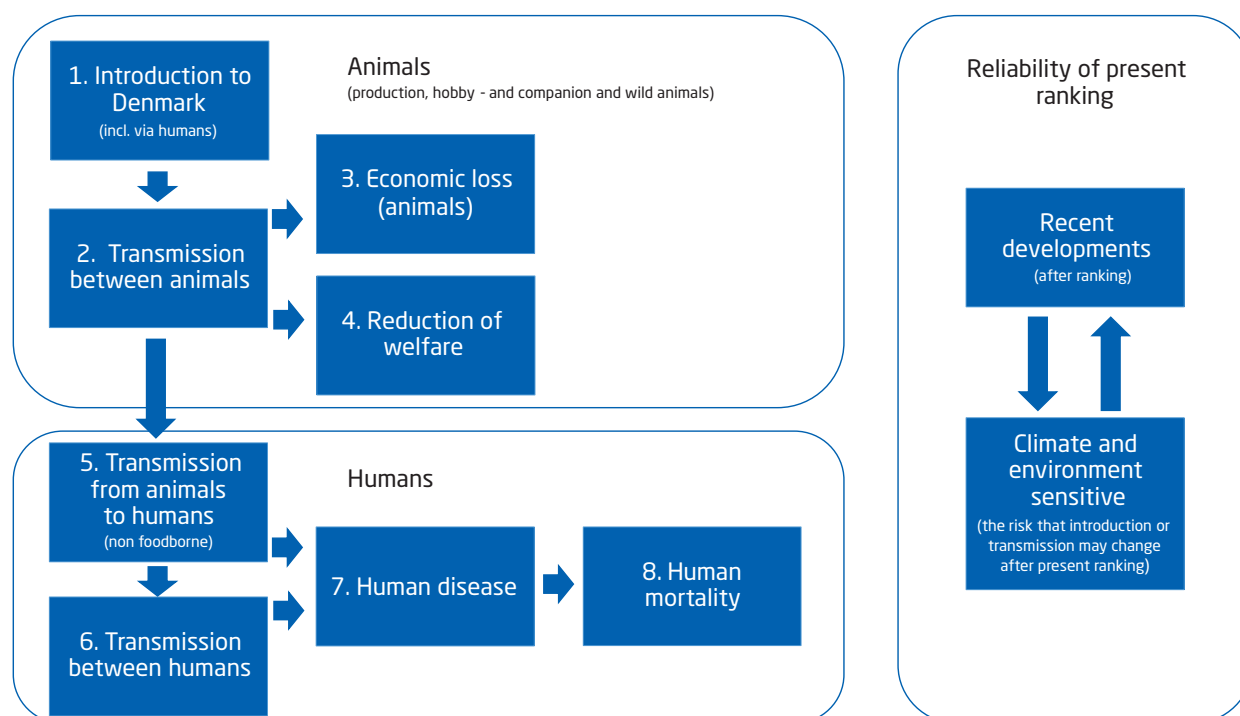
eight different ranking criteria depending on the specific purpose of the ranking. The eight ranking criteria are shown in Figure 4.3. In addition to the eight ranking criteria, the online version includes two extra criteria that assess the reliability of the present ranking. The extra criteria take recent developments into account as well as the climatic and environmental sensitivity of each emerging disease, anticipating that rank may rapidly change, especially for vector-borne diseases. As an example, the record warm summer of 2018 suddenly created an unexpected risk in Northern Europe of pathogens transmitted by Hyalomma ticks and thus affected the ranking of the zoonotic Crimean Congo Hemorrhagic Fever transmitted by Hyalomma ticks. The final ranking model will be publicly available for download on the DK-Vet website during 2023.

4.4 References

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5. A One Health status on surveillance, outbreak investigation and action plans for *Campylobacter* in Denmark

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5.1 *Campylobacter* surveillance in humans

In Denmark, between 3,740 and 5,389 human *Campylo-bacter* cases have been registered yearly in the past five years (See Table A1). In 2022, the number of registered *Campylobacter* cases was 5,142, 28% of which were travel-related. Since 2019, a subset of human samples (around 10-15%) have been sent routinely to Statens Serum Institut for subtyping by whole genome sequencing in order to detect clusters and outbreaks. Figure 5.1 shows the number of domestic cases from 2018 to 2022, the proportion of cases in clusters, and clusters with a food match.

In 2022, the threshold for investigation of clusters was changed to examine genetic clusters of human cases down to five cases. This was done to gain further knowledge of their aetiology. Since this surveillance setup only captures the tip of the iceberg, it is estimated that whenever a cluster of five cases is detected, this covers an outbreak of a least 40-50 cases.

From 2018 to 2022, 62 genetic clusters were detected with five *C. jejuni* cases or more constituting 32% (849 / 2,683) of the sequenced human isolates. Twenty-six clusters comprised ten or more cases constituting 23% (618 / 2,683) of the sequenced human isolates. The largest cluster contained 124 cases (spanning 2018-2022) and was described in Anonymous 2020 [1].

Figure 5.1. Registered human cases with Campylobacter infections *(with no history of travel, pink), Denmark (2018-2022). Sequenced human isolates (C. jejuni and C. coli, orange), human isolates in clusters (≥2 human isolate, light blue), human isolates in clusters with a detected food match (dark blue)*
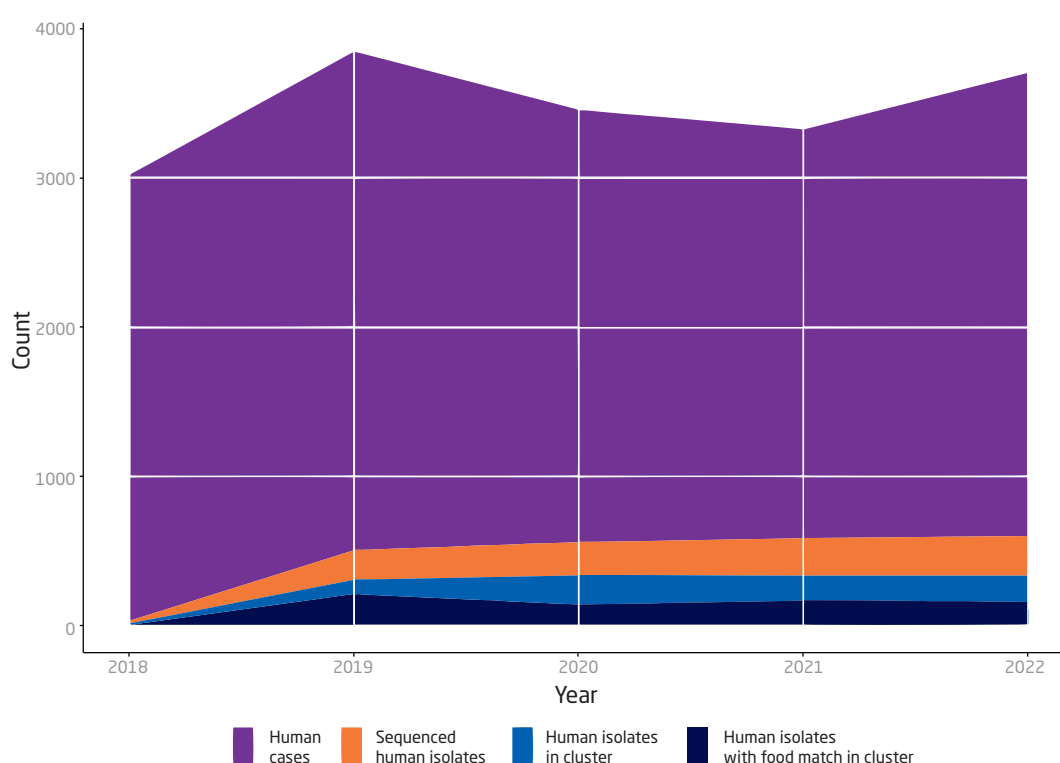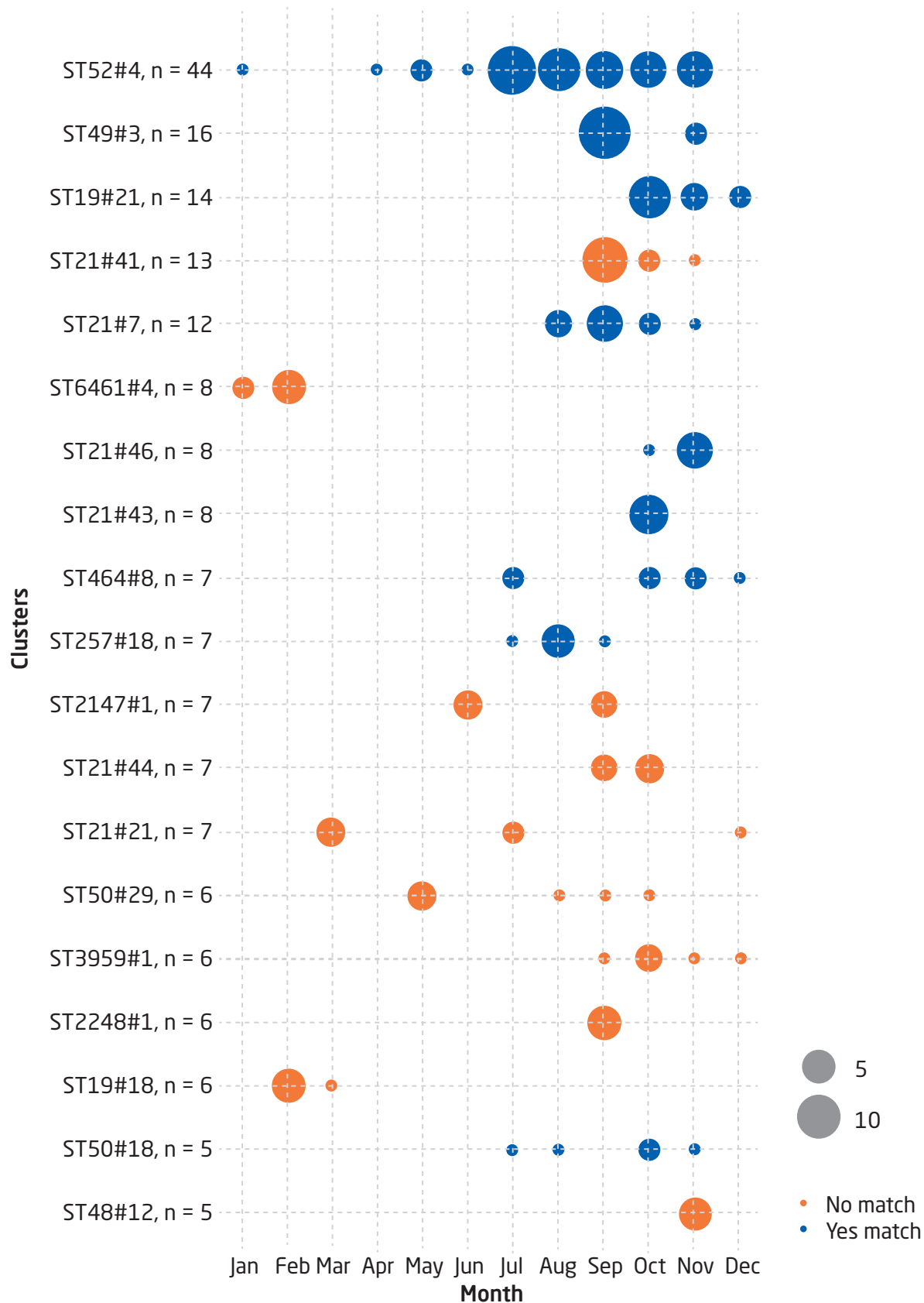
Figure 5.2. Persistence over time (2022) of the C. jejuni *genetic clusters. Only clusters with 5 or more human cases in 2022 are illustrated (regardless of travel history). Clusters matching food isolates are blue. The size of bubbles indicates the number of cases per year*

In 2022, nineteen genetic clusters with five or more cases were detected (Figure 5.2) comprising 26% (192 / 737) of the sequenced cases. For nine of these clusters a food match was detected within the same or the previous year. Food matches were linked to Danish produced chicken meat, except from one that was linked to imported chicken meat. In total, 25% (184 / 737) of the sequenced human isolates in 2022, was matched to a source.

Since chicken meat is consumed by the majority of the Danish population, and it is hard to remember brand or type of meat, the interviews of cases in the genetic clusters do not add much to the aetiology. The exception is point source outbreaks with a specific source e.g. the suspected milk outbreak in Bornholm in 2021 [2].

5.2 Surveillance of *Campylobacter* in broiler flocks

Campylobacter status of broiler flocks is monitored through cloacal swab samples obtained at the slaughterhouses where all flocks are sampled. In 2022, 18.6% of broiler flocks tested positive for *Campylobacter* (Appendix Table A9). Since 2014, a decrease in the prevalence of flocks testing positive on cloacal swabs has been observed which might be a result of the measures taken at farms to prevent introduction of *Campylobacter*. As usual, the surveillance of *Campylobacter* in broiler flocks shows a higher proportion of positive flocks in the late summer months (Figure 5.3), and a much higher prevalence of *Campylobacter* in outdoor-raised flocks than in indoor-raised flocks (data not shown).

5.3 Surveillance of *Campylobacter* in fresh broiler meat at the slaughterhouses

More than 85% of the conventional Danish broilers are slaughtered at the two largest slaughterhouses in Denmark, where the Danish Food and Veterinary Administration (DVFA) has carried out surveillance of *Campylobacter* in fresh meat for more than a decade. In 2013, the surveillance sample type was changed to include leg skin samples collected from chilled carcasses ready for human consumption. Similar to the observations of *Campylobacter* in broiler flocks, the prevalence of *Campylobacter* in Danish broiler meat is higher in the late summer months (Figure 5.4) and in the meat samples from outdoor-raised chicken flocks compared to conventional meat samples (data not shown).

5.4 Action plans against *Campylobacter*

Denmark has had National Action Plans against *Campylobacter* since 2008. The first Action Plan focused solely on broilers and broiler meat, but the focus has broadened in the later Action Plans.

Figure 5.3. Percentage of broiler flocks positive for Campylobacter *per month, 2018-2022*
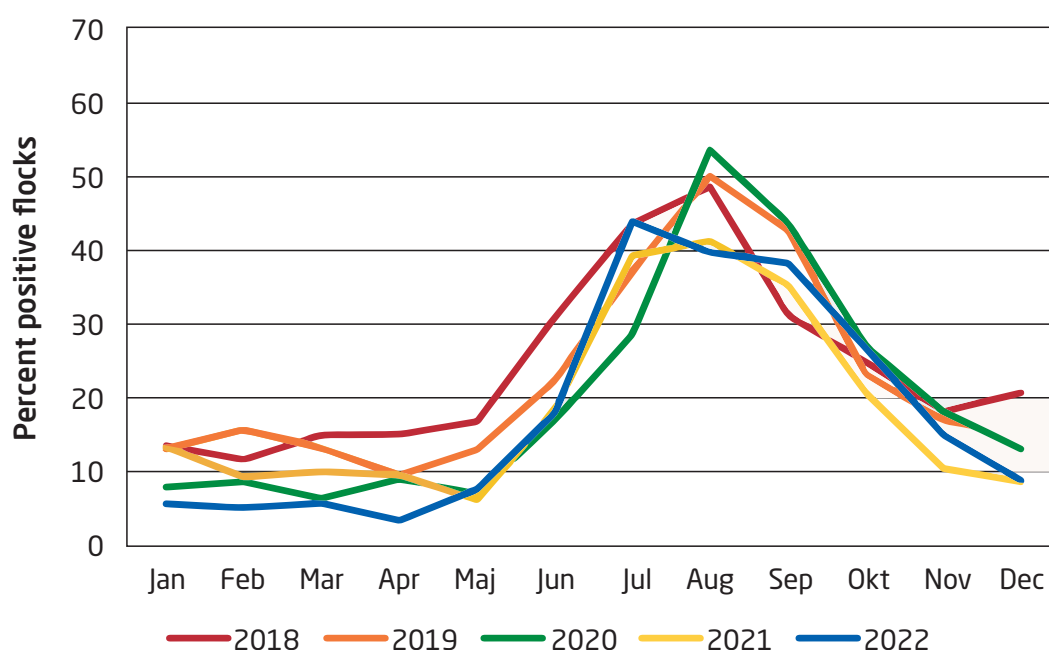
Source: Danish Agricultural & Food Council

Figure 5.4. Prevalence of Campylobacter in the surveillance of leg skin samples from conventionally produced broilers, 2018-2022
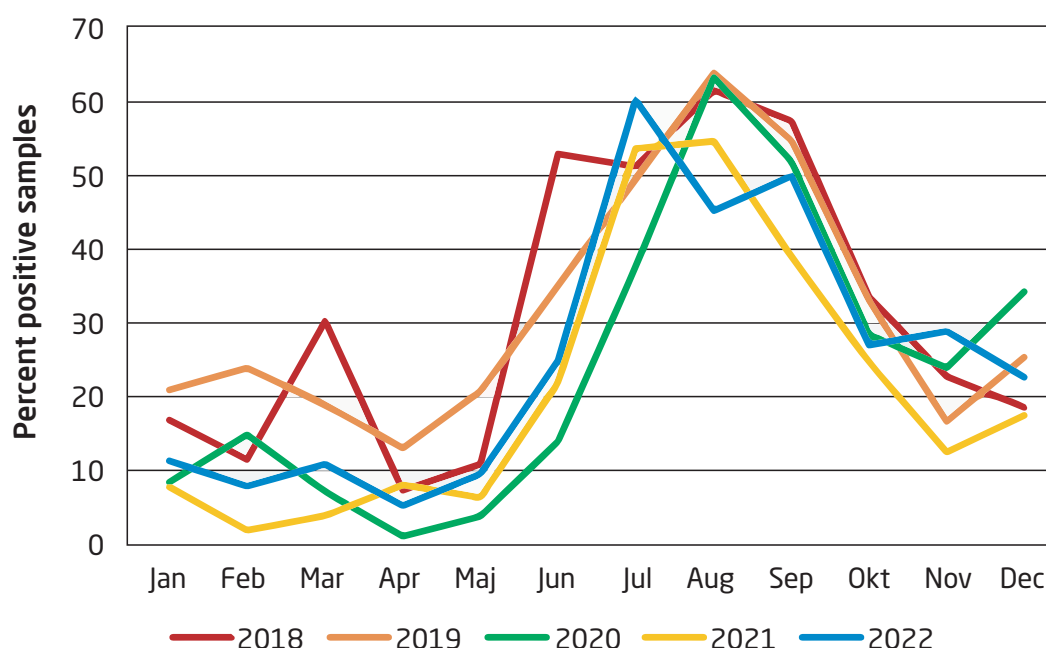
Source: Danish Veterinary and Food Administration

5.5 Action plans against *Campylobacter*, 2018-2021

The third Action Plan was adopted in 2018 and is described by Anonymous (2018) [3].

The main goal of the Action Plan was to obtain a 5% reduction in registered human cases each year. This was the first time a specific target on the reduction of human cases was included in the Action Plan. The goal however, was not reached in 2018 or 2019. In the same period, the number of clinical microbiological laboratories using PCR based methods increased (see chapter 3). These methods are more sensitive, resulting in a higher number of registered cases. Moreover, in 2019, a large outbreak of human campylobacteriosis occurred. In 2020, the goal was reached, however this was primarily due to the Covid-19 pandemic, which resulted in a marked decrease of travel related human cases, as described in Anonymous (2021) [4]. In 2021, the number of human cases remained at the level of 2020.

In broiler flocks, the target was to maintain the low prevalence obtained in 2017 (17.6%). This target was not reached. In 2018 the prevalence increased to 24.6% positive flocks, but decreased again to 22.7% in 2019, 20.4% in 2020 and in 2021 the prevalence was 19.1% [4].

In broiler meat, the target was to reduce the risk of illness from *Campylobacter* to 50% by 2021 relative to the risk in 2013 – applying the Relative Risk Model (RRM) made by Nauta et al. (2012) [5]. By the end of 2021, the risk of getting *Campylobacter* from broiler meat was 53% of the risk in 2013, nearly reaching the target of the Action Plan. Close to half of the reduction of risk was reached in 2021.

5.6 Action plans against *Campylobacter*, 2022-2026

The initiatives in the new Action Plan from 2022-2026 are based on the experiences, results and knowledge obtained from the previous Action Plans. The Action Plan was prepared by DVFA in collaboration with Danish Agriculture and Food Council, Confederation of Danish Industry, Danish Butchers Association FoodDenmark and DTU Food. The Action Plan isavailable on the DVFA website (fvst.dk).

The main target of the Action Plan is to reduce the number of human cases, a specific target on the reduction was not set this time. However, it was decided to set separate targets for the different production systems (conventional and organic/free range) and to set individual targets for each of the medium/major slaughterhouses (slaughterhouses slaughtering above 1 million broilers pr. year).

For conventional broiler flocks, the goal is to maintain the low prevalence of positive flocks at approximately 15% and for organic/free ranges broiler flocks the target is, to keep it at, or below 65% positive flocks. Moreover, the aim is to further reduce the number of positive broiler flocks over a 5-year period. At the slaughterhouse-level (broiler meat), it was the plan that individual targets should be set, when the updated baseline of the RRM was obtained. In 2022 it was decided not to use the RRM for setting the new targets. Instead, targets for reduction and maximum levels of prevalence and concentration (number of positive samples above 1000 cfu/g) were set using the 3-year average (2019-2021) for each of the slaughterhouses as a baseline. Furthermore, it was decided to set different goals for the maximum level of concentration of *Campylobacter* in the meat, for the summer- and winter period, considering the seasonal differences in the prevalence of *Campylobacter* positive broiler flocks.

Most efforts and measures from the previous Action Plan are continued, such as surveillance of broiler flocks at slaughterhouses and in retail. Screening of other possible sources such as cattle and imported meat is also carried out. Whole genome sequencing of isolates is performed in order to compare with the sequences of isolates from the surveillance of human cases (Figure 5.1 & Figure 5.2). Consumer information is issued regularly to raise awareness on the importance of kitchen hygiene. Further research on sources and on mitigation measures is also a part of the plan.

The Action Plan is dynamic, meaning that targets and measures will be followed and adjusted according to the development in the production of broilers as well as contribution to infection from other sources.

5.7 Conclusion

The One Health surveillance of *Campylobacter* in Denmark consists of different monitoring and research as well as control activities. Routine comparison of human and food isolates is crucial to enhance outbreak management and gain more knowledge on the etiology of *Campylobacter*. The monitoring of flocks with cloacal swabs as well as monitoring of fresh meat at the slaughterhouse level continues to be done in the Action Plan 2022-2026. Likewise, is the comparison of isolates from the human monitoring of *Campylobacter* and from broiler meat to identify human outbreaks also continued in the new plan. Screening of the potential other sources (and comparison to human isolates) such as cattle and imported broiler meat, as well as research projects on sources, transmission and on mitigation measures are also included in the Action Plan. Consumer information is issued regularly to raise awareness e.g. on the importance of kitchen hygiene, hygiene when barbecuing, and recommendations when travelling abroad.

5.8 References

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6. Surveillance and control programmes

The collaboration on zoonoses between national and regional authorities, the industry and non-governmental organisations in Denmark is presented in Figure 6.1. An overview of the notifiable and non-notifiable human and animal diseases, presented in this report, is provided in Appendix Table A26 and Table A27, respectively, including reference to the relevant legislation.

6.1 Surveillance of human disease

Information on human cases due to zoonotic pathogens presented in this report is extracted from the Danish Microbiology Database (MiBa) or reported to Statens Serum Institut (SSI) through different channels depending on the disease:

- Notifiable through the laboratory surveillance system: *Salmonella, Campylobacter, Yersinia,* Shiga toxin-producing E. coli (STEC) and *Listeria*.
- Individually notifiable zoonotic pathogens: *Chlamydia psittacci* (ornithosis), *Leptospira* (Weils disease), *Mycobacterium*, Bovine Spongiform Encephalopathy (BSE) prions (var. Creutzfeldt-Jakob Disease), STEC and Lyssavirus (rabies).
- Non-notifiable zoonotic pathogens: *Brucella*.

In Denmark, the physicians report individually notifiable zoonotic diseases to the Danish Patient Safety Authority and SSI. Physicians send specimens from suspected cases to one of the clinical microbiology laboratories depending on the geographical region. A copy of the results of the diagnostic analysis from regional clinical microbiology laboratory is transmitted to MiBa. All cases of infections with laboratory notifiable pathogens are collected in the Register of Enteric Pathogens maintained by SSI. *Campylobacter, Salmonella* and *Yersinia* cases are extracted from MiBa and STEC and *Listeria* are reported to SSI directly from the clinical microbiology laboratories. Furthermore, all culturable *Salmonella* and STEC and a subset of *Yersinia* and *Campylobacter* isolates are sent to SSI for further characterisation and the results are recorded in the Register of Enteric Pathogens. Cases are reported as episodes, i.e., each patient-infectious agent combination is only recorded once in any six-month period. Overviews of results from the Register of Enteric Pathogens are presented as follows:

- All laboratory-confirmed human cases are presented in Appendix Table A1.
- STEC O-group distribution in humans is presented in Appendix Table A2.
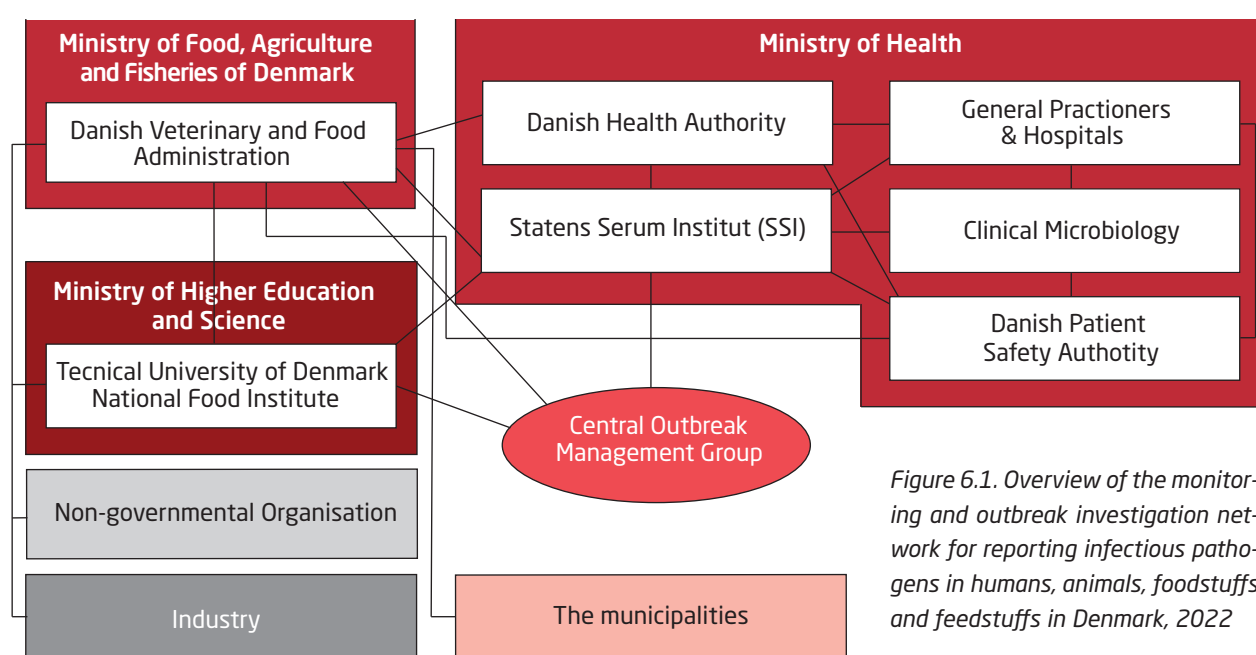- The *Salmonella* serovar distribution is presented in Appendix Table A4.

Figure 6.1. Overview of the monitoring and outbreak investigation network for reporting infectious pathogens in humans, animals, foodstuffs and feedstuffs in Denmark, 2022

6.2 Outbreaks of zoonotic gastrointestinal infections

In Denmark, local and regional foodborne outbreaks are typically investigated by the Food Inspection Unit in collaboration with the Public Health Medical Officers at the Danish Patient Safety Authority, and the regional clinical microbiology laboratories. National outbreaks are investigated by SSI, the National Food Institute at the Technical University of Denmark (DTU Food) and the Danish Veterinary and Food Administration (DVFA) in collaboration. These institutions may also aid in the investigation of regional or local outbreaks. Representatives from these institutions meet regularly in the Central Outbreak Management Group to discuss surveillance results, compare the reported occurrence of zoonotic agents in animals, food and feedstuffs with that in humans, and coordinate the investigation of outbreaks. The formal responsibility of investigating food or waterborne outbreaks is currently divided between three ministries: the Ministry of Health for infectious diseases; the Ministry of Food, Agriculture and Fisheries for foodborne and animal related outbreaks, and the Ministry of Environment for outbreaks of diseases related to supply of tap water.

Outbreaks may be detected in various ways. Clusters of cases may be noted in the local clinical laboratory or identified at SSI through the laboratory surveillance of gastrointestinal bacterial infections by subtyping of bacterial isolates from patients. Food business operators are obliged to contact the DVFA if the food they served or produced are suspected to have caused illness. Individuals who experience illness related to food intake in settings such as restaurants or workplace cafeterias may report these incidents directly to the Food Inspection Unit. General practitioners and hospitals are obliged to report all suspected food- and waterborne infections to the Danish Patient Safety Authority and to SSI.

A list of verified outbreaks (not including household outbreaks) reported to the Food- and waterborne Outbreak Database are presented in Appendix Table A3 and some of the outbreaks from 2022 are outlined in Chapter 1.

6.3 Surveillance and control of animals and animal products

In Denmark, action plans and programmes on zoonoses have been in place for more than 25 years. The first plan targeted *Salmonella* in the broiler production and was developed as a response to an increase in the number of human cases related to eating broiler meat. Since then, plans have been developed for *Salmonella* in pigs and pork, *Salmonella* in layers (eggs), *Campylobacter* in broilers and *S.* Dublin in cattle and beef.

All plans have been outlined in cooperation between industry, research institutes and authorities, and are followed by a technical working group and a steering committee. This ensures progress, that new knowledge is incorporated in the plans, and an assessment of achievement of targets.

At EU level, harmonised surveillance programmes and common targets have been set for the broiler and laying egg production. An overview on the status on the targets can be seen in Table A25.

Salmonella surveillance and control programmes for poultry including table eggs, pigs and cattle are presented in Appendix Tables A28-33. Sample analysis, including serotyping and testing of antimicrobial resistance is performed at official laboratories designated by the DVFA. An overview of the methods used for subtyping is presented in Appendix Table A34.

Overviews of results from surveillance and control of *Salmonella* are presented as follows:
- Results from the table egg production are presented in Appendix Tables A5-A6.
- Results from the broiler production are presented in Appendix Tables A4 and A7.
- Results from the duck and turkey productions are presented in Appendix Tables A4 and A8.
- Results from the pig production are presented in Appendix Tables A4, A11 and Figures A1-A3.
- Results from the cattle production are presented in Appendix Tables A4, A12-A13 and Figure A4.
- Results from the rendering plants are presented in Appendix Table A14.
- Results from the feed production are presented in Appendix Tables A15-A16.
- Results based on suspicion of diseases in pets, zoo animals and wildlife are presented in Appendix Tables A20-A21.

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a) The Danish Veterinary and Food Administration (DVFA) is one authority that operates from more locations throughout the country. To be able to distinguish the locations the terms DVFA is used synonymous with the location in Glostrup and Food Inspection Unit followed by the location synonymous with the location in question.

Overviews of results from monitoring and control of *Campylobacter* are presented as follows:
- Results from the broiler production are presented in Appendix Tables A9-A10.

Pig and cattle carcases are screened for *Mycobacterium* and *Echinococcus* during meat inspection at the slaughterhouse. Although swine kept under controlled housing conditions in Denmark are exempted from examination for *Trichinella* at slaughter, all slaughter pigs, sows and boars are still examined at slaughter. Free range pigs, horses, wild game (e.g., wild boar) and other species susceptible to *Trichinella* must still be tested. In addition, boars and bulls are tested for *Brucella* and bulls are tested for *Mycobacterium* at semen collection centres. All positive results for notifiable infectious diseases are reported to the DVFA. Results are presented in Appendix Table A11-A12.

Results from the surveillance for Bovine Spongiform Encephalopathy (BSE) in cattle, and Transmissible Spongiform Encephalopathy (TSE) in sheep/goat are presented in Appendix Tables A22-A23.

6.4 Official testing of zoonotic pathogens in foodstuffs

In Denmark, control of zoonotic microorganisms in foodstuffs is mainly carried out as projects which are coordinated at the central level of the DVFA. Sampling and testing are carried out with the following purposes:
- To verify that food business operators comply with microbiological criteria laid down in the legislation.
- To verify the microbiological safety of food for which no microbiological criteria are laid down at EU Community level.
- To monitor the effect of established risk management procedures to evaluate if these provide the desired results or need to be reconsidered.
- To generate data for the preparation of risk profiles and risk assessments to support microbial risk management
- To discover emerging problems with microbiological contaminants.

Appendix Table A24 provides information on the centrally coordinated studies conducted in 2022.

For further information, consult the website of the DVFA, www.foedevarestyrelsen.dk (in Danish).

In 2022, Statens Serum Institut (SSI) extracted 899 registered *Salmonella* cases including the available travel information from the Danish Microbiology Database (MiBa) that receives copies of reports from all Danish departments of clinical microbiology. Travel information was available from 83.6% of the *Salmonella* cases in 2022.

A significant increase was seen in cases with a history of travel reported less than seven days before onset of disease from 11.0% in 2021 to 39.9% in 2022 (Table 6.1). This was probably caused by more travel after COVID-19 restrictions was lifted, see also Annual Report on Zoonoses in Denmark 2020 for the effect of COVID-19 restrictions on travel related *Salmonella* cases.

A significant increase of total number of *S.* Enteritidis cases was seen from 114 in 2021 to 251 in 2022 (Table A1). The increase was caused by the significant increase of travel related *S.* Enteritidis cases from 18.3% in 2021 to 58.5% in 2021 (Table 6.1), including both travel related cases and travel related outbreak cases (Figure 6.2). Travel related *S.* Typhimurium and S. 1,4,[5],12:i:- cases increased from 5.6% in 2021 to 18.7% in 2022 (Table 6.1).

The total number of *S.* Typhimurium and S. 1,4,[5],12:i:- cases were unchanged, being 208 in 2022 and 205 in 2021 (Table A1). Numbers reflecting that *S.* Typhimurium and *S.* 1,4,[5],12:i:- cases were mostly acquired domestically (both sporadic and outbreak related), but also better reporting of travel status and therefore less cases with travel status unknown (Figure 6.2).

Table 6.1. Top 10 Salmonella *serotypes in humans and information about travel abroad, 2021-2022*

2022	Number of patients (%)	% of patients[a] infected Abroad[b]	Domestically	2021	Number of patients (%)	% of patients[a] infected Abroad[b]	Domestically
Enteritidis	251 (27.9)	58.5	41.5	Typhimurium	117 (16.9)	5.6	94.4
Typhimurium	104 (11.6)	18.7	81.3	Enteritidis	114 (16.5)	18.3	81.7
1,4,[5],12:i:-	104 (11.6)	17.4	82.6	1,4,[5],12:i:-	88 (12.7)	6.9	93.1
Infantis	22 (2.4)	19.0	81.0	Braenderup	42 (6.1)	2.4	97.6
Newport	20 (2.2)	55.6	44.4	Newport	27 (3.9)	15.0	85.0
Mikawasima	16 (1.8)	20.0	80.0	Dublin	25 (3.6)	0.0	100.0
Paratyphi B var Java	15 (1.7)	61.5	38.5	Montevideo	17 (2.5)	0.0	100.0
Dublin	13 (1.4)	0.0	100.0	Chester	14 (2.0)	0.0	100.0
Virchow	13 (1.4)	58.3	41.7	Bovismorbificans	11 (1.6)	9.0	91.0
Agona	12 (1.3)	63.6	36.4	Oranienburg	10 (1.4)	14.3	15.7
Other serotypes	329 (36.6)	39.1	60.9	Other serotypes	227 (32.8)	15.7	84.3
Total	899	39.9	60.1	Total	692	11.0	89.0

a) Patients with unknown travel information (16.4% of all patients in 2022 and 28.2% in 2021) were excluded from the percent calculations.
b) Infected abroad is defined as travel abroad in a seven-day period prior to disease onset.

Source: Statens Serum Institut

Figure 6.2. Monthly distribution of S. Enteritidis *and* S. Typhimurium *incl. the monophasic variant 1,4,[5],12:i:- cases, 2018-2022*
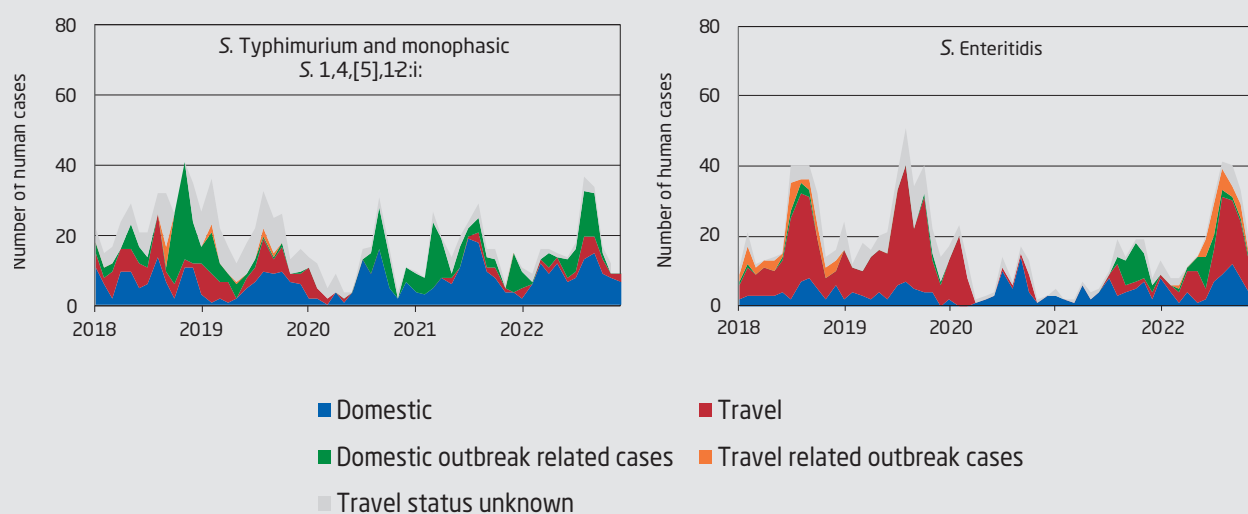
Source: Statens Serum Institut

7. Outcome and future perspectives of One Health collaborations

By Pikka Jokelainen (PIJO@ssi.dk), Marianne Sandberg and Tine Hald

The health of humans, animals and our shared environment are interconnected. Protection of animal health and public health from zoonotic threats requires a One Health approach and collaborations across sectors and country borders. Cross-sectoral One Health collaboration is increasingly emphasised and applied in Denmark, in Europe and globally and societal, political and environmental changes call for continuous evolution of the One Health approach.

7.1 Impactful outcomes, science-to-policy experiences and perspectives for future from One Health EJP

One Health European Joint Programme (One Health EJP, 2018-2023) is a European flagship initiative for One Health collaborations. Gathering 44 partners across Europe to address foodborne zoonoses, Antimicrobial Resistance (AMR) and emerging threats, the programme has delivered impactful outputs. Danish participation has been active, and supported collaborations also at national level in particular between Statens Serum Institut (SSI) and the National Food Institute at the Technical University of Denmark (DTU-FOOD). For example, the two institutes hosted together the Annual Scientific Meeting of One Health EJP in 2021 and a Continuing Professional Development Module in 2022. In 7.1.1-7.1.3, examples of activities of the One Health EJP are briefly described.

A key part of the legacy of One Health EJP is its recently published Strategic Research and Innovation Agenda (SRIA). The SRIA summarises the main outcomes and impacts of the One Health EJP, and discusses future perspectives for One Health in Europe. It highlights the importance of international, cross-sectoral, multidisciplinary collaborations and the trust built in such collaborations. Dialogue with stakeholders has proven useful to ensure impact at national, European and global levels. Harmonisation of methods and approaches across sectors is needed for comparable data.

Environmental aspects were not in the core of the scope of One Health EJP, but they were identified as important. Future One Health initiatives should have more collaboration with environmental and ecosystem health sectors and could more strongly contribute to a green, sustainable future.

After September 2023, the end of the implementation period of One Health EJP, no direct continuation for similar collaboration is foreseen. However, several other large projects have focus on One Health, and many One Health EJP partners continue collaborations also outside formal projects.

7.1.1 Discovering the sources of *Salmonella, Campylobacter,* STEC and antimicrobial resistance

The DiSCoVeR project was one of the Joint Research Projects under One Health EJP. It brought together researchers and experts from different disciplines (microbiology, bioinformatics and epidemiology) and sectors (veterinary science, food safety, public health, and environmental health) from 19 institutions in 13 European countries to address the challenges of source attribution in an interdisciplinary manner. As there exists no gold standard for conducting source attribution, DiSCoVeR took a comprehensive approach applying several different methodologies and models in a comparative fashion.

Comprehensive datasets covering a broad range of reservoirs and sources, including those not traditionally part of the existing monitoring and surveillance activities (e.g., pets, wildlife, and environmental sources), were collected. A substantial number of the pathogen isolates was also sequenced and formed the basis of the whole genome sequencing (WGS)-based source attribution approaches. The final databases included: *Salmonella* (n = 145,000 isolates; s = 4,185 sequences), *Campylobacter* (n = 5,361 isolates/sequences), STEC (n = 7,552 isolates; s = 3,418), and ESBL (n = 10,674 isolates). Metadata including phenotypic information are made open accessible through Zenodo, where the WGS data is currently stored at a secure sharing platform available for all partners and with ongoing work to further expand. The WGS data will eventually be uploaded to the European Nucleotide Archive (ENA).

Another important output of DiSCoVeR is a critical and systematic assessment of existing source attribution models and development of new phenotypic and genomic-based attribution models for foodborne pathogens and antimicrobial resistance. For *Salmonella, Campylobacter,* and STEC, several types of national and multi-country WGS-based attribution models were developed. Overall, the results were in agreement and in line with those

found with the 'conventional' subtyping approaches (phenotypic and MLST based), which gives credibility to both the results and the different models. Findings were further supported by a systematic literature review and meta-analysis of case-control studies of sporadic *Salmonella* and *Campylobacter* infections and an aggregated analysis of EU *Salmonella* outbreak data. Although the nuances and the level of attribution of these types of studies are different from the subtyping approaches, the results are comparable and dissimilarities can to a large extent be explained. In conclusion, WGS-based models have some clear advantages (e.g. higher predicting accuracy due to the increased discriminatory power), but they are also more resource demanding, and in some situations, phenotypic and/or epidemiological models may give results that are just as useful.

From a One Health perspective, the work in DiSCoVeR gave rise to some reflections and recommendations. First of all, surveillance activities are still very much focused on livestock and food, whereas the environment, including e.g. wildlife, is only sporadically monitored resulting in data scarcity. The role of the environment and pets as sources for human infections, therefore, remains unclear and is complicated by bi-/multi-directional transmission, specifically addressed by one of the models. Still, a research synthesis of all the findings confirm that livestock populations are the main reservoirs for the target pathogens except for ESBL, where human-to-human transmission are more important. From a risk assessment point of view, particularly, *Salmonella* in pigs and pork and *Campylobacter* in broilers and chicken meat stand out as areas, where targeted future control and intervention could be implemented/intensified to reduce the burden of human infections significantly.

Other recommendations based on the work in DiSCoVeR include, but are not limited to, harmonizing sampling and reporting further, including an expansion of the existing minimum requirement for accompanying metadata and subtyping results, and promote capacity building on integrated surveillance, burden of disease, source attribution, risk assessment, and system thinking at country level.

7.1.2 ORION
The ORION project was an EU initiative aimed to support the inter-sectorial harmonization and use of data, to inform the decision-making in One Health surveillance. Moreover, the project focused on data FAIRness (Findability, Accessibility, Interoperability and Reusability).

Within the ORION, three scientific studies were carried out at DTU-Food. Those studies were based on the integration of national datasets collected for surveillance of *Campylobacter* along the Danish poultry meat chain (from two national surveillance components), which provided information on the flock´s infection status (positive or negative) and carcass contamination levels (cfu/g). In one study it was assessed the impact of flocks produced from high-risk farms on the risk of human campylobacteriosis posed by a meal contaminated from fresh poultry meat. Whereas in the next study the occurrence of flocks cross-contamination (CC) at slaughterhouses was assessed. Finally, the relative contribution of the CC flocks on the risk of human campylobacteriosis was assessed. These studies gives a practical example of how inter-sectorial data integration can be routinely used for data-driven risk assessment modelling, to inform risk-based control of *Campylobacter* (and of similar foodborne pathogens) along the food chain, within OH systems. In this way, surveillance actors and stakeholders can decide the prioritization of risk mitigation measures and control actions "from farm to patient", according to resources available and feasibility. For example, especially in countries with low *Campylobacter* flock prevalence and high relative contribution of CC flocks to the human risk; the control measures could be prioritized to high-risk farms (to reduce flock prevalence at the pre-harvest), and could be combined with other actions aimed to remove/minimize cross-contamination at slaughter (e.g. logistic slaughtering).

Currently (mid-2023) the outcomes from the three studies, are under consideration within the technical working group of the Danish National *Campylobacter* Action Plan. Moreover, the mused data-driven approach, has been presented to EFSA, as a future project-idea for standardizing (at EU level) the inter-sectorial data integrations and analysis, which are aimed to inform risk assessment models for foodborne pathogens across EU Member States. Therefore, outputs of the ORION project, have the potential to mitigate the risk of human campylobacteriosis not only in Denmark, but also in the rest of Europe.

7.1.3 Science-to-policy translation or OHEJP SimEx
The One Health EJP Simulation Exercise (OHEJP SimEx) aimed at practicing One Health capacity and interoperability across public health, animal health and food safety sectors in a outbreak scenario. The OHEJP SimEx was delivered through a sequence of scripts covering the different stages of an outbreak investigation at a national level, involving both the human food chain and the raw pet feed industry. Altogether 255 participants from 11 European countries took part in national level two-day exercises during 2022. Recommendations for future One Health simulation exercises were also summarized; such exercises are essential to practice, challenge and improve national One Health strategies.

In Denmark, OHEJP SimEx conduction took place on May 30-31, 2022. SSI, DTU-FOOD and the Danish Veterinary and Food Administration (DVFA) - the three organisations that constitute in the Central Outbreak Management Group (COMG) - participated in the exercise. The Training Audience included representatives of communication teams from each of the three organisations. The national aims were i) to improve the existing collaboration in COMG and increase understanding about roles and responsibilities among the involved organisations, and ii) to strengthen the national communication of foodborne outbreaks to different target groups and stakeholders.

OHEJP SimEx conduction in Denmark highlighted the unique strengths of the well-functioning COMG. The exercise was excellent for networking, which supported the first national aim. The focus on communication was considered useful, and key outcomes from One Health EJP SimEx in Denmark include more explicit integration of communication aspects to the structure and workflow of COMG.

7.1.4 Science-to-policy translation in One Health EJP
Evidence-based decision making and policy making in relation to complex challenges, such as those requiring a One Health approach, are not easy. The experiences from Science-to-Policy approaches of One Health EJP provide useful experiences for this.

A dedicated Science to Policy Translation work package, co-lead by SSI, established collaborations with both national and international stakeholders (public institutes, ministries, ECDC, EFSA, EEA, EMA, FAO, WOAH, WHO-Europe). The work was based on dialogue and started with surveying the needs related to foodborne zoonoses, antimicrobial resistance and emerging infectious threats of key stakeholders to inform the Strategic Research and Innovation Agenda. Later, focus was moved to match the needs with consortium outputs by targeted dissemination. The different stakeholders were invited to become involved at strategically relevant timepoints. The dissemination activities included reports, meetings and workshops, and ensuring that the consortium outputs were made easily findable and available.

The structures and the dialogue allowed timely identification of synergies. A key achievement was bringing stakeholders to discuss together around the same table, which supported e.g. the establishment of the European cross-agency One Health Task Force. Success of One Health Science-to-Policy approaches requires understanding of the mandates and needs of different stakeholders, funding and structural support, building trust across networks, and applying suitable dissemination processes.

7.2 Scaling up One Health surveillance activities in Europe - OH4Surveillance and UNITED4Surveillance
Two new initiatives funded under EU4Health programme strengthen surveillance using One Health approach. UNITED4Surveillance is an ongoing Joint Action, and its sister-initiative OH4Surveillance will start soon. The OH4Surveillance consortium is coordinated by SSI and gathers countries to work together to set up and scale up One Health surveillance to priority pathogens, in close collaboration with EFSA. Focus in Denmark will be on West Nile Virus and zoonotic influenza viruses, in collaboration between SSI and University of Copenhagen.

7.3 New European Partnerships on research for improved animal health and welfare, contingency and sustainable food systems
A number of Danish instiutions have been active in the preparation of a large European partnership focusing on animal health and welfare (EUP AH&W). EUP AH&W aims to progress Europe towards healthy and sustainable live-stock production systems (for both terrestrial and aquatic animals), including the reduction of anti-microbial usage, and to improve production animal welfare, in line with the European Green Deal and farm-to-fork strategy. Moreover, the EUP AH&W will strengthen public health and well-being by facilitating cross-sector collaboration in a One Health – One Welfare perspective. The objective is also to facilitate the collaboration between sectors within countries and between institutions in different countries.

Yet another One Health related Partnership is the PSFS FutureFoodS. According to FAO a sustainable food system is "a food system that delivers food security and nutrition for all in such a way that the economic, social and environmental bases to generate food security and nutrition for future generations are not compromised". The ambition of the PSFS FutureFoodS is to collectively develop and implement an EU-wide committed research and innovation (R&I) partnership which accelerates the transition towards diets that are healthy, safe and sustainably produced and consumed in resilient EU and global food systems. DTU National Food Institute will especially contribute to the partnership with regard to sustainable nutrition, risk-benefit assessments and science to policy activities.

Moreover, an ongoing Coordination and Support Action BE READY is building a consolidated European Research and Innovation Area that provides the foundation of the candidate European partnership for pandemic preparedness. From Denmark, SSI participates in BE READY.

7.4 Preparedness for emerging threats – DURABLE, EU-HIP and EU-WISH

SSI has collaborated with the Health Emergency Prepared-ness and Response Authority (HERA) since its early days, and now the collaborations are strengthened by several large projects under EU4Health programme, all notably applying One Health approaches: DURABLE is HERA's Laboratory Network that provides scientific advice based on research conducted in a network of top laboratories, EU-HIP works towards interoperability of national IT systems with HERA's upcoming IT-platform for intelligence gathering, and upcoming EU-WISH will enhance and extend wastewater surveillance for priority targets across Europe.

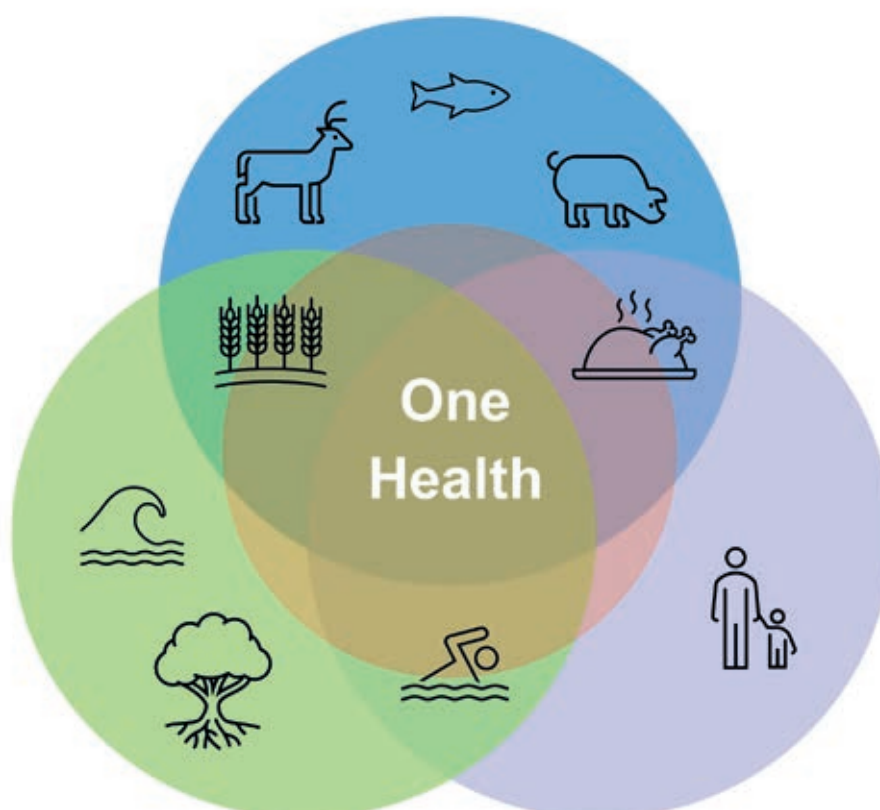## 7.5 Building on the collaborations created to address COVID-19

COVID-19 pandemic showed that multidisciplinary, cross-sectoral collaborations are needed to address complex challenges. Such collaborations were established quickly in Denmark, making the country a trailblazer for gen-erating and using data, including One Health data, for COVID-19 response. Now that WHO has declared that COVID-19 is no longer a public health emergency of international concern, it is time to build on and extend these collaborations, to be better prepared to address other current and future challenges. A multidisciplinary One Health approach is crucial in this.

7.6 Further reading

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Figure 7.1. Conceptual diagram of One Health. Original by Abbey Olsen [15], adapted by Brian Lassen

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8. International topics

By Gudrun Sandø (gus@fvst.dk)

8.1 Codex Alimentarius

In 2022, the Codex Alimentarius Commission adopted "Guidelines on the Management of Biological Foodborne Outbreaks". The outline of the guidelines started in 2018 and Denmark has been chairing the work with the EU-Commission and Chile as co-chairs.

The guidelines give advice on how to prepare, detect, manage, and recover when biological foodborne outbreaks occur. There is an emphasis on cooperation between institutions and establishing local and national networks to facilitate communication and quick response.

Human disease and outbreak data

Table A1. Zoonoses in humans, number of laboratory-confirmed cases, 2017-2022

Zoonotic pathogen	Incidence per 100,000 inhabitants 2022	Reported no. of cases					
		2022	2021	2020	2019	2018	2017
Bacteria							
Brucella abortus/melitensis[a,b]		1	1	1	7	3	3
Campylobacter coli/jejuni[c,e]	87.0	5,142	3,740	3,742	5,389	4,546	4,257
Chlamydia psittaci[c]	0.3	16	25	27	32	16	14
Leptospira spp.[c]	0.1	6	10	14	14	19	22
Listeria monocytogenes[c]	1.5	86	62	43	62	47	58
Mycobacterium bovis[c]	0.0	0	0	0	0	1	2
Salmonella total[c,e]	15.2	899	692	614	1,120	1,168	1,067
S. Enteritidis[c,e]	4.2	251	114	117	310	268	226
S. Typhimurium[c,d]	3.5	208	205	149	272	306	290
Other serotypes[c]	5.8	344	301	302	449	594	551
STEC total[c,e]	22.6	1,330	927	448	630	495	346
O157	0.8	47	32	39	60	43	50
Other O-groups or non-typeable	6.6	393	376	198	359	259	215
Yersinia enterocolitica total[c,e,f]	12.6	747	454	413	374	366	354
Yersinia enterocolitica (Biotype 2,3 and 4)	2.9	174	137	106	139	-	-
Viruses							
Lyssavirus[c]	0	0	0	0	0	0	0

a) Not notifiable, hence the incidence cannot be calculated.

b) Data presented are from one laboratory (Statens Serum Institut) only, representing a proportion of the Danish population. The proportion of the population represented varies from year to year, thus results from different years are not comparable. Testing for these pathogens is carried out only if specifically requested on the submission form.

c) Notifiable.

d) Including the monophasic variant of *S. Typhimurium* (*S.* 1,4,[5],12:i:-).

e) Includes also only notified cases.

f) A subset, of Yersinia enterocolitica (40,7%) was isolated and sent from the local clinical departments to SSI for surveillance. Characterisation disclosed 55,7% (219 isolates) being apathogenic biotype 1a, and these are excluded from the total number for 2022.

Source: Statens Serum Institut

Table A2. STEC O-group distribution in humans[a], 2022

O-group	Number of episodes	Proportion of total (%)	O-group	Number of episodes	Proportion of total (%)
O157	47	3.5	O128	16	1.2
O26	42	3.2	O63	13	1.0
O103	41	3.1	Other	117	8.8
O146	38	2.9	Notification[b,c]	949	71.4
O145	26	2.0			
O27	24	1.8			
O91	17	1.3			
Continued in the next column			Total	1,330	

a) All O-groups that resulted in ten or more episodes are listed.
b) Including isolates sent for verification at SSI, but not possible determine O-group.
c) Cases not sent for verification at SSI and/or only notified through the clinical notification system.

Source: Statens Serum Institut

Table A3. Food- and waterborne disease outbreaks reported in the Food- and waterborne Outbreak Database (FUD) (n=63), 2022

Pathogen[a]	No. of patients	Patients laboratory confirmed	Setting	Source	FUD no.[e]
Campylobacter jejuni, ST49	16	16	National	Chicken meat	2123
Campylobacter jenuni, ST19	14	14	National	Chicken meat	2134
Campylobacter jejuni, ST21	8	8	National	Chicken meat	2143
Campylobacter jejuni, ST21	7	7	National	Unknown	2135
Campylobacter jejuni, ST21	8	8	National	Chicken meat	2131
Campylobacter jejuni, ST21	12	12	National	Chicken meat	2130
Campylobacter jejuni, ST21	13	13	National	Unknown	2129
Campylobacter jejuni, ST2248	6	6	National	Unknown	2133
Campylobacter jejuni, ST3959	6	6	National	Unknown	2140
Campylobacter jejuni, ST464	7	7	National	Chicken meat (imp)[c]	2070
Campylobacter jejuni, ST48	5	5	National	Unknown	2150
Clostridium perfringens	7	0	Take-away	Vension steak with mushrooms	2139
Clostridium perfringens	13	0	Take-away	Chili con carne	2071
Cryptosporidium IIaA15G1R1	8	8	Regional	Unknown	2101
Cryptosporidium IIaA15G1R1	17	17	National	Unknown	2102
E. coli multiple types (EAEC, ETEC, STEC)	11	5	Take-away	Mixed food	2079
Lectins	25	0	School	Green lentils	2181
Lectins	74	0	Kindergarten	Butter bean soup	2147
Continued on the next page					

Table A3. Food- and waterborne disease outbreaks reported in the Food- and waterborne Outbreak Database (FUD) (n=63), 2022 (Continued from previous page)

Pathogen[a]	No. of patients	Patients labora-tory confirmed	Setting	Source	FUD no.
Listeria monocytogenes, ST8	9	9	National	Cold-cut meat	2074
Listeria monocytogenes, ST8	2	2	National	Unknown	2098
Listeria monocytogenes, ST37	9	9	Regional	Unknown	2080
Listeria monocytogenes, ST37	5	5	National	Unknown	2006
Listeria monocytogenes, ST7	10	10	National	Fish patties	2127
Listeria monocytogenes, ST1607	4	4	National	Unknown	1969
Norovirus	30	5	Regional	Mixed food	2207
Norovirus	8	0	Restaurant	Mixed food	2173
Norovirus	91	0	National	Oysters	2162
Norovirus	59	0	Restaurant	Buffet meals	2153
Norovirus	61	3	Restaurant	Buffet meals	2151
Norovirus	18	0	Canteen	Oysters	2149
Norovirus	28	0	Take-away	Open sandwhich	2137
Norovirus	125	5	National	Mixed food	2126
Norovirus	31	2	Canteen	Buffet meals	2124
Norovirus	60	1	Restaurant	Buffet meals	2122
Norovirus	9	0	Restaurant	Oysters	2113
Norovirus	14	0	Restaurant	Mixed food	2111
Norovirus	19	3	Take-away	Rum balls	2109
Norovirus	61	5	Canteen	Stir fry	2105
Salmonella Ball ST3502	3	3	International	Unknown	2118
Salmonella Enteritidis ST11	5	5	National	Unknown	2161
Salmonella Enteritidis ST11	24	24	National	Unknown	2084
Salmonella Jukestown ST5005	6	6	International	Unknown	2078
Salmonella Mikawasima ST185	9	9	National	Unknown	2087
Salmonella Strathcona ST2559	6	6	National	Unknown	2117
Salmonella 4,[5],12:i:-, ST34	11	11	National	Unknown	2116
Salmonella 4,[5],12:i:-, ST34	6	6	National	Minced beef	2086
Salmonella 4,[5],12:i:-, ST34	4	4	International	Chocolate	2067
Salmonella Typhimurium ST36	15	0	National	Unknown	2100
Salmonella Typhimurium ST36	5	0	Regional	Unknown	2088
STEC O145:H28 ST32 (stx2a)	11	11	National	Unknown	2083
STEC O26:H11 ST21 (stx2a) and *Campylobacter jejuni* ST19	5	2	Farm	Raw milk from cow	2076
Unknown	34	0	Canteen	Chili con carne	2183
Unknown	19	0	Take-away	Chicken sandwich	2114
Unknown	62	0	Canteen	Unknown	2104

Continued on the next page

Table A3. Food- and waterborne disease outbreaks reported in the Food- and waterborne Outbreak Database (FUD) (n=63), 2022 (Continued from previous page)

Pathogen[a]	No. of patients	Patients laboratory confirmed	Setting	Source	FUD no.
Unknown	60	0	Catering service	Pulled turkey	2103
Unknown	6	0	Restaurant	Buffet meals	2093
Unknown	40	0	Restaurant	Buffet meals	2085
Unknown	13	0	Take-away	Creamed potatoes	2070
Unknown	2	0	Restaurant	Mixed food	2058
Unknown	10	0	Restaurant	Mixed food	2056
Vibrio parahaemolyticus	3	1	Restaurant	Oysters	2094
Yersinia enterocolitica, ST18	8	8	National	Unknown	2099
Yersinia enterocolitica, ST18	7	7	National	Unknown	2154
Total	1,284	297			

a) ST = Sequence Type.
STEC = Shigatoxin-producing *Escherichia coli.*
EIEC = Enteroinvasive *Escherichia coli.*
ETEC = Enterotoxigenic *Escherichia coli.*
EAEC = Enteroaggregative *Escherichia coli.*
b) Data only include outbreak cases from 2022.
c) (imp) = imported product.

Source: Food- and waterborne Outbreak Database (FUD)

Monitoring and surveillance data

Table A4. Top 15 (humans) serotype distribution (%) of Salmonella *from humans, animals, carcases, Danish and imported meat, 2022. N=number of culture positive units[a]*

	Human cases N=899	Pork[b] batches N=90	Beef[c] batches N=5	Broiler[d] flocks N=6	Layer[d] flocks N=1	Duck[e] batches N=1	Imported meat (batches) Pork[e] N=10	Duck[e] N=25
Enteritidis	27.9	-	-	-	-	-	-	48.0
Typhimurium	11.6	14.4	20	-	-	-	10.0	24.0
4,5,12:i:-	11.6	32.2	-	-	-	-	60.0	4.0
Infantis	2.4	3.3	-	-	-	-	-	8.0
Newport	2.2	-	-	16.7	-	100	-	-
Mikawasina	1.8	-	-	-	-	-	-	-
Paratyphi B var. Java	1.7	-	-	-	-	-	-	-
Dublin	1.4	-	80	-	-	-	-	-
Virchow	1.4	-	-	-	-	-	-	-
Agona	1.3	-	-	-	-	-	-	-
Stanley	1.2	-	-	-	-			-
Coeln	1.0	-	-	16.7	100	-	-	-
Hadar	0.9	-	-	16.7	-			-
Saintpaul	0.9	-	-	-	-	-	-	-
Strathcona	0.9	-	-	-	-		-	-
Other	21.0	44.4[f]	-	50.0[g]	-	-	30.0[h]	16.0[i]
Unknown	10.7	5.6	-	-	-	-	-	-

a) One isolate per serotype per unit is included, thus the number of isolates may exceed the number of units.
b) Sampling of pork carcases at slaughterhouses according to the surveillance programme (Table A33).
c) Sampling of beef carcases at slaughterhouses according to the surveillance programme (Table A32).
d) Sampling of production flocks prior to slaughter according to surveillance programmes (Tables A29).
e) Centrally coordinated study (see section 6.4 and Table A24 for more information).
f) *S.* Derby (29), *S.* Ohio (3), *S.* Senftenberg (2), 4,12:i:- (2), *S.* Give (1), *S.* Idikan (1), *S.* Lagos (1), *S.* Putten (1).
g) *S.* Cerro (1), *S.* Montevideo (1), 4,12:i:- (1).
h) *S.* Choleraesuis var. Kunzendorf (1), *S.* Derby (2).
i) *S.* Give (2), *S.* Indiana (1), *S.* Senftenberg (1.

Source: Danish Veterinary and Food Administration and Statens Serum Institut

Table A5. Occurrence of Salmonella *in the table egg production[a], 2012-2022*

	Rearing period[b] (parent flocks)		Adult period[c] (parent flocks)		Pullet-rearing flocks		Table egg layer flocks	
	N	Positive	N	Positive	N	Positive	N	Positive
2012	9	0	8	0	197	1	359	3
2013	10	0	7	0	173	0	373	4
2014	22	0	8	0	150	0	347	2
2015	15	0	8	0	123	0	344	0
2016	15	0	10	0	132	0	426	3
2017	7	0	8	1	138	1	446	3
2018	7	0	6	0	124	1	454	12
2019	7	0	6	0	101	0	411	8
2020	8	0	9	0	134	0	432	8
2021	6	0	9	0	112	0	429	4
2022	4	0	8	1[d]	90	0	418	1[e]

a) See Tables A28 and A30 for description of the surveillance programmes.
b) *Salmonella* was not detected in grandparent flocks during rearing period (1 flocks).
c) *Salmonella* was not detected in grandparent flocks during adult period (4 flocks).
d) *S.* Derby.
e) *S.* Coeln.

Source: Danish Agriculture and Food Council, and Danish Veterinary and Food Administration

Table A6. Occurrence of Salmonella *in the table egg layer flocks sorted by type of production, 2012-2022*

	Deep litter		Free range		Organic		Cage	
	N	Positive	N	Positive	N	Positive	N	Positive
2012	101	0	37	1	136	1	131	1
2013	108	0	37	1	137	3	94	0
2014	97	0	30	0	125	1	95	1
2015	108	0	29	0	172	0	86	0
2016	125	1	31	0	196	1	74	1
2017	126	0	42	1	217	2	61	0
2018	139	4	46	1	227	4	42	3
2019	135	1	34	2	220	5	22	0
2020	151	3	40	1	216	4	25	0
2021	151	2	44	1	213	1	21	0
2022	90	0	24	0	127	1[a]	13	0

a) *S.* Coeln.

Source: Danish Agriculture and Food Council, and Danish Veterinary and Food Administration

Table A7. Occurrence of Salmonella *in the broiler production[a], 2012-2022*

	Rearing period[b] (parent flocks)		Adult period[c] (parent flocks)		Broiler flocks		Slaughterhouse[d] (flocks/batches)	
	N	Positive	N	Positive	N	Positive	N	Positive
2012	123	0	183	0	3,448	27	368	0
2013	128	0	152	1	3,498	34	288	0
2014	121	2	131	3	3,470	26	277	4
2015	91	0	289	1	3,631	23	148	0
2016	184	0	182	3	3,606	21	203	1
2017	170	2	250	1	4,290	25	259	0
2018	184	1	149	1	4,245	35	249	1
2019	210	0	137	1	4,012	12	254	0
2020	357	0	217	1	3,604	13	231	0
2021	154	0	290	1	3,758	6	263	0
2022	166	0	267	2[e]	3,680	6[f]	230	2[g]

a) See Tables A28-A29 for description of the surveillance programmes.
b) *Salmonella* was not detected in grandparent flocks during rearing period (2 flocks).
c) *Salmonella* was not detected in grandparent flocks during adult period (8 flocks).
d) From 2008, meat from all AM positive flocks are heat treated at slaughter. Sampling is now carried out as verification of the AM results of the negative flocks.
e) *S.* Newport (1), *S.* Isangi (1).
f) *S.* Cerro (1), *S.* Coeln (1), *S.* Hadar (1), *S.* Montevideo (1), *S.* Newport (1), *S.* 4.12:I:- (1).
g) *S.* Newport (1), *S.* Typhimurium (1).

Source: Danish Agriculture and Food Council, and Danish Veterinary and Food Administration

Table A8. Occurrence of Salmonella *in turkey flocks, 2012-2022*

	Turkey flocks[a]	
	N	Positive
2012	23	0
2013	56	3
2014	10	0
2015	80	1
2016	76	0
2017	24	1
2018	13	0
2019	85[b]	0
2020	198	0
2021	115	0
2022	132	3[c]

a) See Table A31 for description of the surveillance programme for turkey flocks. The major turkey slaughterhouse in Denmark closed down in 2004. Therefore, most commercially reared turkey flocks are transported abroad for slaughter.
b) The increase in number of tested flocks is primarily based on a change of registration.
c) *S.* Newport

Source: Danish Veterinary and Food Administration

Table A9. Occurrence of Campylobacter *in broiler flocks, 2012-2022[a]*

	Sock samples at farm		Cloacal swabs at slaughter		Neck skin samples at slaughter[b]	
	N (Flocks)	% pos	N (Flocks)	% pos	N (Batches)	% pos[c]
2012	3,376	11.6	-	-	-	-
2013	3,508	13.1	-	-	-	-
2014	-	-	3,474	27.7	-	-
2015	-	-	3,274	19.6	-	-
2016	-	-	3,184	20.8	-	-
2017	-	-	3,316	16.6	-	-
2018	-	-	3,411	24.6	1,120	9.7
2019	-	-	3,327	22.7	1,063	7.4
2020	-	-	3,189	20.2	985	7.0
2021	-	-	3,332	19.5	1,150	7.5
2022	-	-	2,990	18.6	1,090	10.5

a) See Table A29 for description of the surveillance programmes. In 2014 the sampling method changed from boot swabs collected in the stable 7-10 days
    before slaughter to cloacal swabs at slaughter according to Danish Order no. 1512 of 13/12/2013.
b) In 2018, additional sampling of neck skin began at the slaughterhouses according to Regulation (EC) 2073/2005, see Table A29 for further description.
c) Percent positive samples >1000 cfu/g.

Source: Danish Agriculture and Food Council

Table A10. Occurrence of Campylobacter *in non-heat-treated chilled broiler meat samples at slaughter and retail[a], 2016-2022*

|		At slaughter[b]		At retail			
		Denmark		Denmark		Import	
		N (samples)	% pos	N (samples)	% pos[c]	N (samples)	% pos[c]
2016	Conventional	999	21.3	1,339	12.8	232	37.9
	Organic/free-range	117	87.2	93	71.0	245	78.8
2017	Conventional	1,258	25.0	-	-	-	-
	Organic/free-range	203	79.0	-	-	-	-
2018	Conventional	1,250	31.0	-	-	-	-
	Organic/free-range	199	91.0	-	-	-	-
2019	Conventional	1,248	32.6	697	12.4	28	36.1
	Organic/free-range	123	68.3	155	31.6	28	82.1
2020	Conventional	1,224	25.8	436	15.2	64	67.3
	Organic/free-range	95	49.5	192	34.4	-	-
2021	Conventional	1,232	22.2	623	11.9	14	64.3
	Organic/free-range	96	36.5	158	30.4	62	69.4
2022	Conventional	1,205	26.1	774	9.8	24	41.7
	Organic/free-range	98	40.8	107	25.2	43	60.5

a) Centrally coordinated studies (see Table A24 and section 6.4 for description). Limit of quantification: 10 cfu/g.
b) Leg-skin samples.
c) The prevalence is calculated as a mean of quarterly prevalences, except organic/free-range results.

Source: National Food Institute and Danish Veterinary and Food Administration

Figure A1. Serological surveillance of Salmonella *in breeding and multiplying pigs[a] based on monthly testing of blood samples, 2017-2022[b]*
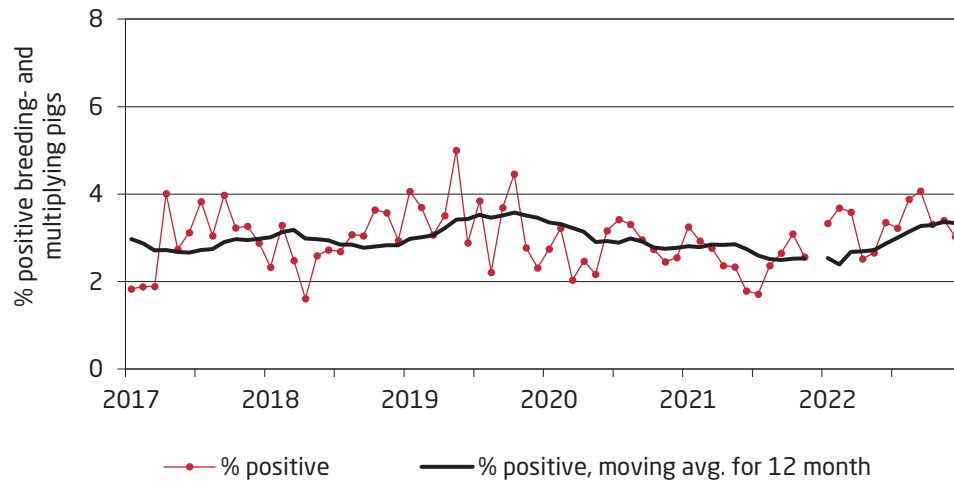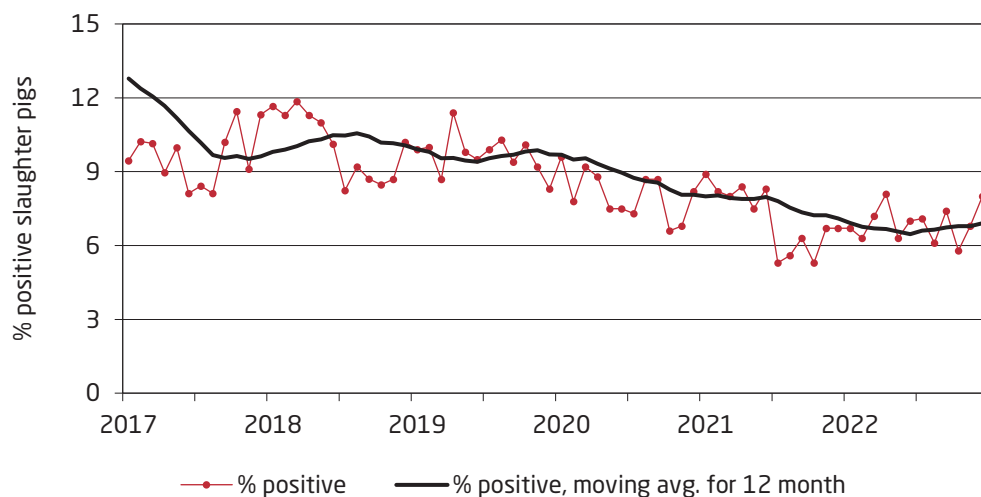

a) For more information about the surveillance programme, see Table A33.
b) Monthly data for the month of December 2021 not available. Therefore, the monthly moving average from January 2022 to November 2022 is based on 11month's data.

Source: Danish Agriculture and Food Council

Figure A2. Serological surveillance of Salmonella *in slaughter pigs[a], 2017-2022. Percentage of seropositive meat juice samples (first sample per herd per month)*

a) For more information about the surveillance programme, see Table A33.

Source: Danish Agriculture and Food Council

Table A11. Occurrence of zoonotic pathogens in pigs and pork in Denmark, 2022

	Herds			Animals/Samples		
Zoonotic pathogen	N	Pos		N	Pos	% pos
At slaughterhouse (slaughter pigs)						
Salmonella spp.[a,b]	5,169	150[g]		-	-	-
Salmonella spp.[a,c] (slaughtering >30,000 pigs/year)	-	-		17,795	-	0.8[h]
Salmonella spp.[a,c] (slaughtering 1,000 or more and less than 30,000 pigs/year)	-	-		84	-	0
Salmonella spp.[a,d]	-	-		-	-	-
Trichinella spp.[e]	-	-		17,140,130	0	-
Mycobacterium spp.[f]	-	-		17,854,036[i]	0	-
Echinococcus granulosis/multilocularis[f]				17,854,036[i]	0	-

a) See Table A33 for description of the *Salmonella* surveillance programme.

b) Data are from December 2022. Slaughter pig herds monitored using serological testing of meat juice samples collected at slaughter.

c) Swab samples from 4 designated areas after 12 hours chilling (4x100cm²).

d) Caecum samples are randomly collected from slaughter pigs at slaughter.

e) Samples collected from slaughter pigs at slaughter were examined using the method described in Regulation (EU) 2015/1375. In 2014, an amendment to EU regulation (EC) No 2075/2005 came into force stating that slaughter pigs, sows and boars kept under "controlled housing conditions" in Denmark are exempted testing for *Trichinella*. Free range pigs must be tested for *Trichinella*.

f) Slaughter pigs were examined by meat inspectors at slaughter.

g) Includes herds belonging to *Salmonella* level 2 and 3 only (See Table A33).

h) When estimating the prevalence of *Salmonella*, both the loss of sensitivity and probability of more than one sample beinge positive in a pool are taken into consideration. A conversion factor has been determined on the basis of comparative studies, as described in Annual Report 2001. Furthermore, the prevalence has been adjusted for double sampling carried out in slaughterhouses with a prevalence of 2% or above (12month average).

i) Includes sows and boars slaughtered.

Source: Danish Veterinary and Food Administration and National Food Institute, Technical University of Denmark

Figure A3. Salmonella in pork, monitored at slaughterhouses[a], 2017-2022
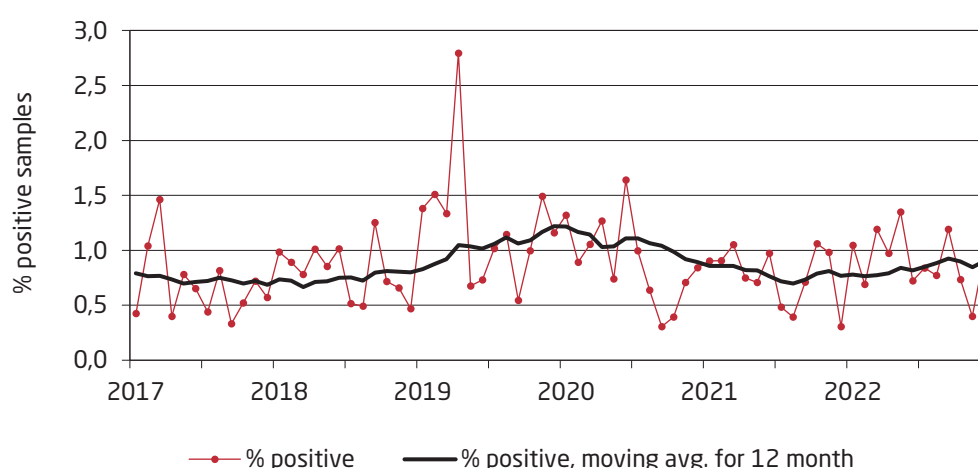
a) For more information about the surveillance programme, see Table A33.

Source: Danish Veterinary and Food Administration

Table A12. Occurrence of zoonotic pathogens in cattle and beef in Denmark, 2022

	Animals/Samples		
Zoonotic pathogen	N	Pos	% pos
At farm			
Brucella spp.[a]	269	0	-
Mycobacterium bovis[b, c]	395	0	-
Coxiella burnetii[d]	102	3	2.9
At slaughterhouse			-
Salmonella spp.[e,f] (slaughtering >=7,500 cattle/year)	7,120	5	0.1[h]
Salmonella spp.[e,f] (slaughtering 250 or more and 7,500 or less cattle/year)	180	-	0
Mycobacterium spp.[b, g]	493,300	0	-
Echinococcus granulosis/multilocularis[g]	493,300	0	-

a) Denmark has been declared officially brucellosis free since 1979. The last outbreak was recorded in 1962. 5-8 ml blood samples were analysed using either the SAT or CFT methods. In addition 34 aborted foetuses were tested, none were positive.

b) Denmark has been declared officially tuberculosis free since 1980. The last case of TB in cattle was diagnosed in 1988.

c) Analysis using the intradermal tuberculin test. Including samples from bulls (examined at pre-entry, every year, and prior to release from semen collection centres) and samples collected in connection with export.

d) One positive sample was seen - it came from a herd that also tested positive in 2020 hence is not reported again.

e) Swab samples from 4 designated areas after 12 hours chilling (4x100cm^2).

f) See Table A32 for description of the surveillance programme.

g) Slaughtered cattle were examined by the meat inspectors at slaughter.

h) When estimating the prevalence of *Salmonella*, both the loss of sensitivity and probability of more than one sample being positive in a pool are taken into consideration. A conversion factor has been determined on the basis of comparative studies, as described in Annual Report 2001.

Source: Danish Veterinary and Food Administration and National Food Institute, Technical University of Denmark

Figure A4. Salmonella in beef, monitored at slaughterhouses[a], 2017-2022
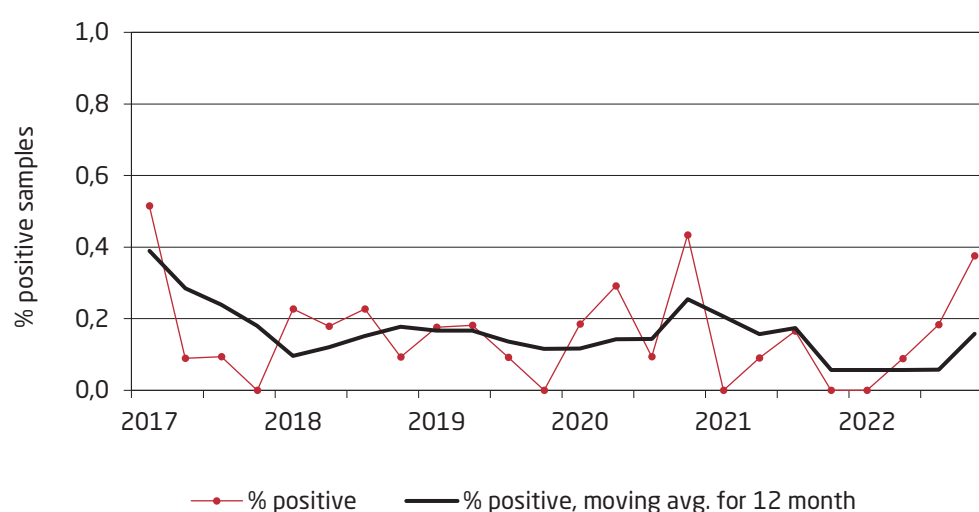
a) For more information about the surveillance programme, see Table A32.

Source: Danish Veterinary and Food Administration

Table A13. Cattle herds in the Salmonella *Dublin surveillance programme[a], December 2022*

Salmonella Dublin level			Non-milk producing herds		Milk producing herds	
			N	%	N	%
Level 1		On the basis of milk samples	-	-	2,060	88.1
		On the basis of blood samples	11,795	97.6		
	Total	Probably S. Dublin free	11,795	97.6	2,060	88.1
Level 2		Titre high in blood- or milk samples	148	1.2	222	9.5
		Contact with herds in level 2	98	0.8	26	1.1
		Other causes	39	0.3	29	1.2
	Total	Non S. Dublin free	285	2.4	277	11.9
Total number of herds			12,080		2,337	

a) See Table A32 for description of the surveillance programme.

Source: SEGES

Table A14. Salmonella *in three categories of meat and bone meal by-products not intended for human consumption[a], 2022*

Category of processing plant	Own-check samples		Product samples	
	N	Positive	N	Positive
1+2: By-products of this material cannot be used for feeding purposes	500	2	273	2
2: By-product of this material may be used for feed for fur animals[b]	0	0	0	0
3: By-products from healthy animals slaughtered in a slaughter-house. Products of these may be used for petfood[c] and for feed for fur animals	671	0	756	0
Total	1,171	2	1,029	2

a) Regulation (EC) No 1774 of 03/10/2002 as amended.
b) No production.
c) For cats and dogs. Only by-products from pigs are used in this pet food.

Source: Daka Denmark A/S

Table A15. Control of Salmonella *in feed processing and feed material (batch-based data), 2020-2022*

	2022		2021		2020	
	N	Positive	N	Positive	N	Positive
Feed materials, farm animals[a]	60	1[d]	60	2	17	0
Feed processing plants (process control)[b]:						
Ordinary inspections[c]	284	8[e]	285	0	132	4

a) Predominantly products of soybean, fish meal and rapeseed cake.
b) Presence of *Salmonella* in compound feed is indirectly monitored by environmental samples collected during feed processing. Companies are sampled one to four times per year.
c) Primarily findings of *Salmonella* in the unclean zone.
d) *S.* Havana (1).
e) *S.* Havana (6); *S.* 4,[5],12:i:- (1); *S.* Brancaster (1).

Source: Danish Veterinary and Food Administration

Table A16. Feed business operators own sampling of Salmonella *in compound feeds, feed processing and feed material (batch-based data), 2020-2022*

	2022		2021		2020	
	N	Positive	N	Positive	N	Positive
Compound feed, farm animals	2,600	1[d]	2,263	0	2,253	9
Feed materials, farm animals[a]	1,969	27[e]	2,148	27	2,300	32
Feed processing plants (process control):						
Ordinary inspections - clean zone[b]	8,656	20[f]	8,344	7	8,252	31
Ordinary inspections - unclean zone[b]	1,232	25[g]	1,222	40	1,239	34
Transport vehicles, clean zone/hygiene samples[c]	1,263	5[h]	1,110	0	1,082	1
Transport vehicles, unclean zone/hygiene samples[c]	165	6[i]	245	10	219	4

Note: Data are from one feed and grain trade organisation only, representing a proportion of feed at the Danish market.

a) Predominantly products of soy (e.g. soybean meal) but also products of rape (e.g. rapeseed cake) and sunflower (e.g. sunflower meal).
b) Presence of *Salmonella* in compound feed is indirectly monitored by environmental samples collected during feed processing.
c) Samples from transport vehicles (hygiene samples) prior to loading of feed compounds.
d) *S.* Falkensee.
e) *S.* Ahamdi (2), *S.* Havana (2), *S.* Idikan (1), *S.* Infantis (2), *S.* Kastrup (1), *S.* Mbandaka (10), *S.* Quakam (1), *S.* Rissen (1), *S.* Senftenberg (3), *S.* Soerenga (1), *S.* Tennesee (1), *S.* Yoruba (2).
f) *S.* Derby (1), *S.* Ententirtis (1), *S.* Falkensee(13), *S.* Idikan (3), *S.* Mbandaka (2).
g) *S.* Blegdam (1), *S.* Falkenesee (1), *S.* Idikan (1), *S.* Kralingen (1), *S.* Mbandaka (1), *S.* Putten (3), *S.* Rissen (10), *S.* Senftenberg (2), *Salmonella* spp. (1), *S.* Swharzengrund (1), *S.* Thyphimurium (1), *S.* Yourba (2).
h) *S.* Durban (1), *S.* Panama (1), *S.* Putten (2), *S.* Tennesse (1).
i) *S.* Idikan (1), *S.* Putten (2), *S.* Rissen (3).

Source: Danish Veterinary and Food Administration and the feed business operators

Table A17. Listeria monocytogenes *in Danish and non-Danish produced ready-to-eat (RTE) foods[a], 2022*

			Samples analysed by a qualitative method[b]		Samples analysed by a quantitative method	
			Batches		Batches	
	Food category	Sampling place	N	Positive	N	Positive[c]
Danish	Fish and fishery products, RTE[d]	Wholesale	15	0	32	2
	Products made from bovine, RTE[d]	Wholesale	8	0	2	0
	Products made from pork, RTE[d]	Wholesale	23	0	13	0
	Chicken products, RTE[d]	Wholesale	3	0	-	-
	Other, RTE[d]	Wholesale	59	0	15	0
Non-Danish[e]	Crustaceans, RTE[d]	Border inspection	19	0	0	0
	Fish and fishery products, RTE[d]	Border inspection	13	0	1	0
	Molluscan shellfish, RTE[d]		11	0		
	Other, RTE[d]	Border inspection	1	0	0	0
	Total		152	0	63	2

a) Samples are collected by the local food control offices according to EU Regulation (EC) No 2073/2005.
b) *Listeria monocytogenes* present in a 25g sample of the product.
c) Levels > 10 cfu/g.
d) Ready-to-eat.
e) Samples from Canada, Chile, China, Costa Rica, Faroe Islands, Greenland, India, Indonesia, Itlay, Norway, Spain, The Netherlands, USA, Vietnam,

Source: Danish Veterinary and Food Administration

Table A18. Histamine in batches of Danish and non-Danish fish products[a], 2022

Food category	Sampling place	Danish		Non-Danish[b]	
		N	Positive	N	Positive
Herring in dressing	Processing plant	3	0	-	-
Herring	Border inspection	-	-	2	0
	Processing plant				
Mackerel	Border inspection	-	-	13	0
	Processing plant	2	0	-	-
Tuna	Border inspection	-	-	23	0
Total		5	0	38	0

a) Samples are collected by the local food control offices according to EU Regulation (EC) No 2073/2005.
b) Samples from Columbia, El Salvador, Ghana, Greenland, Maldives, Mauritius, Philippines, Seychelles, Thailand, Turkey, UK, Vietnam.
c) The findings of histamine did not exceed the limits according to EU Regulation (EC) No 2073/2005.

Source: Danish Veterinary and Food Administration

Table A19. Salmonella *in Danish and non-Danish produced food items[a], 2022*

Food category	Sampling place	Danish		Non-Danish[b]	
		N	Positive	N	Positive
Molluscan shellfish, intended to be cooked	Processing plant	20	0	50	0
Products made from beef, intended to be cooked	Border inspection	-	-	-	-
	Processing plant	85	0	-	-
Products made from pork, intended to be cooked	Border inspection	-	-	-	-
	Processing plant	130	3[d]	-	-
Products made from poultry, intended to be cooked	Processing plant	100	0	10	0
Fruits and vegetables	Processing plant	210	0	-	-
Meat (non-specified)		60	0	-	-
Crustaceans, RTE[c]	Border inspection	-	-	45	0
	Processing plant	-	-	60	0
Gelatin and collagen	Border inspection	-	-	15	0
Non-specified, RTE[c]	Processing plant	10	0	-	-
Infant formula, dried	Border inspection	-	-	-	-
Total		615	3	180	0

a) Samples are collected by the local food control offices according to EU Regulation (EC) No 2073/2005.
b) Brazil, Canada, Chile, China, Greenland, Mexico, United States, Vietnam.
c) Ready-to-eat.
d) Two positive samples were from the same batch.

Source: Danish Veterinary and Food Administration

Table A20. Occurrence of zoonotic pathogens in zoo and pet animals in Denmark[a], 2022

	Zoo animals				Pet animals[c]			
	Mammalians & reptiles		Birds		Dogs		Cats	
Zoonotic pathogen	N	Pos	N	Pos	N	Pos	N	Pos
Chlamydia psittaci[b]	0	0	63	19	0	0	0	0
Lyssavirus (classical)	0	0	-	-	2	0	8	0
European Bat Lyssavirus	0	0	-	-	2	0	8	0

a) All samples are analysed based on suspicion of disease and does not reflect the country prevalence.
b) The number N and Pos represents cases. One case may contain more birds sampled at the same location /address.
c) No samples were analysed for cats, dogs, and other pet animals.

Source: Statens Serum Institut and Danish Veterinary and Food Administration

Table A21. Occurrence of zoonotic pathogens in wild and farmed wildlife in Denmark[a], 2022

	Farmed wildlife		Wildlife			
	Birds		Mammals		Birds	
Zoonotic pathogen	N	Pos	N	Pos	N	Pos
Echinococcus multilocularis	0	0	21	0	0	0
Lyssavirus (classical)[b]	0	0	12	0	0	0
European Bat Lyssavirus[b]	0	0	12	0	0	0
West Nile virus[c,d,e]	91	0	18	0	318	0

a) All samples are analysed based on suspicion of disease and does not reflect the country prevalence.
b) Samples are analysed using PCR. The results are not specified concerning the Lyssa virus types.
c) The surveillance of West Nile virus in Poultry is based on farmers voluntary submitting samples for surveillance.
d) Bats were tested for West Nile virus.
e) No samples were positive for West Nile Virus. But approximately 12% of the migratory birds tested (N=243) were positive for WNV antibodies.

Source: Statens Serum Institut and Danish Veterinary and Food Administration

Table A22. The Bovine Spongiform Encephalopathy (BSE) surveillance programme[a] for cattle, 2022

Type of surveillance	N[b]	Positive
Active surveillance		
Slaughtered animals	1	0
Risk categories:		
Animals from herds under restriction	0	0
Emergency slaugther	1,607	0
Fallen stock	22,868	0
Slaughterhouse antemortem inspection revealed suspicion or signs of disease	0	0
Passive surveillance		
Animals suspected of having clinical BSE	0	0
Total	24,475	0

a) According to the EU Regulation (EC) 999/2001 as amended, Commission Decision 2009/719/EC as amended and Danish Order no. 1442 of 11/12/2019 as amended.

b) Samples (brain stem material) are tested using a IDEXX technique. Confirmatory testing is carried out using histopathology or immunohistochemistry. Further confirmation on autolysed material is performed at the European Union TSE reference laboratory.

Source: Danish Veterinary and Food Administration, data extraction from the EFSA database, April 2022

Table A23. The Transmissible Spongiform Encephalopathy (TSE) surveillance programme[a] for sheep and goats, 2022

Type of surveillance	N[b]	Positive
Active surveillance		
Animals from herds under restriction	0	0
Fallen stock (>18 months)	609	1
Not slaughtered for human comsumption	0	0
Slaughtered for human consumption	0	0
Passive surveillance		
Animals suspected of having clinical TSE	0	0
Total	609	1

a) According to the EU Regulation (EC) 999/2001 as amended, Commission Decision 2009/719/EC as amended and Danish Order no. 1491 of 12/12/2019 as amended.

b) Samples (brain stem material) are tested using a IDEXX technique. Confirmatory testing is carried out using histopathology or immunohistochemistry. Further confirmation on autolysed material is performed at the European Union TSE reference laboratory.

Source: Danish Veterinary and Food Administration, data extraction from the EFSA database, April 2022

Table A24. Centrally coordinated studies conducted in 2022

Title of project	No. of planned samples	Pathogen surveyed	Further information
BU microbiology - slaughterhouses	50	Various	Not published
C*ampylobacter* spp. in fresh, chilled Danish broiler meat at slaughterhouses (conventional)	1,250	*Campylobacter* spp.	To be published[a]
Campylobacter spp. in fresh, chilled Danish broiler meat at slaughterhouses (organic)	100	*Campylobacter* spp.	To be published[a]
Campylobacter spp. in fresh, chilled Danish broiler meat	800	*Campylobacter* spp.	Appendix Table 10[a]
Campylobacter spp. in imported imported broiler meat	120	*Campylobacter* spp.	Appendix Table 10[a]
Campylobacter spp. in imorted and intra-traded poultry meat	200	*Campylobacter* spp.	
Campylobacter spp. on cattle carcasses	300	*Campylobacter* spp.	To be published[a]
Campylobacter spp. contamination in poultry slaughterhouses	500	*Campylobacter* spp.	Appendix Table 9[a]
DANMAP - Antibiotic resistance in poultry, pork and cattle	366	AMR	To be published[a]
DANMAP and EU surveillance of antibiotic resistance in broiler, pork and cattle meat at retail (appendicitis samples)	800	AMR	To be published[a]
EU surveillance of antibiotic resistance in retail	470	AMR.	To be published[a]
Export -USA- environmental samples	50	*Listeria monocytogenes*	Not published
Export- USA swab	468	*Salmonella*	Not published
Import - Intensified control of Brazilian beef and poultry meat	50	*Listeria monoctogenes, Salmonella*	To be published
Import - Microbiologic control of fish, fish products and bivalve molluscan shellfish from 3rd.countries	110	*Listeria monoctogenes, Salmonella*	To be published
Import - Microbiological control of food of animal origin, excluding fish	50	*Listeria monoctogenes, Salmonella*	To be published[a]
Import - Special control microbiology - not animal Reg.(669/2009)	100	Various	To be published[a]
Listeria monocytogenes, Salmonella spp, *Escherichia coli* and *Staphylococci* in fish products from Greenland	10	*Listeria monocytogenes, Sal- monella* spp., *Escherichia coli, staphylococci*	To be published[a]
Microbiologic classification of mussel production areas in Denmark	60	*Salmonella* spp., *Escherichia coli*	To be published[a]
Part 1: Minced meat - wholesale	300	According to Reg. 2073/2005	To be published[a]
Part 2: Prepared meat - wholesale	300	According to Reg. 2073/2005	To be published[a]
Part 3: Ready-to-eat meat products - whole-sale	300	According to Reg. 2073/2005	To be published[a]
Part 7: Fruit and vegetables	300	According to Reg. 2073/2005	To be published[a]
Part 6: Fish and fish products - wholesale	300	According to Reg. 2073/2005	To be published[a]

Table A24. Centrally coordinated studies conducted in 2022 (Continued from previous page)

Title of project	No. of planned samples	Pathogen surveyed	Further information
Part 8: *Listeria monocytogenes* in other RTE products - wholesale	300	*Listeria monocytogenes*	To be published[a]
Salmonella in imported pork and beef and in duck meat	700	*Salmonella* spp.	To be published[a]
Salmonella in feed materials from feed companies	60	*Salmonella* spp.	Appendix Table A15
Salmonella in intratraded shell eggs - retail	25	*Salmonella* spp.	To be published[a]
Salmonella in intratraded shell eggs whole-sale	25	*Salmonella* spp.	To be published[a]
Salmonella process samples from feed companies	280	*Salmonella* spp.	Appendix Table A15
Salmonella spp. and *Escherichia coli* in raw frozen scallops from Greenland	25	*Salmonella* spp., *Escherichia coli*	To be published[a]
Salmonella in fresh poultry meat	700	*Salmonella* spp.	To be published[a]

a) Results will be published on the DVFA website www.foedevarestyrelsen.dk (in Danish).

Source: Danish Veterinary and Food Administration

Table A25. Status on targets for Campylobacter *and* Salmonella, 2022

National Action Plans	Target	Status
Campylobacter in broilers 2022-2026		
Flocks at farm	Maintaining low prevalence in flocks of 15% for conventional flocks and 65% for organic/free-range flocks	The prevalance in flocks in 2022 was 18.6% in total (Table A9), 12.7% for conventional flocks and 50.3% for organic/free-range flocks
Fresh meat at slaughterhouse	In 2022 the target for fresh meat at slaughterhouse was not yet decided	
Salmonella in poultry[a]		
Laying hen flocks of *Gallus gallus*	Initially eradication, later a reduction strategy in the table egg production	1 positive flock (0.2%) (Table A5-A6) Eggs from positive flocks are destroyed or heat treated
Carcases at slaughterhouse	Initially eradication, later a reduction strategy in the broiler production Zero-tolerance in Danish broiler meat	2 positive batches (Table A7) Positive batches are heat treated
Salmonella in pigs 2014-2017		
Carcases at slaughterhouse	Max. 1% *Salmonella* at carcase level	0.8% (Table A11)
Salmonella Dublin in cattle 2021-2025		
Herds at farm	Eradication of *S*. Dublin in all herds, i.e. all herds in level 1[b]	11.7% of milk-producing herds and 2.4% of non-milk producing herds are in level 2 (Table A13)

EU Regulations		
Regulation (EC) No. 1190/2012		
Breeding and fattening turkey flocks	Max. 1% positive for *S*. Enteritidis and *S*. Typhimurium[c]	No fattening flocks positive with target serovars (N=132) (Table A8)
Regulation (EC) No. 200/2010		
Breeding flocks of *Gallus gallus*	Max. 1% adult flocks positive for *S*. Typhimurium[c], *S*. Enteritidis, *S*. Hadar, *S*. Infantis and *S*. Virchow	0.0% (0 flocks) (Table A5 and A7)
Regulation (EC) No. 1168/2006		
Laying hen flocks of *Gallus gallus*	MS specific targets, for Denmark: Max. 2% adult flocks positive for *S*. Typhimurium[c] and *S*. Enteritidis	0.0% (0 flocks) positive with target serovars (Table A5)
Regulation (EC) No. 646/2007		
Broiler flocks of *Gallus gallus*	Max. 1% positive *S*. Typhimurium[c] and *S*. Enteritidis	0.03% (1 flock) positive with target serovars (Table A7)

a) Supplementary to EU-regulations.
b) See Table A32 for explanation of the herd levels.
c) Including the monophasic variant of *S*. Typhimurium (*S*. 1,4,[5],12:i:-).

Source: Danish Veterinary and Food Administration

Monitoring and surveillance programmes

Table A26. Overview of notifiable and non-notifiable human diseases presented in this report, 2022

Pathogen	Notifiable	Notification route
Bacteria		
Brucella spp.	no	-
Campylobacter spp.	1979[a]	Laboratory[b]
Chlamydophila psittaci (Ornithosis)	1980[a]	Physician[c]
Listeria monocytogenes	1993[a]	Physician
Leptospira spp.	1980[a]	Physician
Mycobacterium bovis/ tuberculosis	1905[a]	Physician (and laboratory[d])
Coxiella burnetii	no	-
Salmonella spp.	1979[a]	Laboratory
STEC	2000[a]	Physician and laboratory
Yersinia enterocolitica	1979[a]	Laboratory
Parasites		
Cryptosporidium spp.	no	-
Echinococcus multilocularis	no	-
Echinococcus granulosus	no	-
Toxoplasma gondii	no	
Trichinella spp.	no	-
Viruses		
Lyssavirus (Rabies)	1964[a]	Physician (via telephone)
Prions		
BSE/Creutzfeld Jacob	1997[a]	Physician

a) Danish Order no. 277 of 14/04/2000. Cases must be notified to Statens Serum Institut.
b) The regional microbiological laboratories report confirmed cases.
c) The physician report individually notifiable infections.
d) The laboratories voluntarily report confirmed cases.

Source: Statens Serum Institut

Table A27. Overview of notifiable and non-notifiable animal diseases presented in this report, 2022

Pathogen	Notifiable	EU legislation	Danish legislation
Bacteria			
Brucella spp.	1920[a]		
Cattle	OBF in 1979[b]	Regulation (EU) 2021/620	Order no 1485 of 12/12/2019
Sheep and goats	ObmF in 1995[c]	Regulation (EU) 2021/620	Order no 1486 of 12/12/2019
Pigs	No cases since 1999	Regulation (EU) 2021/620	Order no 1392 of 12/12/2019
Campylobacter spp.	no	-	-
Chlamydophila psittaci	-	-	-
Birds and poultry	1920	-	Order no 1385 of 12/12/2019
Listeria monocytogenes	no	-	-
Leptospira spp. (only in production animals)	2003	-	Order no. 1171 of 17/7/2020
Mycobacterium bovis/tuberculosis	1920[a]		-
Cattle	OTF in 1980[d]	Decision 2003/467/EC	Order no. 1447 of 12/12/2019
Coxiella burnetii	2005	-	Order no. 1171 of 17/7/2020
Salmonella spp.	1993[e]		
Cattle		-	Order no. 2416 of 14/12/2021
Swine		-	Order no. 1079 of 1/6/2021
Eggs for consumption		-	Order no. 499 of 23/3/2021
Hatching eggs		-	Order no. 782 of 2/6/2020
Poultry for slaugther		-	Order no. 1819 of 2/12/2020
STEC	no	-	-
Yersinia enterocolitica	no	-	-
Parasites			
Cryptosporidium spp.	no	-	-
Echinococcus multilocularis	2004	Regulation (EU) 2016/429	Order no. 1171 of 17/7/2020
Echinococcus granulosus	1993	Regulation (EU) 2016/429	Order no. 1171 of 17/7/2020
Trichinella spp.	1920[a]	Regulation (EU) 2015/1375	Order no. 1714 of 15/12/2015
Viruses			
Lyssavirus (Rabies)	1920	-	Order no. 1454 of 12/12/2019
Prions			
TSE			
Sheep and goats	yes	Regulation 999/2001/EC (as amended)	Order no. 1491 of 12/12/2019
BSE			
Cattle	yes[f]	Regulation 999/2001/EC (as amended)	Order no. 1442 of 11/12/2019

a) Clinical cases, observations during the meat inspection at the slaughterhouse, positive blood samples or finding of agents are notifiable.
b) Officially Brucellosis Free (OBF) according to Council Directive 64/432/EC as amended and Commission Decision 2003/467/EC. No cases in since 1962.
c) Officially *Brucella melitensis* Free (ObmF) according to Commission implementing regulation (EU) 2021/620. The disease has never been detected in sheep or goat.
d) Officially Tuberculosis Free (OTF) implementing regulation (EU) 2021/620, and Commission Decision 2003/467/EC. No cases in since 1988 or in deer since 1994.
e) Only clinical cases notifiable.
f) Denmark was recognized as a country with negligible risk for BSE at World Organisation for Animal Health (OIE) general session in May 2011.

Source: Danish Veterinary and Food Administration

Table A28. Salmonella *surveillance programme for the rearing flocks and adult flocks of the grandparent and parent generation of the broiler and table egg production, 2022*

Time	Samples taken	Material	Material
Rearing flocks		*Grandparent generation*	*Parent generation*
Day-old[a,b,c]	Per delivery	5 transport crates from one delivery: crate liners (>1 m² in total) or swab samples (>1 m² in total). Analysed as one pool	5 transport crates from one delivery: crate liners (>1 m² in total) or swab samples (>1 m² in total). Analysed as one pool
1st & 2nd week[b, c]	Per unit	-	2 pairs of boot swabs (analysed as one pool) or 1 faecal sample of 60 g
4th week[a,b,c]	Per unit	5 pairs of boot swabs (analysed as two pools), or 2 faecal samples consisting of 150 g each (no pooling)	2 pairs of boot swabs (analysed as one pool) or 1 faecal sample of 60 g
8th week[a,b,c]	Per unit	2 pairs of boot swabs (analysed as one pool) or 1 faecal sample of 60 g	2 pairs of boot swabs (analysed as one pool) or 1 faecal sample of 60 g
2 weeks prior to moving[a,c,d]	Per unit	5 pairs of boot swabs (analysed as two pools), or 2 faecal samples consisting of 150 g each (not pooled) or 2 pairs of boot swabs (analysed as one pool) and 1 dust sample	2 pairs of boot swabs (analysed as one pool) or 1 faecal sample of 60 g
Adult flocks		*Grandparent generation*	*Parent generation*
After each hatch[b,c,e]	Per hatch	Wet dust samples. Up to four hatchers of the same flock can be pooled	Wet dust samples. Up to four hatchers of the same flock can be pooled
Every week[b,c,f]	Per unit	-	5 pairs of boot swabs (analysed as two pools), or 2 faecal samples consisting of 150 g each (not pooled) or 2 pairs of boot swabs (analysed as one pool) and 1 dust sample
Every 2 weeks[f]	Per unit	5 pairs of boot swabs (analysed as two pools), or 2 faecal samples consisting of 150 g each (not pooled) or 2 pairs of boot swabs (analysed as one pool) and 1 dust sample	-
0-4 weeks after moving, 8-0 weeks before slaughter	Per unit	5 pairs of boot swabs (analysed as two pools), or 1 faecal sample consisting of 2x150 g	5 pairs of boot swabs (analysed as two pools), or 1 faecal sample consisting of 2x150 g
22-24 weeks after moving[f]	Per unit	5 pairs of boot swabs (analysed as two pools), or 2 faecal samples consisting of 150 g each (not pooled) or 2 pairs of boot swabs (analysed as one pool) and 1 dust sample	5 pairs of boot swabs (analysed as two pools), or 2 faecal samples consisting of 150 g each (not pooled) or 2 pairs of boot swabs (analysed as one pool) and 1 dust sample
After positive findings[c,d,g]	Per unit	5 pairs of boot swabs (analysed as two pools), 2 dust samples (250 ml) and 5 birds (analysed for antimicrobial substances)	5 pairs of boot swabs (analysed as two pools), 2 dust samples (250 ml) and 5 birds (analysed for antimicrobial substances)

a) Sampling requirements set out by Regulation (EC) No 200/2010.
b) Samples collected by the food business operator.
c) Sampling requirements set out by Danish Order no. 782 of 02/06/2020.
d) Samples collected by the Danish Veterinary and Food Administration.
e) Sampling requirements set out by Danish Order no. 782 of 02/06/2020.
f) If samples are negative, sampling is repeated 14 days later.

Source: Danish Veterinary and Food Administration

Table A29. Salmonella *and* Campylobacter *surveillance programme for the broiler flocks, 2022*

Time	Samples taken	Material
Salmonella		
15 - 21 days before slaughter[a,b,c]	Per flock	5 pairs of boot swabs. Herds up to 500 animals: the 5 samples can be pooled in to 2 pools
7 - 10 days before slaughter[d,e]	Per flock	5 pairs of boot swabs. Herds up to 500 animals: the 5 samples can be pooled in to 2 pools
After slaughter[b,d,f]	Per batch	From slaughterhouses slaughtering 1,000 chickens or hens per day or more: 300 neck skin samples of 1 gram, pooled into subsamples of 60 gram from one batch per week. From slaughterhouses slaughtering less than 1,000 chickens or hens per day: 15 neck skin samples of approx. 10 gram pooled into 5 subsamples of 25 gram from one batch every fifth day of slaughter
Campylobacter		
After slaughter[b,d]	Per flock	12 cloacal swabs from 24 animals, analysed in one pool[g,h]
After slaughter[b,f]	Per batch	From slaughterhouses slaughtering 1,000,000 chickens or more per year: 15 neck skin samples of approx. 10 gram, pooled into five subsamples of 25 gram from one batch per week. From slaughterhouses slaughtering less than 1,000,000 chickens per year and more than 10,000: 15 neck skin samples of approx. 10 gram pooled into 5 subsamples of 25 gram from one batch every tenth day of slaughter

a) Sampling requirements set out by Regulation (EC) 200/2012.
b) Samples collected by the food business operator.
c) Once a year, one pair of socks is collected by the Danish Veterinary and Food Administration.
d) Sampling requirements set out by Danish Order no. 1819 of 02/12/2020.
e) Samples are collected by a representative of the slaughterhouse, laboratory or the Danish Veterinary and Food Administration.
f) Sampling requirements set out by Regulation (EC) 2073/2005.
g) For flocks to be slaughtered outside Denmark, 1 pair of boot swabs is collected by the owner 10 days before slaughter at the latest.
h) If the flock is slaughtered over several days, the last batch is sampled.

Source: Danish Veterinary and Food Administration

Table A30. Salmonella *surveillance programme for the pullet-rearing, table egg layer and barnyard/hobby flocks in the table egg production, 2022*

Time	Samples taken	Material
Pullet-rearing		
Day-old[a,b]	Per delivery	5 transport crates from one delivery: Crate liner (> 1 m² in total) or swab samples (> 1 m² in total) (Analysed as one pool)
4, 8 and 10 weeks old and 1 week before moving[a,b]	Per flock	5 pairs of boot swabs (analysed as two pools) or 5 faecal samples of 60 gram
2 weeks before moving[a,c]	Per flock	5 pairs of boot swabs (analysed as two pooled samples) or 5 faecal samples of 60 gram.
Table egg layers (Production for certified packing stations)		
24 weeks old[a,c]	Per flock	2 pairs of boot swabs (analysed as one pool) or 1 faecal sample consisting of 2x150 g. 250 ml (100 g) dust or a dust sample by a cloth of min. 900 cm²
Every 2 weeks from age 20 weeks[a,b,d,]	Per flock	2 pairs of boot swabs (analysed as one pool) or 1 faecal sample consisting of 2x150 g.
After positive serological findings[c]	Per flock	5 pairs of boot swabs (analysed as two pools) or 5 faecal samples consisting of 60 gram each
After positive findings of other serotypes than *S.* Enteritidis, *S.* Hadar, *S.* Infantis, *S.* Virchow or *S.* Typhimurium including the monophasic variant *S.* 1,4,[5],12:i:-[c]	Per flock	5 pairs of boot swabs (analysed as two pool) or 5 faecal samples consisting of 60 gram each, 2 dust samples (250 ml) and 5 birds (analysed for antimicrobial substances)[g]
Barnyard and hobby flocks[e]		
Every 9 weeks[a,b,f]	Per flock	2 pairs of boot swabs (analysed as one pooled sample) or 2 faeces samples consisting of 60 gram each (analysed as one pooled sample).

a) Sampling requirements set out by Danish Order no. 499 of 23/03/2021.
b) Samples collected by the food business operator.
c) Samples collected by the Danish Veterinary and Food Administration.
d) According to Regulation (EC) 2160/2003 sample collection must be carried out every 15 weeks as a minimum.
e) Voluntary for hobby flocks.
f) For flocks with 30 birds or less: No testing if only delivered to a well-known circle of users, who are informed about the fact that no *Salmonella* control was performed.
g) If samples are negative, sampling is repeated 14 days later.

Source: Danish Veterinary and Food Administration

Table A31. Salmonella *surveillance programme for the turkey flocks, 2022*

Time	Samples taken	Material
Turkey production		
Max. 21 days before slaughter[a,b]	Per flock	2 pairs of boot swabs. Analysed individually

a) Sampling requirements set out by Regulation (EC) 1190/2012 and Danish Order no. 1819 of 02/12/2020.
b) Samples collected by the food business operator or the local food control offices.

Source: Danish Veterinary and Food Administration

Table A32. Salmonella *surveillance programme[a] for the cattle production, 2022*

No. of samples	Samples taken	Purpose/Comment
Milk producing herds		
4 samples distributed over 18 maximum months	Bulk tank samples	Calculation of herd level[b]
Non-milk producing herds		
1 sample every 3 months at slaughter[c]	Blood samples	Calculation of herd level[b]
Sampling once or twice a year in heifer herds on rearing farms, depending on whether the heifers originate from a single or several dairy herds	Blood samples	Calculation of herd level[b,d]
Beef carcases at the slaughterhouse		
5 samples daily, pooled into one analysis	Swab samples from 4 designated areas after 12 hours chilling (4x100cm^2)	Slaughterhouses slaughtering 7.500 or more cattle per year
5 samples every second month, analysed individually	Swab samples from 4 designated areas after 12 hours chilling (4x100cm^2)	Slaughterhouses slaughtering 2.500 or more and less than 7.500 cattle per year
5 samples every 6th month, analysed individually	Swab samples from 4 designated areas after 12 hours chilling (4x100cm^2)	Slaughterhouses slaughtering 250 or more and less than 2.500 cattle per year
No sampling		Slaughterhouses slaughtering less than 250 cattle per year

a) Danish Order no. 2416 of 14/12/2021. It is compulsory to have an action plan to eradicate *Salmonella* Dublin in Level 2 herds. Before the 1.st of Juli 2021, the Order no. 1791 of 02/12/2020 var applicable, in which sampling of heifer herds was not mandatory.
b) Herd levels based on serological testing (blood and milk):
      Level 1: Herd assumed free of infection based on bulk milk samples (milk producing herd) or blood samples (non-milk producing herd).
      Level 2: Herd not assumed free of infection.
c) No samples are taken, if the herd has been tested for *S.* Dublin within the last 3 months.
d) The number of samples from heifers depend on herd size.

Source: Danish Veterinary and Food Administration and SEGES

Table A33. Salmonella *surveillance programme^a for the pig production, 2022*

Time	Samples taken	Purpose/Comment
Breeding and multiplier herds		
Every month	10 blood samples per epidemiological unit	Calculation of *Salmonella*-index based on the mean seroreaction from the last three months with more weight to the results from the more recent months (1:3:6)[b]
Max. twice per year	Herds with *Salmonella*-index 5 or above: Pen-faecal samples	Clarify distribution and type of infection in the herd[c]
Sow herds		
When purchaser of piglets is assigned to level 2 or 3, max. twice per year	Pen-faecal samples	Clarify distribution and type of infection in the herd, and possible transmission from sow herds to slaughter pig herds
Herds positive with *S.* Typhimurium, *S.* Infantis, *S.* Derby and *S.* Choleraesuis are considered positive for the following 5 years[d]	No samples are collected from the herd during the 5-year period when the herd is considered positive, unless the herd is proven negative	Reduce repeated sampling in positive herds infected with a persistent serotype
Slaughter pigs, herds		
At slaughter	Meat juice, 60-100 samples per herd per year. Herds in RBOV [e]: one meat juice sample per month	Calculation of slaughter pig index based on the mean proportion of positive samples from the last three months with most weight to the result from the most recent month (1:1:3). Assigning herds to level 1-3 and assigning herds to risk-based surveillance (RBOV)[e]
Slaughter pigs, animals		
At slaughter	Caecum samples, avg. 25 samples per month, 12 months per year	Random collection of samples for monitoring of the distribution of serotypes and antimicrobial resistance.
Pork carcases at the slaughterhouse		
5 samples daily, pooled into one analysis[f]	Swab samples from 4 designated areas after 12 hours chilling (4x100cm²)	Slaughterhouses slaughtering more than 30.000 pigs per year
5 samples every second month	Swab samples from 4 designated areas after 12 hours chilling (4x100cm²)	Slaughterhouses slaughtering 10.000 or more pigs and less than 30.000 pigs per year
10 samples per year, 5 each 6 month	Swab samples from 4 designated areas after 12 hours chilling (4x100cm²)	Slaughterhouses slaughtering 1.000 or more pigs and less than 10.000 pigs per year
No sampling		Slaughterhouses slaughtering less than 1000 pigs per year

a) Sampling requirements set out by Danish Order no. 1079 of 01/06/2021.
b) Herds with index above 10 have to pay a penalty for each pig sold.
c) The herd owner must inform buyers of breeding animals about the type of *Salmonella*.
d) These serotypes are primarily spread by live trade and are known to persist in herds. *S.* Typhimurium includes the monophasic variant *S.* 1,4,[5],12:i:-.
e) RBOV: risk-based surveillance in herds with a slaughter pig index of zero (no positive samples in the previous three months) the sample size is reduced to one sample per month.
f) f a slaughterhouse, within the last month, finds a sample positive for *Salmonella* and at the same time has a *Salmonella* prevalence above or equal to 2% (12month average), the sampling frequency doubles to 10 samples daily, pooled into two analyses with 5 samples in each.

Source: Danish Veterinary and Food Administration

Table A34. Typing methods used in the surveillance of foodborne pathogens in Denmark, 2022

Methods	Human	Food	Animal
Salmonella enterica			
Serotyping	All isolates (mainly WGS)	All isolates (by WGS)[a]	All isolates (by WGS)
Antimicrobial resistance testing	All *Salmonella* except *S.* Enteritidis	Almost all isolates	Isolates for DANMAP and EFSA
MLVA	In relation to International outbreak	None	None
WGS	All isolates	All isolates[a]	All isolates
Campylobacter coli/jejuni			
Antimicrobial resistance testing	Isolates from 4 districts for DANMAP surveillance	Isolates for DANMAP and EFSA	Isolates for DANMAP and EFSA
WGS	Subset representing 10-15% of isolates	Few (isolates from chilled chicken meat)[a]	None
STEC			
Serotyping	All isolates (mainly WGS)	All isolates (by PCR & WGS)	All O157 isolates
Virulence profile	All isolates (mainly WGS)	All isolates (by PCR & WGS)	All O157 isolates
WGS	All isolates	All isolates[b]	None
Listeria			
WGS	All isolates	Selected isolates (ST typing and outbreak investigations)	None
Yersinia enterocolitica			
Serotyping	All pathogenic isolates sent to SSI	None	None
WGS	Outbreaks investigations, research	None	None

a) Other commercial laboratories have been used for some centrally coordinated studies. Alternative methods (not listed here) may have been used for these samples.
b) No STEC isolates were isolated from food in 2022.

Source: Statens Serum Institut and the Laboratory of the Danish Veterinary and Food Administration

Population and slaughter data

Table A35. Human population, 2022

Age groups (years)	Males	Females	Total
0-4	160,600	152,121	312,721
5-14	327,475	310,613	638,088
15-24	366,562	351,972	718,534
25-44	752,503	731,910	1,484,413
45-64	774,610	776,582	1,551,192
65+	556,171	649,458	1,205,629
Total	2,937,921	2,972,656	5,910,577

Source: Statistics Denmark, 1 July 2022

Table A36. Number of livestock establishments, livestock and animals slaughtered, 2022

	No. of establishments	Livestock (capacity)	Number slaughtered
Slaughter pigs	7,133	13,565,113	17,854,036
Cattle	14,888	1,486,686	493,300
Broilers	275	20,687,700	101,974,900
Layers (excl. barnyard)	201	4,761,200	-
Turkeys	46	360,467	4,400
Sheep & lambs	5,916	129,742	-
Goats	3,102	18,255	-
Horses	-	-	507

Source: Statistics Denmark and Danish Veterinary and Food Administration - the Central Husbandry Register, May 2022

Table A37. Number of establishments, flocks and livestock capacity in the broiler production, 2022

	No. of establishments	No. of flocks	Livestock (capacity)
Rearing period (grandparent)	2	10	50,000
Adult period (grandparent)	4	13	93,500
Rearing period (parent)	20	90	762,300
Adult period (parent)	48	139	1,115,600
Hatcheries	5	0	0
Broilers	275	687	20,687,700

Source: Danish Veterinary and Food Administration, as per 31 December 2022

Table A38 Number of establishments, flocks and livestock capacity in the table egg production, 2022

	No. of establishments	No. of flocks	Livestock (capacity)
Rearing period (grandparent)	1	1	17,500
Adult period (grandparent)	5	7	75,000
Rearing period (parent)	2	2	13,500
Adult period (parent)	8	9	73,400
Hatcheries	7	0	0
Pullet-rearing	34	58	1,437,500
Layers (excl. barnyard)	201	263	4,761,200

Source: Danish Veterinary and Food Administration, as per 31 December 2022

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