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Annual Report on Zoonoses in Denmark 2023

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Annual Report on Zoonoses in Denmark 2023

Edited by:
Brian Lassen
National Food Institute
Technical University of Denmark

Luise Müller
Statens Serum Institut

Channie Kahl Petersen, Gudrun Sandø
The Danish Veterinary and Food Administration

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National Food Institute
Technical University of Denmark
Henrik Dams Allé
Building 204
DK - 2800 Kgs. Lyngby
Denmark
Phone: +45 35 88 64 20
E-mail: vdha@food.dtu.dk

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Contents

Introduction

Starting in 1994, this year marks the 30th anniversary of the report of Annual Report of Zoonoses in Denmark 2023 and the collaboration between institutions in Denmark on reporting important information on zoonoses to the public. The collaboration continues to grow and evolve - the latest being the KOZO partnership investigating non-food-borne zoonotic outbreaks.

Campylobacter continues to be the most common bacterial foodborne illness, with 5,186 cases in 2023 in Denmark. The number of *Salmonella* cases continued to increase for the forth year in a row, to 1,207 cases in 2023. For both illnesses, the number of cases seems to move towards the same levels as observed before the Covid-19-epidemic in 2020-2021. The numbers of Shiga-Toxin producing *Escherichia coli* (STEC) cases increased from 1,330 in 2022 to 1,431 cases in 2023. This increase can be explained by a change in diagnostics.

Food and waterborne outbreaks

In total, 64 foodborne outbreaks with 1,760 patients were reported in 2023. The number of foodborne outbreaks is on the same level as in 2022, where 63 outbreaks were registered.

Norovirus (NoV) was the leading cause of foodborne outbreaks in Denmark, causing 13 outbreaks and affecting a total of 462 persons. The most common way of acquiring NoV infection was through exposure to symptomatic or healthy carriers among kitchen staff. A total of 363 persons were affected by an unknown pathogen linked to pulled pork.

Salmonella spp. caused 18 outbreaks in Denmark in 2023, with six of them being part of international outbreaks. The largest international outbreak was with *Salmonella* Enteritidis sequence type 11, where more than 200 cases were reported in 13 countries. The investigations are further described in Chapter 7.

Eleven *Campylobacter* outbreaks were reported in 2023 as in 2022, and as in 2021 sequence type ST52 was the most frequent cause. Four outbreaks of listeriosis were also reported in Denmark in 2023, but the source was not identified.

KOZO - the coordination group for zoonotic threats in Denmark

The Danish national coordination group "KOZO" was established in 2022 to address zoonotic threats. KOZO facilitates cross-sector collaboration among authorities to prepare for, assess, and manage zoonotic outbreaks. Unlike the Central Outbreak Management Group which focuses on foodborne outbreaks, KOZO covers non-food borne zoonotic diseases such as animal influenza and tickborne encephalitis. The core group includes experts from human-, animal-, wildlife-health, and the surrounding environment. Regular meetings ensure effective communication and coordination across sectors, making KOZO an essential One Health forum.

Applied AI in food safety related to *Listeria monocytogenes*

Whole genome sequencing (WGS) is a powerful tool for characterizing pathogens, especially in food safety control. It's widely used for surveillance of foodborne pathogens and outbreak investigations. Countries like Denmark, France, and the United Kingdom have adopted WGS, replacing older methods. WGS, combined with machine learning, can help predict outcomes like virulence potential and disinfectant resistance. Despite its potential, adoption in the food industry remains limited. Current practices rely on conventional microbiological methods, which lack resolution to differentiate between strains. WGS technology can address these limitations and enhance food safety.

WGS is gradually replacing routine microbiological methods in the food industry. It enables faster and more precise pathogen identification. WGS generates extensive sequencing data, providing valuable insights into microorganisms. Experts can predict bacterial features like antibiotic resistance and virulence using genetic elements. *Listeria monocytogenes*, a common pathogen in food, challenges quality assurance systems. The chapter describes a new machine learning tool that is called ListPred look to predict the virulence potential and disinfectant tolerance, aiding risk assessment and food safety.

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 2023. 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.

Vector borne zoonoses

In 2023, Denmark experienced a cool season for vectors, yet an average number of mosquito genera were present. The recently discovered West Nile fever mosquito, *Culex modestus*, that can feed on both birds and mammals, is raising concerns about its potential to transmit West Nile Virus (WNV) and Usutu virus. Despite testing negative for these viruses, Cx. is a vector of importance. Additionally modestus, a model predicted the correlation of tick activity patterns with Lyme neuroborreliosis (LNB) incidence. Tick-borne encephalitis (TBE) cases have also increased in Denmark, with TBEV detected in ticks from Tisvilde Hegn. The virus's spread may be linked to migratory birds and deer.

In 2023, no exotic mosquitoes were recorded in Denmark. However, a Hyalomma tick, also known as the hunting tick, was found on a horse near Ringsted. These ticks, typically found in North Africa, Asia, and parts of Europe, can potentially carry the Crimean-Congo Hemorrhagic Fever virus. Despite Denmark's climate not favoring their survival, adult Hyalomma ticks emerged due to warmer springs and summers. Additionally, the *Dermacentor reticulatus*, or meadow tick, is expanding northward in Germany and has been observed in Denmark. Dogs in Denmark are diagnosed with severe *Babesia canis* infections transmitted by *D. reticulatus* ticks.

Denmark has amended its Executive Order on Notification of Infectious Diseases

Denmark has expanded the legal scope for using laboratory data in national infectious disease surveillance. The amended Executive Order on Notification of Infectious Diseases allows comprehensive monitoring, aiding disease control efforts. Clinicians report diseases through an electronic system, and microorganisms are monitored in laboratories. The Health Act designates Statens Serum Institut (SSI) as the data owner for the Danish Microbiology Database (MiBa), enabling better surveillance, including antimicrobial resistance monitoring. The Personal Identification Number (CPR) facilitates linking laboratory and epidemiological data. Over 90 microorganisms require reporting, with 40 necessitating individual clinician reports.

Increase in human infection of *Salmonella* Enteritidis

Salmonella Enteritidis is the most prevalent serotype in Denmark, accounting for about a third of human cases. Poultry and egg products are common sources. The number of cases were quite stable from 2014-2019. In 2020-2021 the number of cases decreased due to the Covid-19 pandemic, where travel-restrictions were implemented. In 2023, there were 384 registered cases, with domestic infections accounting for 48%. Whole genome sequencing identified 10 outbreaks, including one linked to pre-fried chicken kebab imported from Poland.

Denmark's *Salmonella* control programme, in place since 1988 for broiler production and 1996 for table egg production, ensures *Salmonella*-free chicken meat and eggs. In 2023 two poultry flocks were positive with *Salmonella* Enteritidis (one free range layer flock and one organic broiler flock). The eggs from the positive flock were sent to heat treatment and the broilers were culled. EU regulations have led to reduced *Salmonella* contamination in the EU. Denmark's stricter programme achieved special guarantees for table eggs (2012) and chicken meat (2018). Imported chicken meat and table eggs must be tested negative for *Salmonella*.

1. Food- and waterborne outbreaks

By the Central Outbreak Management Group

Food- and waterborne outbreaks in Denmark are reported in the Food-and waterborne Outbreak Database (FUD). Appendix Table A3 lists the outbreaks that occurred in 2023. Household outbreaks and clusters not verified as common source foodborne outbreaks are excluded. Outbreak investigation procedures in Denmark are described in Chapter 5.

In 2023, 64 foodborne outbreaks were reported in FUD (Figure 1.1, Table A3) and the total number of persons affected by foodborne outbreaks was 1,760 with an average of 28 persons per outbreak (range 2-323). Of the 64 outbreaks, 30 were local/regional and 34 were national outbreaks, of which six were part of international outbreaks. The number of foodborne outbreaks in 2023 is on the same level as in 2022, where 63 outbreaks were registered [1]. The number of foodborne outbreaks reported in Denmark by pathogens in the last five years from 2019 to 2023 is illustrated in Figure 1.2.

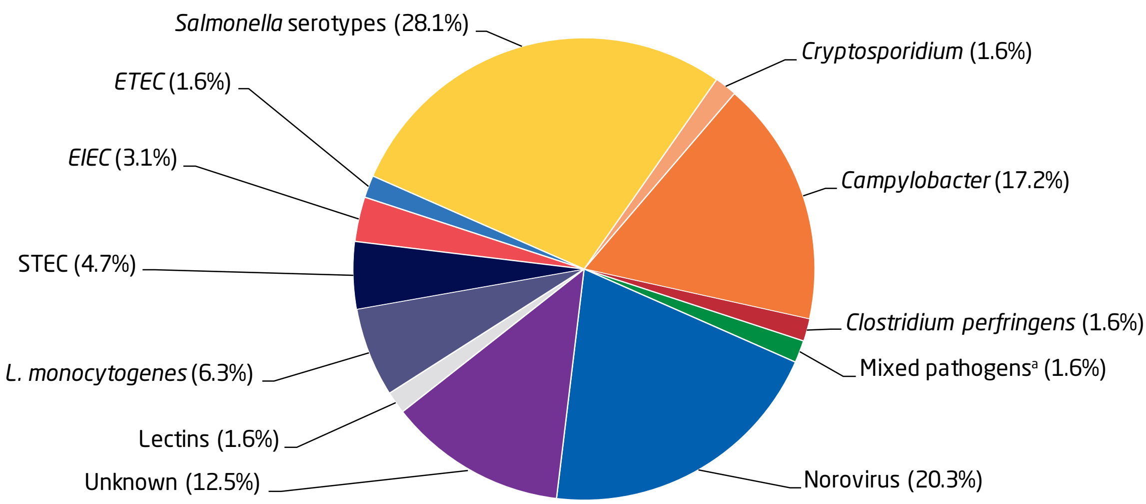
1.1 Norovirus outbreaks

Norovirus (NoV) accounted for 13 foodborne outbreaks in 2023, which was at the same level as 2022 where 14 outbreaks were registered. The majority of outbreaks (eight outbreaks and 320 affected persons) were related to ill kitchen staff or a healthy carrier of virus among the kitchen staff primarily in canteens or other catering settings (see Table 1.1 and Table A3). Five outbreaks resulting in 142 ill persons were related to the consumption of imported raw oysters served in restaurants.

1.2 *Salmonella* outbreaks

In 2023, there was an increase of outbreaks caused by *Salmonella* from 11 outbreaks in 2022 to 18 outbreaks in 2023. This increase was primarily caused by *Salmonella* Enteritidis, accounting for eight outbreaks in 2023 compared to 0-2 outbreaks of *Salmonella* Enteritidis per year

Figure 1.1 Aetiology of the 64 foodborne disease outbreaks reported with a causative agent in the Food- and waterborne Outbreak Database (FUD), 2023. Percentage of total outbreaks indicated in brackets



a) One outbreak with *Clostrdium perfringens* and *Bacillus cereus*

Source: Food- and waterborne Outbreak Database (FUD)

from 2018-2022. The increase followed a general trend in Europe in 2023 and at least three of the outbreaks were part of international outbreaks. Trends and outbreaks of *Salmonella* Enteritidis in 2023 are described in detail in Chapter 7. The ten other *Salmonella* outbreaks were caused by nine different serotypes (two were *Salmonella* Typhimurium).

The largest *Salmonella* outbreak in 2023, with 31 registered cases, was due to *Salmonella* Muenchen sequence type (ST) 82 (FUD2211), which was the first outbreak of this serotype registered since 2019. Cases were identified in two periods; The majority became ill between 19 March and 15 April 2023, and the others became ill between 14 - 31 May 2023. Interviews with 27 cases or relatives revealed that the outbreak was not due to travelling or any common event and was not related to a specific place. Despite further investigation with comparison of consumer purchase data, follow-up on menus and places of eating out and trace back of products, the source was not determined. The outbreak eventually stopped.

1.3 *Campylobacter* outbreaks

The number of registered *Campylobacter* outbreaks in 2023 was 11, which was the same level as in 2022 where 11 outbreaks were also registered. All outbreaks were national outbreaks caused by *Campylobacter jejuni*. For eight outbreaks, the source was identified as chicken meat, primarily based on a whole genome sequencing (WGS) match between human samples and food isolates – one of which was from imported chicken. A long-lasting outbreak in 2021 and 2022 caused by *C. jejuni* ST52 (FUD1974) related to Danish chicken further continued with 21 cases in 2023, making the total count 89 cases despite the multiple preventive efforts to reduce transmission of *Campylobacter* in chicken farms and slaughterhouses.

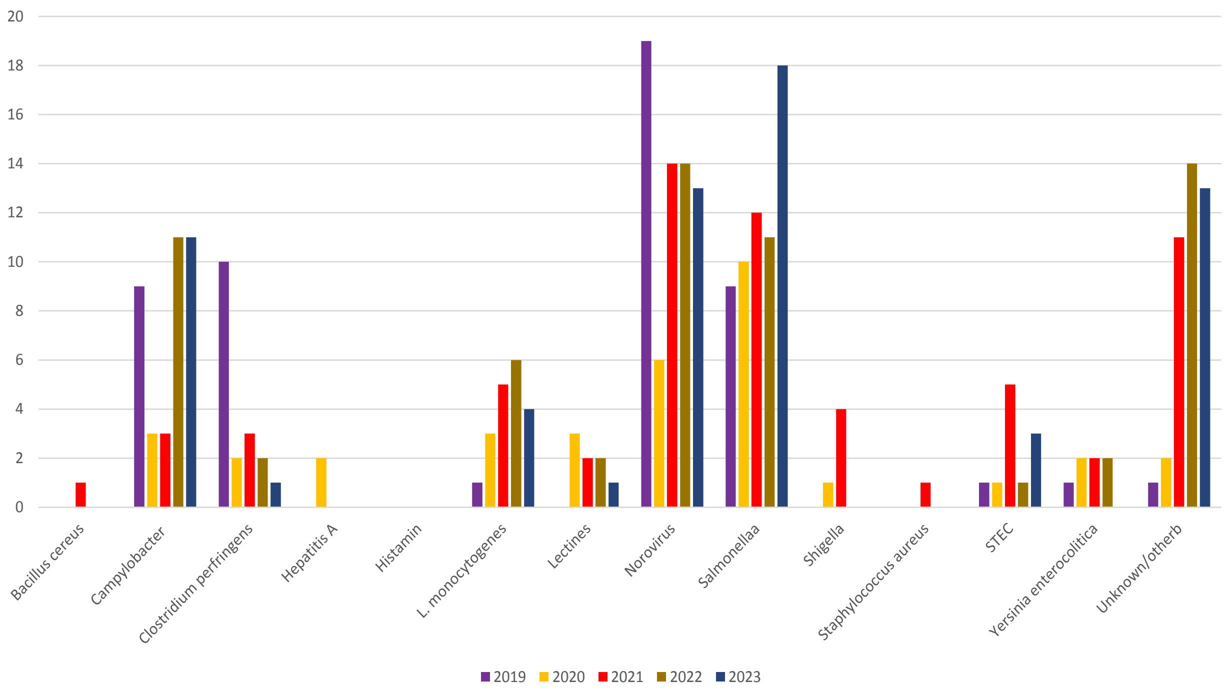
1.4 Other outbreaks of interest

In 2023, four small clusters of *Listeria monocytogenes* were registered with 2-4 cases. The sources were not revealed for these. An ongoing outbreak due to *L. monocytogenes* ST1607 that started in 2019 continued in 2023, where additionally seven cases were registered making the total count to 15 cases (FUD1969/FUD2262). The outbreak strain has been found in a salmon product and a sample taken from the environment of a Danish fish producer. Since *Listeria* is known to persist in production environments for years – there is a suspicion that the source could be related to the same fish producer throughout the period – however, the investigation is (by April 2024) still ongoing to determine if this is the case. A severe outbreak of shiga-toxin-producing *Escherichia* coli O157 (FUD2261) called for an intensive investigation in 2023 – this outbreak is described in the box.

1.5 References

1. Anonymous 2024. Annual Report on Zoonoses in Denmark 2023. National Food Institute, Technical University of Denmark.

Figure 1.2. Number of foodborne outbreaks by pathogen reported in Denmark, 2019-2023



a) Note for *Salmonella* that travel-related outbreaks were not included from 2019 onwards
b) 8 unknown, 1 *Cryptosporidium*, 1 ETEC, 2 EIEC, 1 *Clostridium perfringens* & *Bacillus cereus*
Source: Food- and waterborne Outbreak Database (FUD)

Table 1.1. Norovirus outbreaks per route of transmission based on number of cases or number of outbreaks, 2021-2023

	2023		2022		2021	
Transmission route/source	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	320	8	367	9	307
Kitchen staff tending to ill persons at home before entering the kitchen	0	0	0	0	3	116
Ill persons/guests attending a buffet	0	0	0	0	0	0
Seafood (oysters)	5	142	4	126	0	0
Unknown route of transmission	0	0	2	121	2	70
Total	13	462	14	614	14	493

Source: Food- and waterborne Outbreak Database (FUD)

By the Central Outbreak Management Group

In September 2023, Statens Serum Institut was notified about an adult patient hospitalised with haemolytic uremic syndrome (HUS) and positive for shiga-toxin-producing *Escherichia coli* (STEC) (FUD2261). Eventually, the sample from the patient turned out to be genetically related to samples from four other patients in August and September 2023 and an outbreak investigation was initiated to find the source and stop the outbreak. The outbreak strain was O157:H7, sequence type 11 and positive for shiga-toxin subtype Stx2a.

The five cases were four 2-35 year-old males. The cases were geographically spread throughout Denmark.. Four had been hospitalized and one developed HUS. Interviews with the patients or relatives pointed towards boeuf onglet bought in the same supermarket chain. The product was further traced through the patients' receipts, and the Danish Veterinary and Food Administration (DVFA) traced the product back to a Danish producer. During control visits at the producer, it was identified that the meat had been brine-cured allowing bacteria from the surface of the meat to penetrate into the centre of the meat. None of the cases had cooked the meat thoroughly and thus the bacteria could then survive and cause illness when consumed. At the time of identification of the source, the product was no longer on the market. However, the DVFA, together with the producer, identified some control measures to ensure that contamination of the meat should not happen in the future.

2. KOZO - the coordination group for zoonotic threats in Denmark

By Lasse S. Vestergaard (lav@ssi.dk), Pikka Jokelainen, Gideon Ertner, Kamilla Grønborg Laut, Anne Hempel-Jørgensen, Tim Volmer Jensen, Nuno Moth-Lund, Peter Lyhne Højberg, Anette Ella Boklund, Lars Erik Larsen, Sten Mortensen, Johanne Ellis-Iversen (johel@fvst.dk).

Building on some of the experiences and lessons learned from the COVID-19 pandemic, a national coordination group to address zoonotic threats, known as "KOZO" (Myndigheds-gruppen til KOordinering af ZOonoser), was established in 2022 among Danish authorities and institutions. The purpose of KOZO is to support cross-sector collaboration between authorities in preparedness, assessment and management of zoonotic threats and outbreaks. KOZO was built on the experiences from the long-running national cross-sector collaboration group to manage foodborne outbreaks. KOZO´s remit is different, coordinating the cross-sector work on all non-food borne zoonotic emerging diseases and threats, such as animal influenza, tickborne encephalitis and Mpox - only to mention a few.

The KOZO core group covers expertise from the fields of human health, animal health, wildlife health, and the environment. The group has permanent representatives from public health, animal health and environment authorities: Danish Veterinary and Food Administration (DVFA), Statens Serum Insitut (SSI), Danish Health Authority (SST), Danish Patient Safety Authority (STPS), Environmental Protection Agency (MST), and experts from University of Copenhagen. The group is chaired by DVFA and meets monthly to discuss new and emerging signals of zoonotic threats, current outbreak management, risk assessments, mitigation measures, and internal and external communication, including coordination of press releases (Figure 2.1). In addition, ad-hoc meetings are organized as need arise. Additional experts and institutional representatives are often invited to provide technical and epidemiological updates and discuss on specific topics, e.g. related to specific pathogens, diseases, vectors or host species. Open technical workshops and seminars are also organized every 3-6 months.

A KOZO steering committee involving members from all the institutions at the director-level meets every six months to discuss overall and strategic matters.

Each of the partners in KOZO have different roles and responsibilities in situations where a zoonotic threat needs to be assessed and managed in Denmark. Being a coordinating forum, KOZO ensures that all stakeholders has access to updated information and views from across all sectors, and thus can form a common understanding of the situation and coordinate an effective overall response.

KOZO is an example of a One Health forum that builds on regular contact and mutual sharing of information across sectors. The forum has proven useful in situations where zoonotic threats emerge, and when information may still be scarce. The core group members and their respective institutions continuously receive signals and information on new zoonotic threats via various formal and informal communication structures and networks. By sharing these pieces of information in KOZO, a common overview and understanding of the situation can be rapidly formed as a common scientific basis for informal discussions and initial risk assessments, facilitating coherent advice and recommendations across the sectors.

Figure 2.1. Activities of the KOZO (Myndighedsgruppen til KOordinering af ZOonoser) group

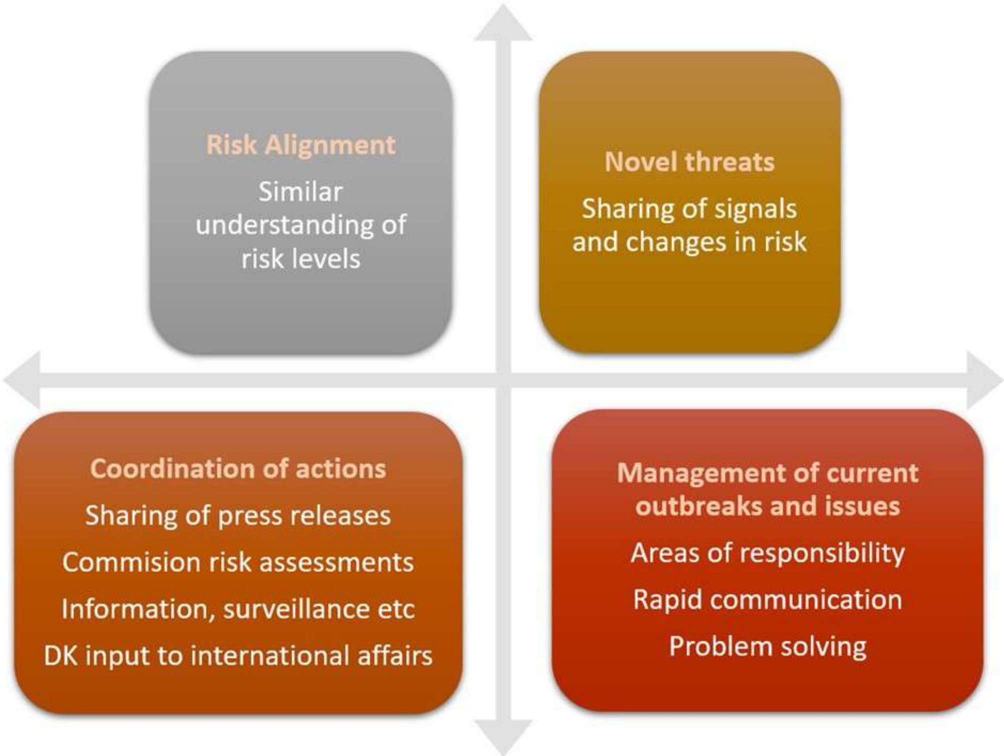


Figure 2.2. Partner logos in the KOZO (Myndighedsgruppen til KOordinering af ZOonoser) group

3. Applied artificial intelligence in food safety related to *Listeria monocytogenes*

By Pimlapas Leekitcharoenphon (pile@food.dtu.dk), Alexander Gmeiner, Mirena Ivanova, Rolf Sommer Kaas, Patrick Murigu Kamau Njage, Lisbeth Truelstrup Hansen

3.1 Bacterial genomic data and artificial intelligence

The advantage of omics-technology, such as whole genome sequencing (WGS), provides an ideal tool for rapid, reproducible, and highly discriminatory characterization of pathogens and is useful in risk-based decision making. The most prominent use of WGS methodologies in a food safety context currently is the surveillance of foodborne pathogens and the detection and investigation of related outbreaks. In many countries, WGS has already been introduced as a potential new standard for foodborne pathogen surveillance. The technology is replacing genotypic routine methods, such as Pulsed-Field Gel Electrophoresis (PFGE) and Multiple-Locus VAriable tandem-repeat analysis (MLVA typing). The shift of foodborne pathogen surveillance towards WGS comes with the implementation of centralized data networks that combine sequencing and metadata from public health, food industry, and environmental isolates in a One Health approach. Examples of such networks, are GenomeTrakr [1]. Other governmental surveillance programs are implemented in Denmark, France, and the United Kingdom [2–4]. Currently, applications of WGS methodologies in the food industry are still limited. Tracking the contamination source of food matrices in production environment is one of the many applications of the WGS. However, such applications are case-specific rather than a routine practice.

Artificial intelligence (AI) applications are increasingly becoming more popular and contribute to broader awareness of AI in the general public, for example through the use of ChatGPT. A complex AI like ChatGPT feeding large amounts of text data and fine-tune it on a specific tasks, such as conversational response generation. The model behind the ChatGPT generates contextually relevant responses based on the patterns and relationships it has learned from the training. One of the branches of AI is machine learning (ML), that uses algorithms and statistical models to analyse and learn patterns from data [5]. This can be text, images, as well as bacterial genomic data. The ML can learn relationships between input data (genomic data) and outcome variables (Figure 3.1) by using the pattern learnt from the genomic data to predict the outcome, for instance virulence potential and resistance to a disinfectant.

The combined application of sequencing approaches and ML techniques has already influenced and transformed many industries (e.g., biotechnology, agriculture, and pharmacology). The application of AI and ML in the food industry for the purpose of enhancing the food safety, appears to be developing at a slower pace, despite evidence of the possibilities and associated benefits. This chapter shows our current research outcome from applying machine learning using bacterial genomes to characterize virulence potential and resistance to disinfectants against *Listeria monocytogenes*, which is one of the most problematic foodborne pathogens to eradicate in the food industry [6].

3.2 Why WGS technology and AI?

Currently, food companies are relying on conventional microbiological methods to manage food safety at their sites. This has been the most commonly used for the past decades. These standarised methods enables the food industry to detect and identify potential pathogenic bacteria in the environment and food products. Identification of pathogenic bacteria is crucial, as different measures and actions will be taken when either *L. monocytogenes*, *Salmonella*, etc. are detected, mostly at genus but also at species level. An increasing number of studies in microbiology have demonstrated the diversity of bacterial strains and their virulence and stress tolerance potential, bacterial damage repair mechanisms. These abilities could affect the recognition of the level of risk the pathogen reperesent level and the decision for consequent actions. However, the identification techniques used today are time-consuming, and more importantly lack the resolution to differentiate between strains of the same species. These limitations can be resolved by using the WGS technology. With the extreme and continuous drop in costs of DNA sequencing, including the convenience and turnaround time for sequencing an entire bacterial genome with long-read sequencing, analytical microbiology has entered a new era - the era of genomes. New section from it is clear that the food industry is continuously working to reduce and remove foodborne pathogens and spoilage bacteria in order to successfully ensure their food products safety and quality, need to harness and understand the potentials of WGS technology. In this decade, WGS will gradually substitute routine

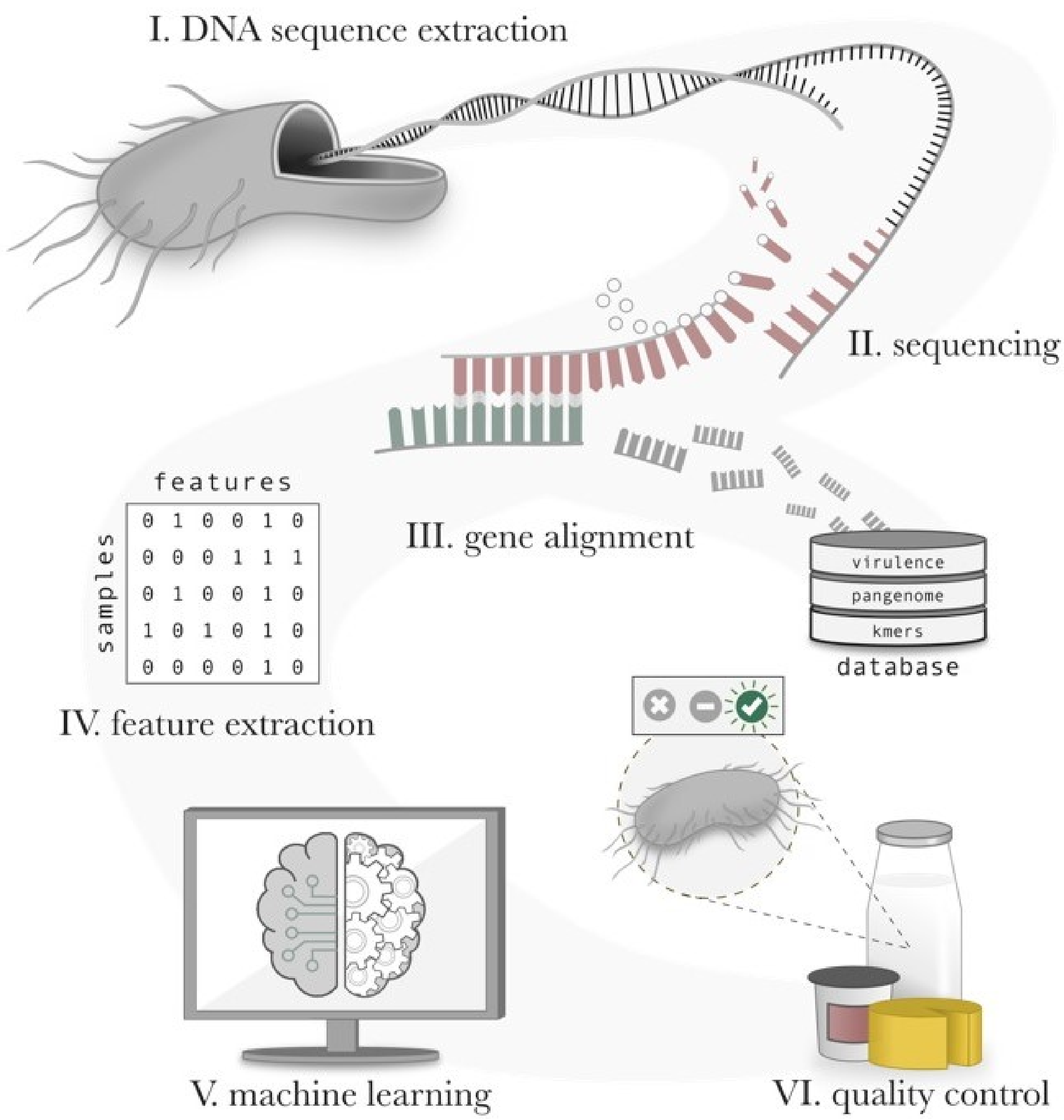


Figure 3.1. A concept of applying whole genome sequence data and machine learning in food safety

microbiological methods and become the core methodology in the routine testing and troubleshooting. This development will result in faster and more precise identification of pathogens than the food industry has seen before. In addition to this, it will generate massive amounts of sequencing data that represents a treasure box of extra information about the microorganisms. Today, many features of bacteria, such as resistance to antibiotics and virulence, can be predicted by their genetic elements by experts within the field. There are two major hurdles the food industry need to overcome in order to apply WGS technology in practice: the lack of specialized training in bacterial genomics and access to advanced computing facilities.

L. monocytogenes is a well-known food pathogen that represent an ongoing challenge in the current quality assurance systems in the food industry, especially dairy companies. A smart tool, for example a tool to predict the virulence level and resistance to disinfectants, is needed for frontline safety and quality assurance. A predicting tool for the resistance level to disinfectants used at dairies is highly relevant, as it directly facilitates the site to choose disinfectants depending on the specific bacterial isolate from found in the environment or food product. AI, such as machine learning, involves the development and application of computer algorithms that improve with experience. These techniques further enable the identification of the combinations of predictors that best predicts the risk outcome. This allow further refinement of risk assessment inputs from big data sets to a fewer number of predictors.

In a situation where contamination is identified, risk managers might raise a series of questions, for example, how dangerous the detected pathogen is, how to eliminate the contamination properly, and how to prevent future contamination through sanitation plans. The application of sequencing technologies in combination with ML analysis offer a great potential to answer these questions and thereby improve food safety. Additionally, the analysis and interpretation of WGS and ML results require extensive microbial, computational, and bioinformatics expertise that is usually rather limited in the food industry. Hence, to facilitate the use of WGS and ML in the food industry, there is a need for user-friendly tools that produce a clear and descriptive output.

3.3 ListPred, a machine learning tool for food safety related to *L. monocytogenes*

ListPred is a machine learning based tool that is developed for analysing WGS data of *Listeria monocytogenes*. ListPred is able to predict two important bacterial traits in *L. monocytogenes:* virulence potential and disinfectant tolerance. The tool only requires limited computational resources and practically no bioinformatic expertise, which is essential for a broad application in the food industry [7]. Basically, ListPred helps food companies to answer two essential questions: how dangerous is *Listeria monocytogenes* , and how to eradicate this foodborne pathogen most efficiently?

The pipeline of the tool combines whole genome sequencing data, ML predictions, and easy interpretable reporting. ListPred can process various inputs, namely raw read or assembled sequencing data from short- or long-read sequencing data. The prediction results are reported in tabular format and are either low, medium, or high for virulence potential and sensitive or tolerant for prediction of disinfectant resistance.

For predicting the virulence potential [8], ListPred uses WGS datasets for ML model training from national surveillance isolates (n=169) with known Clinical Frequency (ratio of the number of clinical isolates to total amount of isolates, as estimate for virulence potential) to estimate the virulence potential.

ListPred explores the prediction of disinfectant tolerance using WGS and ML by using 1,649 *L. monocytogenes* WGS samples and their respective phenotypes with tolerance to quaternary ammonium compound (QAC) disinfectants [7] in order to train different ML predictors [9]. ListPred shows promising results for predicting tolerance to QAC disinfectants with balanced accuracy scores up to 0.97±0.02.

3.4 Where to get ListPred?

ListPred is available in three variations depending on the users experience and computational prerequisites. For users that are comfortable with the execution of command line programs, look to process multiple isolates at the same time, and run the analysis offline, the source code for the ListPred Snakemake pipeline is available on GitHub (https://github.com/genomicepidemiology/ListPred/tree/master/workflow).

For users with command-line experience who are looking to process multiple isolates and want a low-effort execution, ListPred is available as Docker Image on Docker Hub (https://hub.docker.com/r/genomicepidemiology/listpred). This solution can be run offline by manually downloading the Image to a local server or online (i.e., Docker handles the download from Docker Hub and subsequent execution).

For users with limited computational experience, a point & click solution in the form of a web application is hosted by the Center for Genomic Epidemiology at National Food Institute, the Technical University of Denmark (DTU) and can be accessed by the following link (http://genepi.food.dtu.dk/listpred).

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4. Vectorborne zoonoses

By Lene Jung Kjær (lenju@sund.ku.dk), Louise Lohse, Anne Marie Michelsen, Peter H. S. Andersen and René Bødker

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 Endemic vector surveillance and research

The vector season 2023 was characterized by a relatively cool weather conditions but still resulted in an average number of all five mosquito genera present in Denmark.

The recently discovered West Nile fever mosquito, *Culex modestus*, found in Denmark, has the ability to feed on both birds and mammals. This dual capability raises concerns about its potential to efficiently transmit West Nile Virus (WNV) and Usutu virus from wild birds to humans and horses[1]. Adapted to warmer regions of Europe, this mosquito species experiences a brief season in Denmark, and in 2023, due to the cold summer, we only collected four Cx. modestus at West Amager, near the capital region of Copenhagen. All 4 mosquitoes and an additional 380 *Cx pipiens/torrentium* from four private gardens in different parts of the country tested negative for Usutu and WNV, although both viruses have been circulating in the Netherlands and Northern Germany since 2018, and despite Usutu virus being identified in a Black bird (*Turdus merula*) in Sweden in 2019.

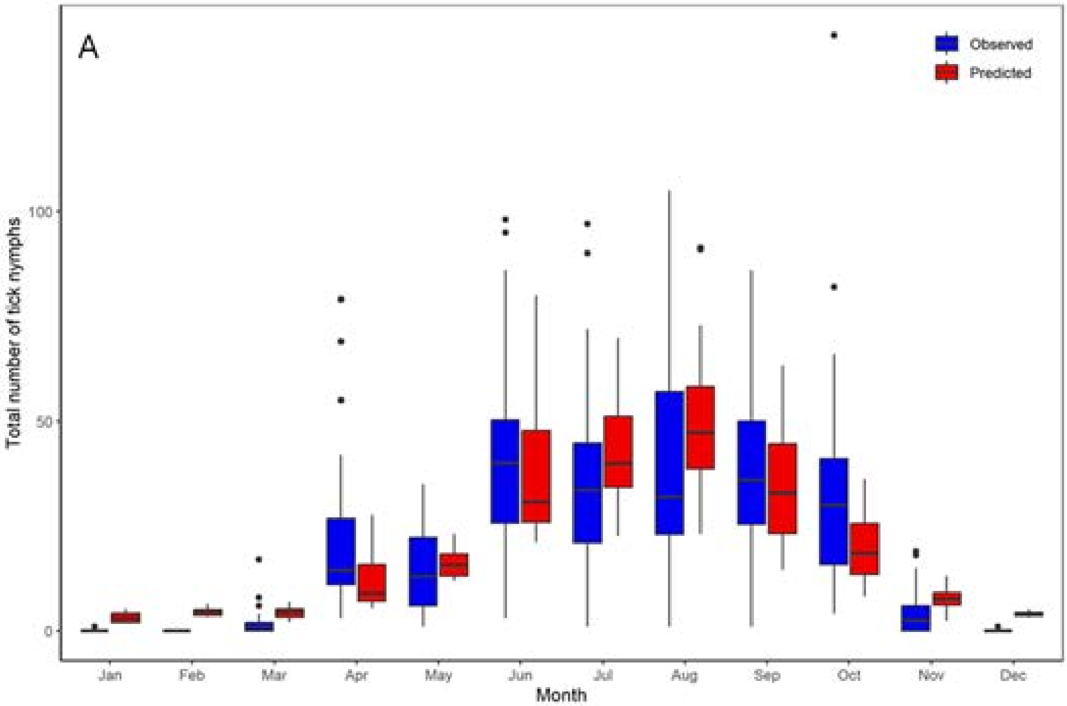
Since 2017, as a part of the ongoing endemic vector surveillance program, endemic *Ixodes ricinus* ticks (also called forest ticks or castor bean ticks) are being monitored at six forest sites in northern Zealand up to every two weeks throughout the year. During these monitoring sessions, ticks are collected from the ground vegetation for 10 minutes at each site to assess tick abundance and activity, providing a measure comparable between sites and over time. In 2023, a model was created to predict the temporal activity patterns of *I. ricinus* nymphs using meteorological data from the Danish Meteorological Institute as predictors. The predicted model outcome (and also observed data over the years) showed how tick nymph activity generally peaked in August, with low to no activity from November to March (Figure 1A). These temporal activity patterns were compared to monthly human Lyme neuroborreliosis (LNB) incidence data obtained from Statens Serum Institut to pinpoint potential overlaps in time. LNB is the most severe form of Lyme borreliosis, is notifiable within the EU, and in Denmark, approximately 180 cases of LNB are reported each year. The model identified a correlation between the timing of predicted high tick activity and elevated LNB incidence, albeit with a one-month lag (2-6 weeks) in the NB data (Fig. 1B). The model created can be helpful in the identification of temporal risk periods and the interpretation of human disease incidence data.

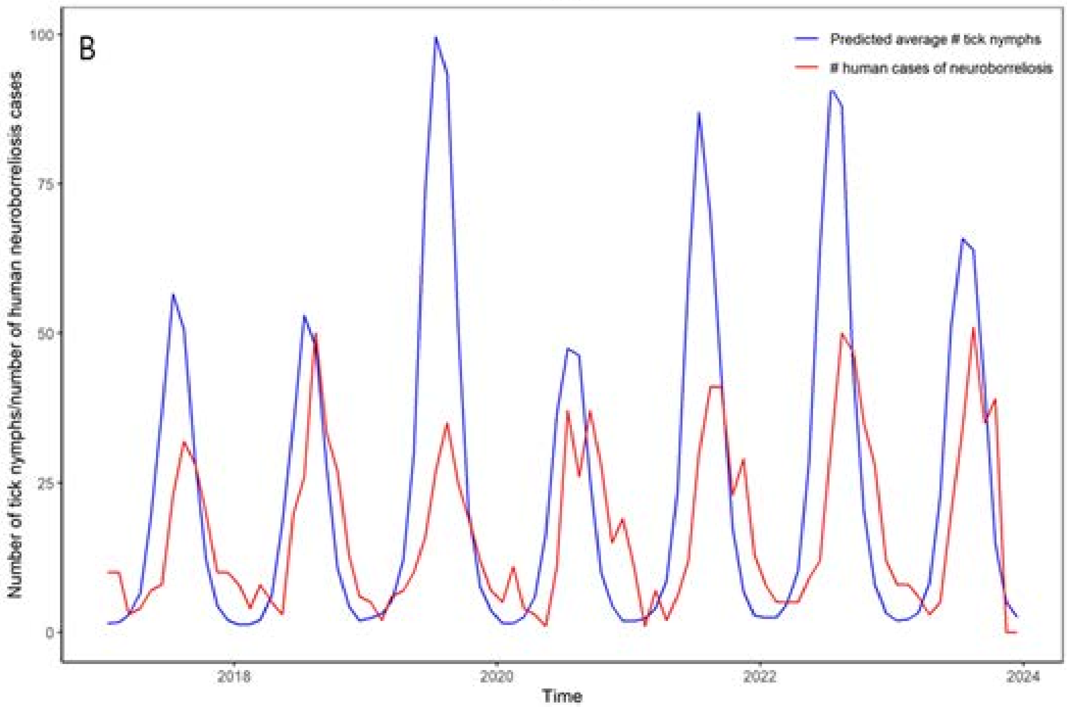
Tick-borne encephalitis (TBE) is primarily transmitted to humans through the bite of infected ticks, leading to inflammation of the brain (encephalitis) and surrounding membranes (meningitis). Before 2019, TBE virus (TBEV) infections in Denmark were mainly confined to Bornholm. However, in 2019, an infection area was identified in Tisvilde Hegn, northern Zealand, and its surroundings, marking an increase in occurrences each year since then. Since 2019, TBEV has been consistently found in ticks from Tisvilde Hegn, including in 2023. Although TBEV has only been detected in ticks at micro foci around the Tisvilde nature playground, new reported TBE cases suggest the virus spread to several locations in northern Zealand from 2020 to 2023. In 2023, 12 human TBE cases were confirmed in Denmark – 5 from Bornholm[2] from Tisvilde Hegn and surroundings, and 5 from Tokkekøb Hegn and surroundings. Full genome sequencing of the virus in Tisvilde Hegn indicates its relatedness to TBEV from Norway. It is speculated that the virus may have been introduced to Tisvilde by infected ticks carried by migratory birds, potentially further spread by deer.

4.2 Surveillance of exotic vectors.

No exotic mosquitoes were recorded in 2023. A Hyalomma tick (also called the hunting tick) was first found in Denmark in 2018. In total three hunting ticks were found in 2018-19, all on horses, except for one detected on a human. In the summer of 2023, a hunting tick was again found on a horse near Ringsted. Hyalomma ticks are normally present in North Africa, Asia, Eastern- and Southern Europe and can be carriers of Crimean-Congo Hemorrhagic Fever virus, which can have a case fatality rate of 10-40% % among infected humans. Hyalomma ticks have since 2018 sporadically been

Figure 4.1. A) Boxplots of observed and model-predicted I. ricinus *nymph numbers from January to December, over all sites and years (2017-2023), and B) Predicted I. ricinus nymph temporal activity patterns averaged over all 6 study sites and reported human LNB cases, 2017-2023. Boxplots show the distribution of data and consists of a box (here in red and blue), which represents the interquartile range (IQR) containing the middle 50% of the data, with a line inside marking the median. Whiskers extend from the box to indicate the furthest data point in each wing that is within 1.5 times the IQR. Any data point further than that distance is considered an outlier, and is marked with a dot.*





found in all our neighboring countries, such as Germany, England, Norway, and Sweden, and are believed to be imported by migrating birds. In Denmark, the climate usually does not allow Hyalomma ticks to survive and molt to adults after introduction, but the adult ticks emerges with warmer springs and summers. It is probably no coincidence that the first hunting tick was found in 2018, where Denmark experienced a record dry early summer with temperatures resembling those of the Mediterranean.

The exotic tick species *Dermacentor reticulatus* (also called the meadow tick) has been expanding its range northward in Germany and is now commonly found up to Hamburg. The species is increasingly being observed in Denmark, and occasionally dogs that have never left Denmark are being diagnosed with severe *Babesia canis* infections[3], which is transmitted by *D. reticulatus* and not the native *I. ricinus* tick. Dermacentor ticks also carry various zoonotic pathogens not found in the Danish endemic ticks, such as *Rickettsia raoulti,* previously identified in introduced Dermacentor ticks in Denmark[4]. Despite ongoing efforts to screen for Dermacentor ticks in areas affected by *Babesia canis* outbreaks, we have not yet found any exotic questing *Dermacentor* ticks in the wild anywhere in Denmark, and thus it remains unclear whether this tick species is repeatedly introduced or has established breeding populations in the country at low levels.

4.3 References

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TBE (Tick Borne Encephalitis) is an infection of the brain caused by the TBE virus and transmitted via tick bites by the tick Ixodes Ricinus also responsible for transmission of the borrelia bacteria (*Borrelia Burgdorferi*). It has been present in limited areas in Denmark for decades, until 2008. Human cases were however only found in Bornholm. Since then, sporadic cases has have been observed in many parts of Denmark but with a focus on North Zealand since 2019 when a microfocus was discovered adjacent to a playground in Tisvilde Hegn and with a high prevalence of infected ticks.

Since then a certain increase in cases in North Zealand has been observed. In 2023 a total of 12 cases infected in Denmark were registered, with the majority in North Zealand and Bornholm. Statens Serum Institut has projected that the observed increase could continue in the coming years, however during the next five years TBE would still be a rare disease in Denmark. There are licensed and effective vaccines and vaccination could be considered for those experiencing risk behavior in known risk areas, i.e. walking in the vegetation away from paths in the transmission period or who occasionally gets bitten by ticks. SSI has estimated that around 50,000 persons need to be vaccinated to prevent one case of TBE rendering universal or even widespread vaccination monetarily inefficient.

5. 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.

5.1 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

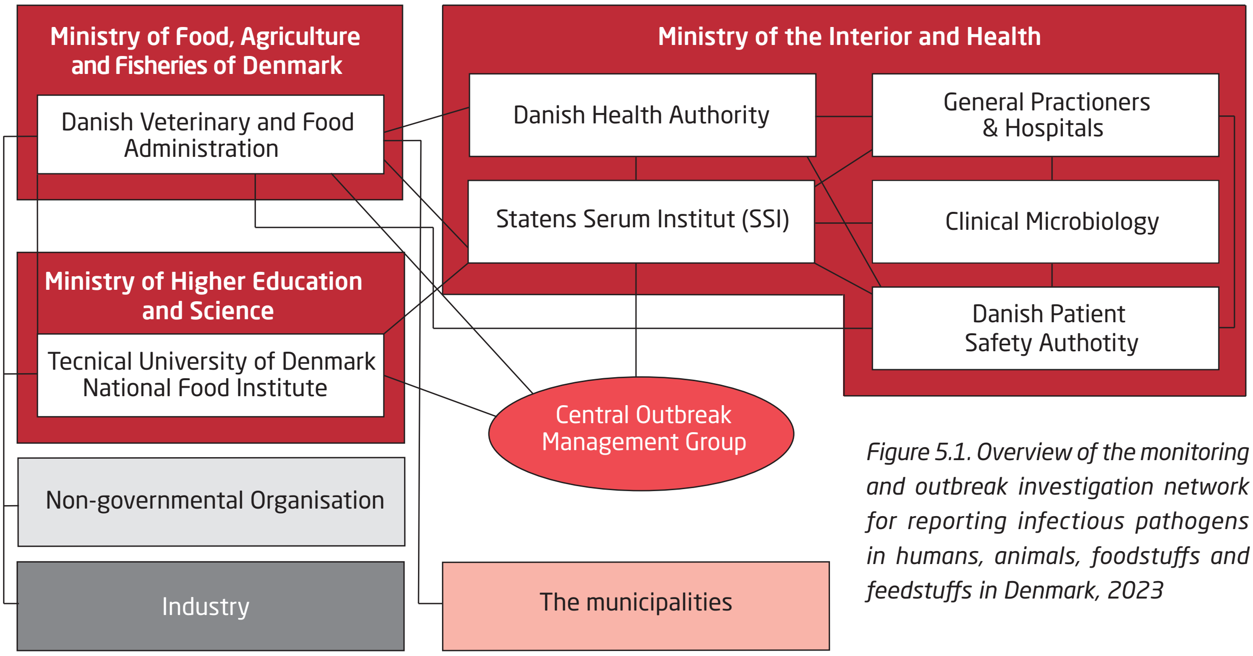


Figure 5.1. Overview of the monitoring and outbreak investigation network for reporting infectious pathogens in humans, animals, foodstuffs and feedstuffs in Denmark, 2023

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.

5.2 Outbreaks of zoonotic gastrointestinal infections

In Denmark, local and regional foodborne outbreaks are typically investigated by the local 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 based on the outbreak source: the Ministry of Health for infectious diseases; the Ministry of Food, Agriculture and Fisheries for foodborne and animal related diseases, and the Ministry of Environment for outbreaks of diseases related to supply of tap water, public swimming pools, etc.

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 outbreaks 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 2023 are described in Chapter 1.

5.3 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 A30-33. 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 Table 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.

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.

5.4 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 2023.

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

In 2023, Statens Serum Institut (SSI) extracted 1207 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 89.8% of the *Salmonella* cases in 2023.

An increase was seen in cases with travel reported less than seven days before onset of disease from 39.9% in 2022 to 46.0% in 2023 (Table 5.1. -Top 10 *Salmonella* serotypes). The annual percentage of travel reported returned to the same level as before covid-19, 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 251 in 2022 to 384 in 2023 (Table A1). The increase was caused by an increase of both travel-related and domestic outbreak related *S.* Enteritidis cases, see also chapter 7 – Enteritidis chapter (Fig. 5.2 for this chapter). Travel-related *S.* Typhimurium and S. 1,4,[5],12:i:- cases increased from 18.7% and 17.4% in 2022 to 31.1% and 26.3% in 2023 (Table 5.1. - Top 10 *Salmonella* serotypes).

The total number of *S.* Typhimurium and *S.* 1,4,[5],12:i:- cases decreased slightly, being 208 in 2022 and 174 in 2023 (Table A1). Numbers reflecting that no major outbreaks were reported with *S.* Typhimurium and *S.* 1,4,[5],12:i:- in 2023 (Fig. 6.2 for chapter).

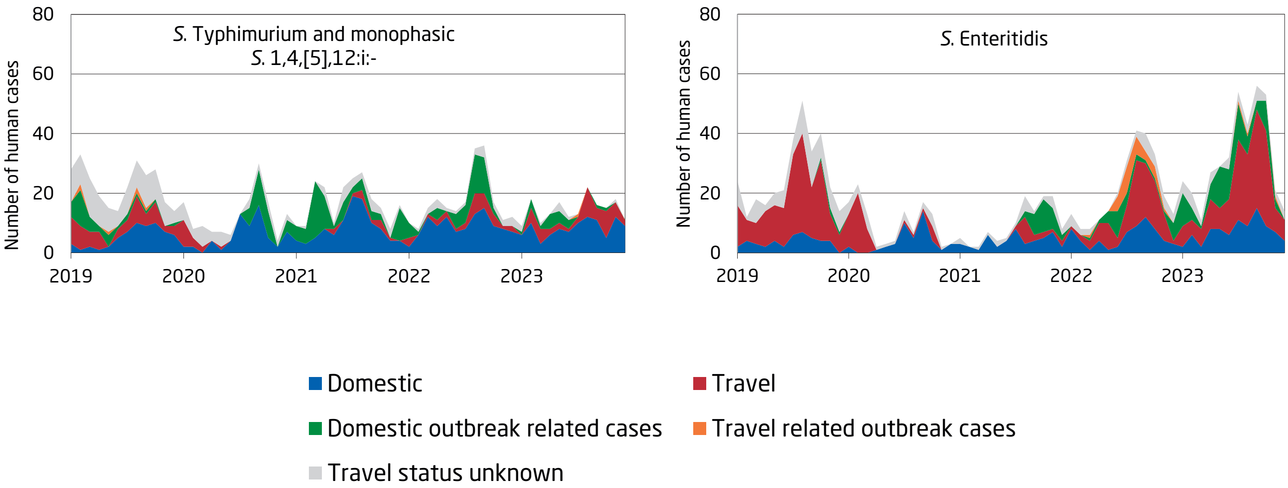
Table 5.1. Top 10 Salmonella serotypes in humans and information about travel abroad, 2022-2023

2023	Number of patients (%)	% of patients[a] infected Abroad[b]	Domestically	2022	Number of patients (%)	% of patients[a] infected Abroad[b]	Domestically
Enteritidis	384 (31.8)	52.2	47.8	Enteritidis	251 (27.9)	58.5	41.5
Typhimurium	93 (7.7)	31.1	68.9	Typhimurium	104 (11.6)	18.7	81.3
1,4,[5],12:i:-	81 (6.7)	26.3	73.7	1,4,[5],12:i:-	104 (11.6)	17.4	82.6
Infantis	43 (3.6)	80.6	19.4	Infantis	22 (2.4)	19.0	81.0
Muenchen	38 (3.1)	5.9	94.1	Newport	20 (2.2)	55.6	44.4
Stanley	33 (2.7)	70.0	30.0	Mikawasima	16 (1.8)	20.0	80.0
Bareilly	20 (1.7)	70.0	30.0	Paratyphi B var Java	15 (1.7)	61.5	38.5
Saintpaul	20 (1.7)	61.1	38.9	Dublin	13 (1.4)	0.0	100.0
Newport	20 (1.7)	17.6	82.4	Virchow	13 (1.4)	58.3	41.7
Chester	17 (1.4)	13.3	86.7	Agona	12 (1.3)	63.6	36.4
Other serotypes	458 (37.9)	57.1	42.9	Other serotypes	329 (36.6)	39.1	60.9
Total	1207	46.0	54.0	Total	899	39.9	60.1

a) Patients with unknown travel information (10.2% of all patients in 2023 and 16.4% in 2022) 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 5.2. Monthly distribution of S. Enteriditis and S. Typhimurium incl. monophasic S. 1,4,[5],12i- cases, 2019-2023



6. New executive order on human surveillance

By Sidsel S. Voss (sisv@ssi.dk) and Susan Cowan (sco@ssi.dk)

There is now a broader legal scope for utilising laboratory data as the basis for the national surveillance of infectious diseases in Denmark with the amended Executive Order on Notification of Infectious Diseases (Stat. Ord. no. 1260 of 27/10/2023) which went into effect on 1 November 2023.

Monitoring of infectious diseases is essential during crises, which became evident during the COVID-19 pandemic. However, monitoring of infectious diseases is also important for our normal everyday lives; e.g. to identify and fight foodborne outbreaks, prevent spreading of serious diseases among children and curb antimicrobial resistance.

With the Danish Health Authority's amended Executive Order on Notification of Infectious Diseases, Denmark gains a more comprehensive, timely and effective monitoring of infectious diseases, which paves the way for strengthened prophylactic efforts and enhanced control of disease outbreaks.

The order stipulates which diseases should be individually reported by clinicians through an electronic notification system that has already been introduced for clinical notifications under the Health Data Authority's Electronic Notification System (SEI2) as part of the modernization of the notification system. The electronic reports are made available both to Statens Serum Institut (SSI) and the Danish Patient Safety Authority (STPS). The order also specifies which microorganisms are included in the laboratory monitoring and for which microorganisms it is mandatory to submit isolates or other biological material to SSI. Some of the submissions that were previously voluntary have been made mandatory to ensure monitoring at a time when PCR methods are replacing cultivation in more and more areas. Furthermore, the order defines the roles of physicians and laboratories in relation to disease monitoring and notification in connection with pregnancy screening and donor screening. The microorganisms included in the Annual Report are listed in Table A26.

Compared to the former legislation, the amended order allows for laboratory-based surveillance to play a more significant role in the surveillance of infectious diseases. Laboratory-based surveillance is based on laboratory data reported to the Danish Microbiology Database (MiBa) by the departments of clinical microbiology, clinical biochemistry and clinical immunology.

The use of laboratory data in the monitoring of infectious diseases does not imply a change in practices for laboratories, as they already report to national databases. It simply means that the data may be used in the national surveillance of infectious diseases. In connection with the preparation of the regulation, a change made was to the Health Act, making SSI the data-owner of all data in MiBa. The Health Act also stipulates the right of SSI to link data from other health registers (e.g. the National Patient Register and the National Vaccination register) to the surveillance data. This allows for a much more comprehensive overview of the infectious diseases under survey, not least concerning antimicrobial resistance monitoring (AMR).

The linking of laboratory data to the epidemiological surveillance data is only possible because of the Personal Identification Number (CPR), which is a unique identifier given to all persons living in Denmark.

The order includes over 90 microorganisms, all of which require reporting of laboratory results. Among these, 40 can cause diseases that require individual reporting by clinicians.

The "Guideline on notification of infectious diseases", prepared along with the order, elaborates on the contents of the order, including its aim, tasks, procedures and what supplementary information must be forwarded to SSI. Additionally, the guideline provides a set of criteria for clinical notification, which is described for each individual notifiable disease.

Furthermore, the "Handbook on submission of isolates etc. for monitoring and referencing" (Danish language: Håndbog om indsendelse af isolater m.v. til overvågning og reference), which targets departments of clinical microbiology and other laboratories in Denmark, provides in-depth information on the objective of submitting isolates, states what needs to be submitted and when and contains information about sampling material, packaging, storage, shipment, notification and ordering. The manual also details which special analyses are carried out at SSI as part of the monitoring efforts, provides response times and explains the elements of the results provided. The manual comprises both microorganisms for which submission is mandatory, and microorganisms submitted as part of a voluntary scheme. The novel elements are as follows:

- Several parasites and fungi and an expansion of the antimicrobial resistance area are now included.
- The order relieves the departments of clinical microbiology of submission of lists to SSI stating the number of disease cases for the majority of diseases and will, in the longer term, be discontinued for all diseases, as the surveillance system becomes ever more automated.
- A range of voluntary schemes to submit isolates to SSI are now made mandatory to ensure sufficient monitoring in the future.
- Various conditions shift from being clinically notifiable to being laboratory-monitored only:
    - » Cases of bacterial meningitis, barring meningococcal meningitis (i.e. meningitis cases caused by *Haemophilus influenzae* type B, *Listeria* and *pneumococci*, among others)
    - » Neuroborreliosis
    - » Mumps (parotitis)
    - » Typhus
    - » Shiga-toxin-producing *E.* coli (STEC), NOT associated with HUS (HUSEC)
- Measles cases (including cases of clinical suspicion) must be notified by phone to ensure prophylactic treatment for any non-immune contacts and to contribute to the measles eradication scheme.
- For whooping cough, the obligation of clinical notification is extended to include cases in children < 6 years (previously, only cases in children < 2 years were notifiable).
- As from now, only variant Creutzfeld-Jakob disease (vCJD) is notifiable. Other types of CJD are no longer notifiable.
- Suspicion of clusters of disease cases of a serious or unusual character is notifiable regardless of whether the cause is known (this applies to notifiable and non-notifiable diseases alike).
- Reporting of treatment information, including treatment outcome, for patients with tuberculosis is now mandatory.

Read more about disease monitoring and notification of infectious diseases (In Danish).

7. *Salmonella* Enteritidis

By Pernille Gymoese, Gudrun Sandø, Luise Müller (LUM@ssi.dk)

7.1. *Salmonella* Enteritidis in humans in Denmark 2023

More than 2000 different serotypes of *Salmonella* are known worldwide. However, *Salmonella* Enteritidis remains to be the most prevalent serotype found in Denmark accounting for about of a third of all human cases followed by *Salmonella* Typhimurium and the monophasic variant (Table 5.1). Poultry and egg products are well-known sources of *S.* Enteritidis.

Figure 7.1 shows the number of *S.* Enteritidis cases from 2014 to 2023. The yearly number of *S.* Enteritidis was quite stable from 2014-2019 with approximately 60% related to travel, 20% related to no travel and 20% unknown. During 2020 and 2021 the number of registered cases decreased due to the Covid-19 pandemic, where travel-restrictions was implemented. In 2022 the number again increased to the usual level. In 2023, the number of registered cases of *S.* Enteritidis was 384 which was a marked increase from 2022 where 251 cases were registered. The number of travel-related S. Enteritidis cases registered in Denmark in 2023 was back to the same level as seen before 2020. However, the ratio of domestic acquired infections had increased in 2022 and 2023 and accounted for 42% and 48% of the cases.

7.2. *Salmonella* Enteritidis outbreaks in 2023

In Denmark, all human isolates of *S.* Enteritidis are sent to the Statens Serum Institut reference laboratory for further identification and typing. The proportion of samples received as isolates or biological material for all *Salmonella* samples was 85.3% in 2023 (Table A26). Figure 7.2 shows the human *S.* Enteritidis cases by genetic clusters defined by whole genome sequencing and presented using the Danish outbreak number from the Danish Food and waterborne database (FUD). Surprisingly, the number of outbreaks increased dramatically from 1-3 per year in 2017-2022 to 10 distinctive outbreaks in 2023. The details of eight of the outbreaks can be seen in appendix Table A3. Two outbreaks started in 2022 and they are described in Annual report on Zoonoses in Denmark 2022 [1] (FUD2084 and FUD2161). One outbreak in the beginning of 2023 was a local outbreak and the source was linked to a catering service of New year dinner (FUD2178). The rest of the outbreaks were national with cases geographically spread in the whole country and three was part of international outbreaks. The largest outbreak with 28 registered cases ran from May to September (FUD2239). Twelve of the cases were female and 16 were male. The age range was 9-98 years with a median age of 30 years. The investigation pointed towards pre-fried chicken kebab. Whole genome sequencing was used to identify match between human cases and product samples. The pre-fried chicken kebab had primarily been sold via restaurants and was withdrawn from the market in August 2023. Extensive traceback investigations revealed that the chicken product was imported from Poland. A total of 13 other countries reporting more than 200 cases related to this outbreak. Concurrent outbreaks of *S.* Enteritidis – one also with seven Danish cases (FUD2223) prompted joint international investigations, revealing poultry meat from Poland, as the likely source of multiple *S.* Enteritidis outbreaks [2].

7.3. Control programme for *Salmonella* in poultry, chicken meat and table eggs

The Danish *Salmonella* control programme in the broiler production has been in place since 1988 and in the table egg production since 1996. The program is designed to ensure that chicken meat and table eggs are free from *Salmonella* when marketed. The program is followed by a technical working group and a steering committee and is adjusted when necessary.

The development of *Salmonella* control programs in poultry at European level, was initiated by the Zoonosis Directive (1999) and the Zoonosis Regulation (2003). Since then, EU regulations on monitoring and common targets have been developed. This has resulted in a decrease in *Salmonella* contaminated eggs and poultry meat in the EU, and a reduction in the number of human cases.

Besides the EU *Salmonella* control program targeting Salmonella at flock level, there is process hygiene criteria for *Salmonella* in chicken and poultry carcasses at the slaughterhouse (EC no 2073/2005, Chapter 2.1), and food safety criteria for *Salmonella* in fresh chicken and turkey meat and for meat preparations, mechanically separated meat and meat products (EC no 2073/2005, Chapter 1).

Based on the low prevalence in the Danish production in combination with the strict program, Denmark achieved special guarantees for table eggs in 2012 and for chicken meat in 2018.

The Danish control program not only complies with the EU-regulation, but is stricter and more intensive, to ensure the safety required for acquiring special guaranties.

Figure 7.1. Human cases of Salmonella Enteritidis by country of exposure in Denmark, 2014-2023

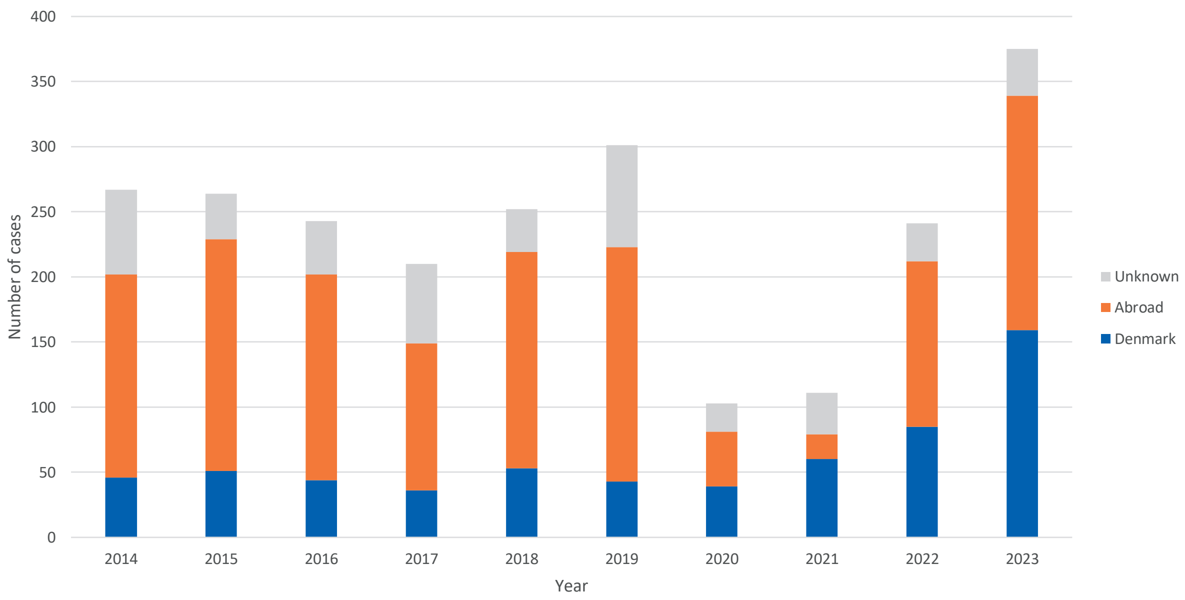
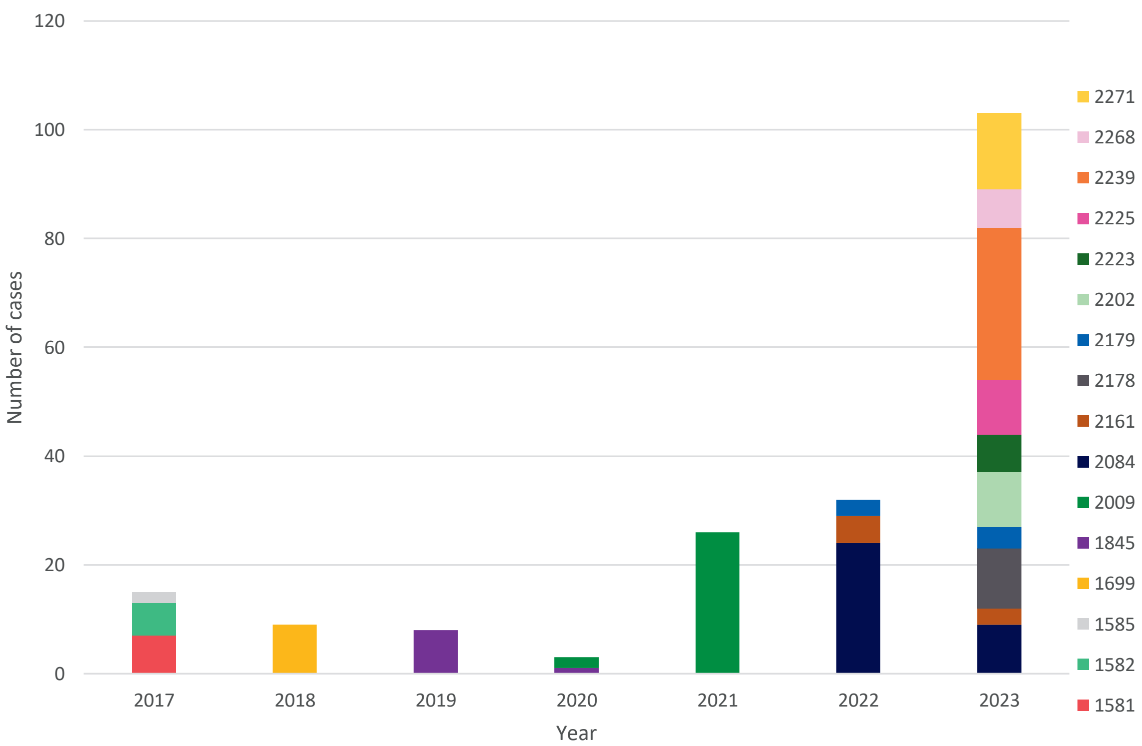


Figure 7.2. Human cases of Salmonella *Enteritidis ST11 by outbreak number (genetic clusters) in Denmark, 2017-2023*



7.4. Special guarantees

When the prevalence of *Salmonella* in certain animal populations and food is very low and strict national control programmes apply, the EU Commission may grant special guarantees to an EU country or region of EU countries (853/2004).

Sweden and Finland achieved special guarantees for Salmonella when they entered the European Community in 1995 and Norway and Iceland when they became EAA countries.

In Denmark, the special guarantees imply that consignments of fresh or frozen chicken meat from other countries must be followed by a trade document, showing that the consignment has been tested according to the regulation (1688/2005) and that the samples were negative for Salmonella. For table eggs the document must show that the layer flock has been tested according to the EU legislation with a negative result.

7.5. *Salmonella* control of imported table eggs and chicken meat

Table eggs are covered by the special guarantees, and the layer flocks to have be tested according to the EU legislation with a negative result.

Fresh or frozen chicken meat, including minced meat and meat from poussins are covered by the special guarantees, and each consignment must be tested before shipment, with a negative result.

Meat preparations (such as marinated or seasoned chicken meat), mechanically separated meat and meat products are not covered by the special guarantees but must comply with the food safety criterion that stipulates absence of Salmonella spp. in 5 x 25 g.

Fresh or frozen meat from adult poultry (hens) is not covered by the special guarantees either. Here another food safety criterion applies, which stipulates absence of *S.* Enteritidis and *S.* Typhimurium in 5 x 25 g.

Sampling according to the regulation on microbiological criteria (2073/2003) is carried out as random sampling e.g. on a weekly basis at the establishment of origin, and not by sampling each consignment.

For heat treated chicken products the general food law applies (178/2002) and findings must be risk assessed according to article 14.

7.6. Results

In 2023 two poultry flocks were positive with *Salmonella* Enteritidis (one free range layer flock and one organic broiler flock). The eggs from the positive flock were sent to heat-treatment and the broilers were culled. See all the results from the surveillance programme on *Salmonella* in flocks and at the slaughterhouse in Table 25.

7.7. Comment

In summary, in 2023 there was a marked increase in *S.* Enteritidis acquired in Denmark and about a third of these were part of outbreaks. One large international outbreak could be linked to imported pre-fried chicken, however the source could not be established for the rest of the outbreaks. There are no indications that Danish-produced chicken meat and table eggs have caused any outbreaks in 2023, because of the strict control programme for *Salmonella* in poultry, chicken meat and table eggs and the fact that *S.* Enteritidis was found only twice in the control programme, followed by heat-treatment of eggs and culling of the broilers. The increase in *S.* Enteritidis was concurrent with other cross-border outbreaks in Europe and this underlines the importance of a coordinated international and cross-sector response across food safety and public health.

7.8. References

1. Anonymous 2023. Annual Report on Zoonoses in Denmark 2022. National Food Institute, Technical University of Denmark
2. European Centre for Disease Prevention and Control, European Food Safety Authority, 2023. Three clusters of *Salmonella* Enteritidis ST11 infections linked to chicken meat and chicken meat products – 26 October 2023.

8. International topics

By Gudrun Sandø (gus@fvst.dk)

In 2023 the Danish Veterinary and Food Administration decided to contribute by commenting on a court case in the Netherlands, which was submitted as a preliminary reference to the EU Court of Justice, because it concerned EU legislation. The case was considered to be fundamental and of major importance to the *Salmonella* surveillance program in poultry flocks in EU member states. When a court case in a member state raises doubt about the interpretation of specific provisions in the EU legislation, the national court involved can submit questions for interpretation to the EU Court of Justice, as was the case here.

According to the regulation on harmonized monitoring for *Salmonella* in breeding flocks, the competent authority can decide to repeat the sampling and testing in exceptional cases where there is reason to question the results of the testing (such as false positive or false negative results).

The food business operator in the case argued that the positive sample in his breeding flock was an example of an "exceptional case", and that re-testing should be carried out. The reasons according to the food business operator were, for one, that follow-up tests with negative *Salmonella* results were carried out by both the food business operator and a Veterinary Health Service in the country. Secondly the food business operator argued that only one of two samples per infected poultry house was positive for *Salmonella* in the routine tests. Finally, the poultry flock was young, vaccinated against *Salmonella* and strict biosecurity measures were applied in the flock.

Based on these circumstances, the food business operator considered it to be unlikely that the herd was infected and the routine samples truly positive.

The Court of Justice of the EU had to rule upon, among other things, the question of when and what is meant by "exceptional cases" in accordance with Regulation no. 200/2010. The Court determined, in line with the Danish Veterinary and Food Administration's written submission, that an exceptional case where the competent authority has reason to doubt a positive test result, is when the authority ascertains events or incidents that prevent correct sampling and/or analysis process or when there is a serious risk that such events have occurred. The fact that follow-up samples turn out to be negative or that only a few of the routine samples taken were positive, does not mean that the case is exceptional. Finally, vaccine status and the farm's history with respect to a specific *Salmonella* type can be taken into account, but are not in themselves sufficient to determine if a case is exceptional.

Human disease and outbreak data

Table A1. Zoonoses in humans, number of laboratory-confirmed cases, 2018-2023

	Incidence per 100.000 inhabitants	Reported no. of cases					
Zoonotic pathogen	2023	2023	2022	2021	2020	2019	2018
Bacteria							
Brucella abortus/melitensis[a,b]		1	1	1	1	7	3
Campylobacter coli/jejuni[c]	87.2	5,186	5,142	3,740	3,742	5,389	4,546
Chlamydia psittaci	0.3	17	16	25	27	32	16
Leptospira spp.	0.2	13	6	10	14	14	19
Listeria monocytogenes	0.9	54	86	62	43	62	47
Mycobacterium bovis	0.0	2	0	0	0	0	1
Salmonella total[c]	20.3	1,207	899	692	614	1,120	1,168
S. Enteritidis[c]	6.5	384	251	114	117	310	268
S. Typhimurium[d]	2.9	174	208	205	149	272	306
Other serotypes	10.9	649	344	301	302	449	594
Shigella/EIEC[c,e]	11.9	709	-	-	-	-	-
Shigella[f]	2.3	139	-	-	-	-	-
EIEC	1.1	63	-	-	-	-	-
STEC total[c,g]	24.1	1,431	1,330	927	448	630	495
O157	0.6	38	47	32	39	60	43
Other O-groups or non-typeable	6.3	375	394	376	198	359	259
Yersinia enterocolitica total[c,h]	20.2	1,199	747	454	413	374	366
Yersinia enterocolitica (Biotype 2,3 and 4)	2.0	118	174	137	106	139	-
Viruses							
Lyssavirus		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) Includes also only notified cases.
d) Including the monophasic variant of S. Typhimurium (S. 1,4,[5],12:i:-).
e) The diagnostic PCR assays target the IpaH-gene shared by both *Shigella* spp. and enteroinvasive *Escherichia coli* (EIEC) species
f) Includes *Shigella* spp., S. boydii, S. flexneri and S. sonnei
g) Shiga toxin-producing *Escherichia coli* (STEC)
h) A subset, of *Yersinia enterocolitica* (39,4%) was isolated and sent from the local clinical departments to SSI for surveillance. Characterisation disclosed 62,7% (271 isolates) being apathogenic biotype 1a, and these are excluded from the total number for 2023.

Source: Statens Serum Institut

Table A2. STEC[a] O-group distribution in humans, 2023

O-group[b]	Number of episodes	Proportion of total (%)	O-group	Number of episodes	Proportion of total (%)
O26	43	3.0	O145	18	1.3
O146	40	2.8	O128	18	1.3
O157	38	2.7	O91	16	1.1
O63	28	2.0	Other	166	11.6
O103	27	1.9	Notification[c]	1,017	71.1
O27	20	1.4	Total	1,431	
Continued in the next column					

a) Shiga toxin-producing *Escherichia coli* (STEC)
b) All O-groups that resulted in ten or more episodes are listed.
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 = 64), 2023

Pathogen[a]	No. of pa-tientsb	Patients labora-tory confirmedb	Setting	Source	FUD no.
Campylobacter jejuni ST21	17	17	National	Chicken meat	2253
Campylobacter jejuni ST21	6	6	National	Unknown	2241
Campylobacter jejuni ST42	9	9	National	Chicken meat	2240
Campylobacter jejuni ST48	14	14	National	Chicken meat	2243
Campylobacter jejuni ST48	5	5	National	Chicken meat	2274
Campylobacter jejuni ST50	12	12	National	Unknown	2236
Campylobacter jejuni ST51	17	17	National	Chicken meat	2248
Campylobacter jejuni ST52	21	21	National	Chicken meat	2257
Campylobacter jejuni ST464	11	11	National	Chicken meat (imp)	2228
Campylobacter jejuni ST527	7	7	National	Chicken meat	2258
Campylobacter jejuni ST577	10	10	National	Unknown	2267
Clostridium perfringens	44	0	Catering service	Pig roast	2249
Clostridium perfringens and Bacillus cereus	37	0	Take-away	Vegan butter tikka	2234
Cryptosporidium parvum IIdA21G1	6	6	International	Unknown	2269
ETEC O6	197	4	Take-away	Mixed food	2254
EIEC O42	52	1	Canteen	Mixed food	2204
EIEC O124	114	6	Canteen	Buffet meals	2226
Lectins	10	0	Canteen	Chili con carne with beans	2212
		Continued on the next page			

Table A3. Food- and waterborne disease outbreaks reported in the Food- and waterborne Outbreak Database (FUD) (n = 64), 2023 (Continued from previous page)

Pathogen[a]	No. of patients[b]	Patients laboratory confirmed	Setting	Source[c]	FUD no.
Listeria monocytogenes ST1	4	4	National	Unknown	2238
Listeria monocytogenes ST4	2	2	Regional	Unknown	2305
Listeria monocytogenes ST8	2	2	National	Unknown	2286
Listeria monocytogenes ST91	2	2	National	Unknown	2302
Norovirus	110	8	Canteen	Buffet meals	2148
Norovirus	33	0	Restaurant	Oysters (imp)	2160
Norovirus	42	0	Catering service	Mixed food	2184
Norovirus	35	1	Restaurant	Oysters (imp)	2192
Norovirus	31	8	Catering service	Open sandwich	2210
Norovirus	20	5	Catering service	Mixed food	2216
Norovirus	9	0	Catering service	Mixed food	2251
Norovirus	22	7	Restaurant	Mixed food	2273
Norovirus	12	0	Restaurant	Oysters (imp)	2279
Norovirus	32	0	Restaurant	Oysters (imp)	2289
Norovirus	53	3	Canteen	Mixed food	2295
Norovirus	33	2	Restaurant	Mixed food	2306
Norovirus	30	0	Restaurant	Oysters (imp)	2307
Salmonella Anatum ST5197	4	4	National	Unknown	2293
Salmonella Bareilly ST203	13	13	National	Unknown	2265
Salmonella Enteritidis ST11	23	11	Catering service	Mixed food	2178
Salmonella Enteritidis ST11	4	4	National	Unknown	2179
Salmonella Enteritidis ST11	10	10	International	Unknown	2202
Salmonella Enteritidis ST11	7	7	International	Unknown	2223
Salmonella Enteritidis ST11	10	10	National	Unknown	2225
Salmonella Enteritidis ST11	28	28	International	Pre-fried chicken kebab (imp)	2239
Salmonella Enteritidis ST11	7	7	National	Unknown	2268
Salmonella Enteritidis ST11	14	14	International	Unknown	2271
Salmonella Mikawasima ST1815	6	6	Catering service	Unknown	2263
Salmonella Montevideo ST2327	6	6	International	Unknown	2250
Salmonella Muenchen ST82	31	31	National	Unknown	2211
Salmonella Stanleyville ST97	6	6	National	Unknown	2252
Salmonella Strathcona ST2559	5	5	International	Unknown	2275
Salmonella 4,[5],12,i- ST34	5	5	National	Unknown	2201
Salmonella Typhimurium ST19	5	5	National	Unknown	2213
Salmonella Typhimurium ST36	11	11	National	Unknown	2230
STEC O103:H2 ST17 (stx1a, stx2d)	4	4	National	Unknown	2264

Continued on the next page

Table A3. Food- and waterborne disease outbreaks reported in the Food- and waterborne Outbreak Database (FUD) (n = 64), 2023 (Continued from previous page)

Pathogen[a]	No. of patients	Patients laboratory confirmed	Setting	Source	FUD no.
STEC O145:H28 ST32 (stx2a, eae)	3	3	National	Unknown	2194
STEC O157:H7 ST11 (stx2a, eae)	5	5	National	Beouf onglet	2261
Unknown	4	0	Restaurant	Mixed food	2203
Unknown	9	0	Restaurant	Veal culotte	2227
Unknown	40	0	Canteen	Mixed meat	2229
Unknown	2	0	Take-away	Pork roast	2231
Unknown	20	0	Catering service	Buffet meals	2233
Unknown	323	0	Canteen	Pulled pork	2256
Unknown	83	0	Boarding school	Mixed food	2260
Unknown	11	0	Canteen	Buffet meals	2278
Total	1760	385			

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, 2023. N=number of culture positive units[a]

	Human cases N=1207	Pork[b] batches N=65	Beef[c] batches N=3	Broiler[d] flocks N=15	Layer[d] flocks N=7
Bareilly	1.7	-	-	-	-
Chester	1.4	-	-	-	-
Derby	0.8	36.9	-	33.33	-
Enteritidis	31.8	-	-	6.67	14.3
Infantis	3.6	4.6	-	-	-
Kentucky	0.9	-	-	-	-
Mikawasima	1.3	-	-	-	-
Muenchen	3.1	-	-	-	-
Newport	1.7	-	-	-	14.3
Oranienburg	1.2	-	-	-	-
Paratyphi B var. Java	1.2	-	-	-	-
Saintpaul	1.7	-	-	-	-
Stanley	2.7	-	-	-	-
Typhimurium	7.7	16.9	-	-	-
4,5,12:i:- & 4(5),12:i:-	6.7	29.2	-	-	-
Virchow	1.1	-	-	-	-
Other	16.2	9.2[e]	100[f]	60[g]	71.4[h]
Unknown	15.3	3.1	-	-	-

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 A30).
e) Brandenburg (1), Ohio (1), London (1), S. enterica 6.7 (1), Senftenberg (1), 4.12:i:- (1),
f) Dublin (3)
g) Ajiobo (2), Newport (3), Goettingen (2), Give (1), Livingstone (1)
h) Kottbus (2), Rissen (1), 4,12:I:- (2)

Source: Danish Veterinary and Food Administration and Statens Serum Institut

Table A5. Occurrence of Salmonella *in the table egg production[a], 2013-2023*

	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
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	90	0	418	1
2023	5	0	11	0	124	0	378	7[d]

a) See Tables A28 and A30 for description of the surveillance programmes.
b) *Salmonella* was not detected in grandparent flocks (2) during rearing period .
c) *Salmonella* was not detected in grandparent flocks during adult (0) period.
d) *S.* Enteritidis (1), S. 4.12:I:- (2), S. Kottbus (2), S. Rissen (1), S. Newport (1)

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, 2013-2023

	Deep litter		Free range		Organic		Cage	
	N	Positive	N	Positive	N	Positive	N	Positive
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
2023	95	3[b]	21	1[c]	109	0	11	0

a) *S.* Coeln.
b) *S.* Kottbus (n=1), *S.* 4,12:I:- (n=2)
c) *S.* Enteritidis

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

Table A7. Occurrence of Salmonella *in the broiler production[a], 2013-202*

	Rearing period[b] (parent flocks)		Adult period[c] (parent flocks)		Broiler flocks		Slaughterhouse[d] (flocks/batches)	
	N	Positive	N	Positive	N	Positive	N	Positive
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	2	3,604	13	231	0
2021	154	0	290	1	3,758	6	263	0
2022	166	0	267	2	3,680	6	230	2
2023	136	0[e]	199	2	3,966	15[f]	240	0

a) See Tables A28-A30 for description of the surveillance programmes.
b) *Salmonella* was not detected in grandparent flocks during rearing period (2 flocks).
c) *Salmonella* was detected in 1 grandparent (*S*. Thyphimurium) flock during adult period (9 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*. Rissen (2)
f) *S*. Derby (5), *S*. Ajiobo (2), *S*. Newport (3), *S*. Goettingen (2), *S*. Livingstone (1), *S*. Give (1), *S*. Enteritidis (1)

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

Table A8. Occurrence of Salmonella *in turkey flocks, 2013-2023*

	Turkey flocks[a]	
	N	Positive
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
2023	151	1[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*. Infantis

Source: Danish Veterinary and Food Administration

Table A9. Occurrence of Campylobacter in broiler flocks, 2013-2023[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]
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	19.1[d]	1,150	14.3
2022	-	-	2,990	18.6	1,090	10.5
2023	-	-	3,364	22.6	1,065	8.8

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 Axx for further description.
c) Percent positive samples >1000 cfu/g.
d) Corrected from 2022 report.

Source: Danish Agriculture and Food Council

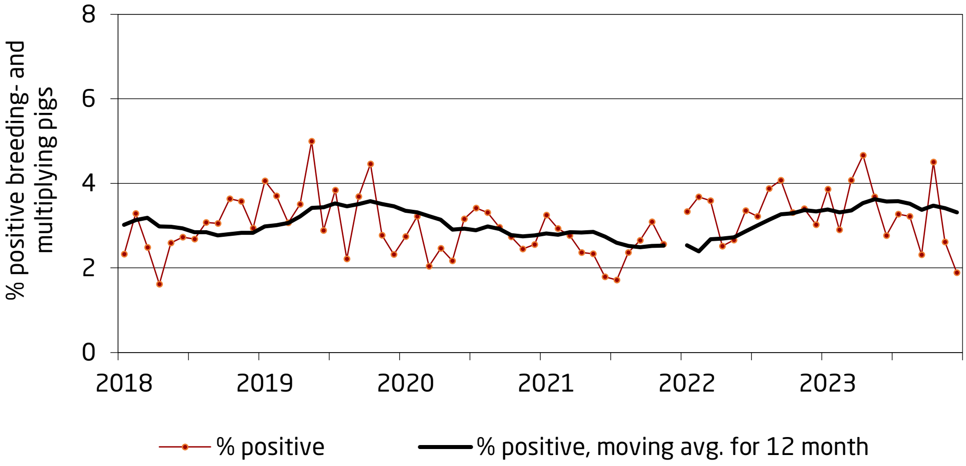
Table A10. Occurrence of Campylobacter in non-heat treated chilled broiler meat samples at slaughter and retail[a], 2017-2023

		At slaughter[b]		At retail			
		Denmark		Denmark		Import	
		N (samples)	% pos	N (samples)	% pos[c]	N (samples)	% pos[c]
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
2023	Conventional	1,232	28.6	798	14.3	32	46.9
	Organic-free-range	96	21.9	115	29.6	47	74.5

a) Centrally coordinated studies (see Table A24 and section 5.4 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

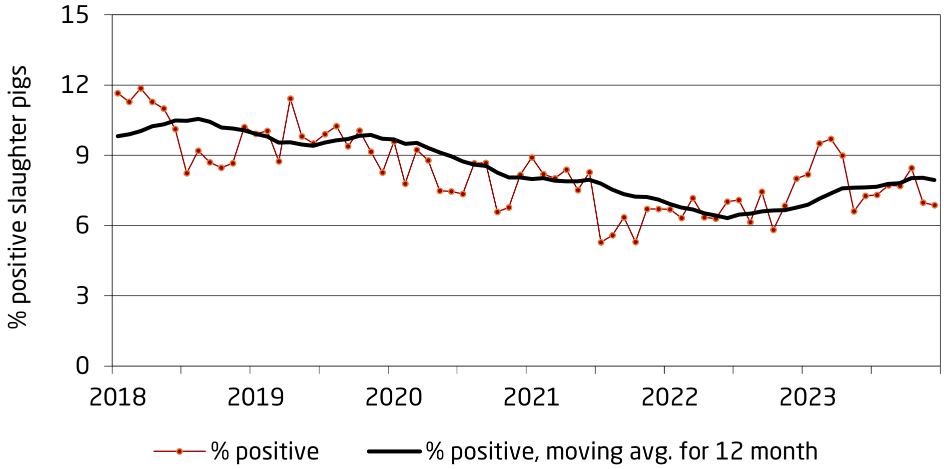
Figure A1. Serological surveillance of Salmonella *in breeding and multiplying pigs[a] based on monthly testing of blood samples, 2018-2023[b]*



a) For more information about the surveillance program, 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 11 month's data.

Source: Danish Agriculture and Food Council

Figure A2. Serological surveillance of Salmonella *in slaughter pigs[a], 2018-2023. 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

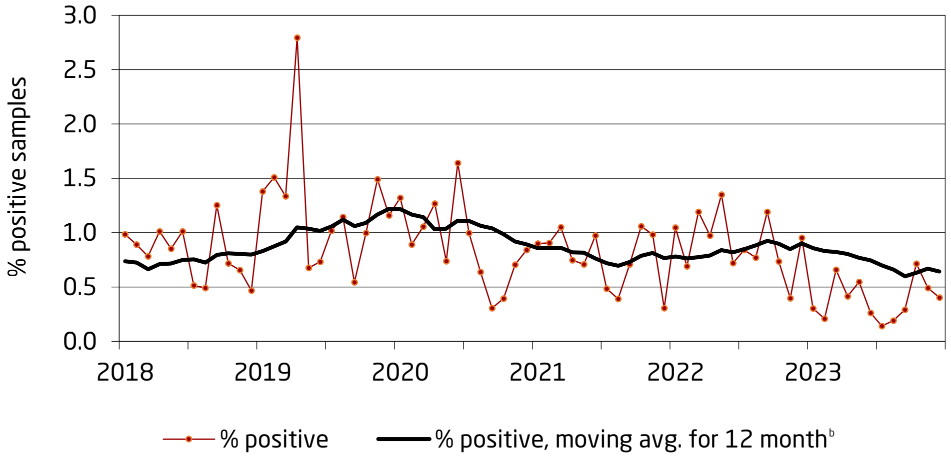
Table A11. Occurrence of zoonotic pathogens in pigs and pork in Denmark, 2023

	Herds		Animals/Samples		
Zoonotic pathogen	N	Pos	N	Pos	% pos
At slaughterhouse (slaughter pigs)					
Salmonella spp.[a,b]	4,256	144[g]	-	-	-
Salmonella spp.[a,c] (slaughtering >30,000 pigs/year)	-	-	16,995	-	0.6[h]
Salmonella spp.[a,c] (slaughtering 1,000 or more and less than 30,000 pigs/year)	-	-	86	-	-
Salmonella spp.[a,d]	-	-	-	-	-
Trichinella spp.[e]	-	-	14,511,599	0	-
Mycobacterium spp.[f]	-	-	14,511,599	0	-
Echinococcus granulosis/multilocularis[f]			14,511,599	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 (4x100cm^2).
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).

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

Figure A3. Salmonella *in pork, monitored at slaughterhouses[a], 2018-2023*



a) For more information about the surveillance programme, see Table A33.
b) The prevalence has not been adjusted for double sampling.

Source: Danish Veterinary and Food Administration

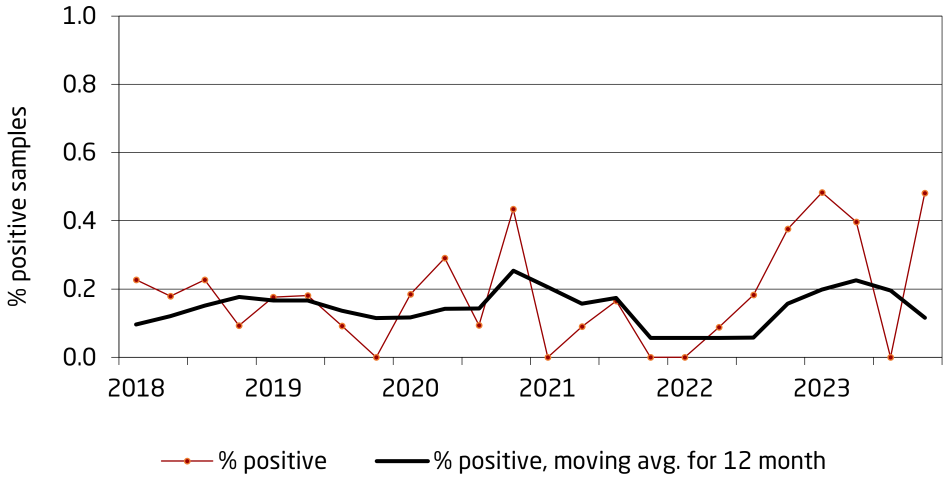
Table A12. Occurrence of zoonotic pathogens in cattle and beef in Denmark, 2023

	Animals/Samples		
Zoonotic pathogen	N	Pos	% pos
At farm			
Brucella spp.[a]	638	0	-
Mycobacterium bovis[b, c]	420	0	-
Coxiella burnetii[d]	126	4	3.2
At slaughterhouse			-
Salmonella spp.[e,f](slaughtering ≥7,500 cattle/year)	3,700	3	0.1[h]
Salmonella spp.[e,f](slaughtering 250 or more and 7,500 or less cattle/year)	125	0	0.0
Mycobacterium spp.[b, g]	427,500	0	-
Echinococcus granulosis/multilocularis[g]	427,500	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], 2018-2023*



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

Source: Danish Veterinary and Food Administration

Table A13. Cattle herds in the Salmonella Dublin surveillance programmea, December 2023

			Non-milk producing herds		Milk producing herds	
Salmonella Dublin *level*			N	%	N	%
Level 1		On the basis of milk samples			1,944	88.3
		On the basis of blood samples	11,328	97.4		
	Total	Probably *S.* Dublin free	11,328	97.4	1,944	88.3
Level 2		Titer high in blood- or milk samples	151	1.3	207	9.4
		Contact with herds in level 2	105	0.9	23	1
		Other causes	43	0.4	27	1.2
	Total	Non *S.* Dublin free	299	2.6	257	11.7
Total number of herds			11,627		2,201	

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], 2023

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	377	3	229	3
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 petfoodc and for feed for fur animals	520	0	443	0
Total	897	3	672	3

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), 2021-2023

	2023		2022		2021	
	N	Positive	N	Positive	N	Positive
Feed materials, farm animals[a]	69	0	60	1	60	2
Feed processing plants (process control)[b]:						
Ordinary inspections[c]	282	11[d]	284	8	285	0

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.* Agona (2), *S.* Falkensee (2), *S.* Havana (2) *S.* Idikan (1), *S.* Mbandaka (3), *S.* Thompson (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), 2021-2023*

	2023		2022		2021	
	N	Positive	N	Positive	N	Positive
Compound feed, farm animals	2,504	1[d]	2,600	1	2,263	0
Feed materials, farm animals[a]	1,837	36e	1,969	27	2,148	27
Feed processing plants (process control):						
Ordinary inspections - clean zone[b]	6,197	26[f]	8,656	20	8,344	7
Ordinary inspections - unclean zone[b]	563	32[g]	1,232	25	1,222	40
Transport vehicles, clean zone/hygiene samples[c]	1,176	1[h]	1,263	5	1,110	0
Transport vehicles, unclean zone/hygiene samples[c]	108	15[i]	165	6	245	10

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), fish meal, 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.* Adelaide (1), *S.* Braenderup (4), *S.* Kentucky (3), *S.* Liverpool (1), *S.* Livingstone (1), *S.* Mbandaka (13), *S.* Rissen (1), *S.* Senftenberg (6), *S.* Typhimurium (2), *S.* Virchow (1), *S.* Yoruba (3).
f) *S.* Entenrica 3.10:i: (1), *S.* Falkensee(23), *S.* Mbandaka (2).
g) *S.* Agona (11), *S.* Cubana (2), *S.* Derby (1), *S.* Falkenesee (5), *S.* Give (1), *S.* Putten (3), *S.* Rissen (7), *S.* Senftenberg (1), *S.* Schleissheim (1).
h) *S.* Agona (1).
i) *S.* Afula (1), *S.* Agona (3), *S.* Enterica 4.5:b:- (1), *S.* Idikan (2), *S.* Paratyphi (1), *S.* Rissen (7).

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], 2023

			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	46	3	29	0
	Products made from bovine, RTE[d]	Wholesale	3	0	12	1
	Products made from pork, RTE[d]	Wholesale	25	1	24	0
	Chicken products, RTE[d]	Wholesale	1	0	2	0
	Other meats, RTE[d]	Wholesale	8	0	7	0
	Other, RTE[d]		19	2	43	0
Non-Danish[e]	Crustaceans, RTE[d]	Border inspection	-	-	12	0
	Products made from pork, RTE[d]	Border inspection	1	0	-	-
	Fish and fishery products, RTE[d]	Border inspection	-	-	3	0
	Total		103	0	132	1

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, Italy, 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,b], 2023

Food category	Sampling place	Danish N	Danish Positive	Non-Danish[b] N	Non-Danish[b] Positive
Hornfish	Processing plant	18	0	-	-
Herring, Pickled	Processing plant	18	0	-	-
Mackerel	Processing plant	36	0	-	-
Herring	Processing plant	-	-	9	0
Mackerel	Border Inspection	-	-	63	0
Amberfish	Border Inspection	-	-	9	0
Tuna (canned)	Border Inspection	-	-	162	0
Tuna, steak	Border Inspection	-	-	27	0
Total		72	0	270	0

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

Source: Danish Veterinary and Food Administration

Table A19. Salmonella *in Danish and non-Danish produced food items[a], 2023*

Food category	Sampling place	Danish N	Danish Positive	Non-Danish[b] N	Non-Danish[b] Positive
Other processed food products and prepared dishes, noodles	At border inspection	-	-	10	0
Crustaceans - shrimps - cooked - frozen	At processing	-	-	30	0
Crustaceans - shrimps - shelled, shucked and cooked - chilled	At processing	-	-	5	0
Crustaceans - shrimps - shelled, shucked and cooked, frozen	At processing	-	-	10	0
Crustaceans, unspecified - cooked - frozen	At processing	-	-	15	0
Products made from beef, fermented sausages	At processing	25	0	-	-
Products made from beef, minced meat, intended to be cooked	At processing	10	0	-	-
Meat (not specified), fermented sausages	At processing	20	0	-	-
Products made from pork, cooked ham	At processing	5	0	-	-
Products made from pork, cooked, chilled, RTE[c]	At processing	5	0	-	-
Products made from pork, fermented sausages	At processing	65	0	-	-
Products made from pork, RTE[c]	At processing	-	-	5	0
Molluscan shellfish, raw, frozen	At processing	-	-	10	0
Total		130	0	85	0

a) Samples are collected by the local food control offices according to EU Regulation (EC) No 2073/2005.
b) Samples are from Italy, Greenland, and Thailand.
c) Ready-to-eat.

Source: Danish Veterinary and Food Administration

Table A20. Occurrence of zoonotic pathogens in zoo and pet animals in Denmark[a], 2023

	Mammals & reptiles		Birds		Dogs		Cats		Others[c]	
Zoonotic pathogen	N	Pos	N	Pos	N	Pos	N	Pos	N	Pos
Chlamydia psittaci[b]	1	-	2	-	-	-	-	-	71	44
Echinococcus spp.	-	-	-	-	-	-	-	-	-	-
Lyssavirus (classical)	-	-	-	-	-	-	1	-	-	-
European Bat Lyssavirus	-	-	-	-	-	-	-	-	-	-

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) In the case of Chlamydia psittaci, others refer to captive birds.

Source: Danish Veterinary Consortium and Danish Veterinary and Food Administration

Table A21. Occurrence of zoonotic pathogens in wild and farmed wildlife in Denmark[a], 2023

	Farmed wildlife						Wildlife			
	Wild boar		Mink and chinchillas		Birds		Mammals		Birds	
Zoonotic pathogen	N	Pos	N	Pos	N	Pos	N	Pos	N	Pos
Echinococcus multilocularis	-	-	-	-	-	-	157[f]	6	-	-
Lyssavirus (classical)[b]	-	-	-	-	-	-	112	0	-	-
European Bat Lyssavirus	-	-	-	-	-	-	42	0	-	-
West Nile virus[c,d]	-	-	-	-	-	-	43[e]	0	44	0

a) All samples are analysed based on suspicion of disease or risk based and does not reflect the country prevalence.
b) Samples are analysed using PCR. The results are not specified concerning the Lyssavirus types. These samples originate fra both dead (brain material) and living (saliva) bats.
c) Samples are analysed using PCR
d) No samples were positive for West Nile Virus. But approximately 2% of analysed (n=216) migratory birds tested were positive for WNV antibodies.
e) The mammals are bats.
f) Foxes.

Source: Danish Veterinary Consortium and Danish Veterinary and Food Administration

Table A22. The Bovine Spongiform Encephalopathy (BSE) surveillance programme[a] for cattle, 2023

Type of surveillance	N[b]	Positive
Active surveillance		
Slaughtered animals	1	0
Risk categories:		
Emergency slaugthers	1,889	0
Slaughterhouse antemortem inspection revealed suspicion or signs of disease	0	0
Fallen stock	19,471	0
Animals from herds under restriction	0	0
Passive surveillance		
Animals suspected of having clinical BSE	0	0
Total	21,361	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, May 2024

Table A23. The Transmissible Spongiform Encephalopathy (TSE) surveillance programmea for sheep and goats, 2023

Type of surveillance	N[b]	Positive
Active surveillance		
Animals from herds under restriction	0	0
Fallen stock (>18 months)	602	0
Not slaugthered for human comsumption	0	0
Slaugthered for human consumption	0	0
Passive surveillance		
Animals suspected of having clinical TSE	0	0
Total	602	0

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 2024

Table A24. Centrally coordinated studies conducted in 2023

Title of project	No. of planned samples	Pathogen surveyed	Further information
BU microbiology - slaugtherhouses	120	Various	Not published
Campylobacter spp. in fresh, chilled Danish broiler meat at slaughteries (conventional)	1250	*Campylobacter* spp	To be published
Campylobacter spp. in fresh, chilled Danish broiler meat at slaughteries (organic)	100	*Campylobacter* spp	To be published
Campylobacter spp. in fresh, chilled Danish broiler meat	100	*Campylobacter* spp	Appendix Table A10
Campylobacter spp. in imported broiler meat	120	*Campylobacter* spp	Appendix Table A10
Campylobacter spp. in imported and intratraded poultry meat	200	*Campylobacter* spp	To be published[a]
Campylobacter spp. on cattle carcasses	175	*Campylobacter* spp	To be published[a]
DANMAP - Antibiotic resistance in poultry, pork and cattle	220	AMR	To be published
DANMAP and EU surveillance Surveillance of antibiotic resistance in broiler, pork and cattle meat at retail (appendicitis samples)	630	AMR	To be published
EU surveillance of antibiotic resistance in retail	630	AMR	To be published
EU surveillance of antibiotic resistance in imported meat	12	AMR	To be published
Export -USA- environmental samples	100	*Listeria monocytogens*	Not published
Export- USA swab	468	*Salmonella*	Not published
IMPORT - Intensified control of Brazilian beef and poultry meat	50	*Salmonella, Listeria monocytogenes*	To be published
IMPORT - Microbiologic control of fish, fish products and bivale 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
IMPORT - Special control microbiology - not animal Reg.(669/2009)	100	Various	To be published
Listeria monocytogenes , *Salmonella* spp., *Escherichia coli* and *staphylococci* in fish producs from Greenland	10	*Listeria monocytogenes, Salmonella* spp., *Escherichia coli, staphylococci*	To be published
Microbiological classification of mussel production areas in Denmark	60	*Salmonella* spp., *Escherichia coli*	To be published
Part 6: Fish and fish products - wholesale	400	*Listeria monocytogenes*	To be published

Continued on the next page

Table A24. Centrally coordinated studies conducted in 2023 (Continued from previous page)

Title of project	No. of planned samples	Pathogen surveyed	Further information
Part 8: *Listeia monocytogenes* in other RTE products - wholesale	400	*Listeria monocytogenes*	To be published[a]
Salmonella in feed materials from feed companies	60	*Salmonella* spp.	To be published[a]
Salmonella in intratraded shell eggs retail	25	*Salmonella* spp.	To be published[a]
Salmonella in intratraded shell eggs wholesale	25	*Salmonella* spp.	To be published[a]
Salmonella process samples from feed companies	280	*Salmonella* spp.	To be published[a]
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, 2023

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 2023 was 15.7% for conventional flocks and 35.6% for organic/free-range (Table A9)
Fresh meat at slaughterhouse[a]	In 2023 individual targets per slaughter-house was decided. 1) A target on prevalence 2) A target on proportion of positive samples >1000 cfu/g in the summer period (june-october) and winter period (november-may)	1) Two out of the four slaughter-houses met their targets on prevalence in 2023 2) Three out of the four slaughter-houses met their targets on proportion of positive samples >1000 cfu/g in the winter period 2022-2023 and summer period 2023
Salmonella in poultry[b]		
Laying hen flocks of *Gallus gallus*	Initially eradication, later a reduction strategy in the table egg production	7 positive flocks (1.9%) (Table A5-A6) Eggs from positive flocks are destroyed or heat treated
Carcases at slaughterhouse[a]	Initially eradication, later a reduction strategy in the broiler production	0 positive batches (Table A7) Positive batches are heat treated
Salmonella in pigs 2014-2017		
Carcases at slaughterhouse	Max. 1% *Salmonella* at carcase level	0.6% (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[c]	11.7% of milk-producing herds and 2.6% 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[d]	No fattening flocks positive with target serovars (N=151) (Table A8)
Regulation (EC) No. 200/2010		
Breeding flocks of *Gallus gallus*	Max. 1% adult flocks positive for *S.* Typhimurium[d], *S.* Enteritidis, *S.* Hadar, *S.* Infantis and *S.* Virchow	0.5% (1 flock) (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	0.8% (3 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) Targets on prevalence was set as a reduction on the 3 year average from 2019-2021.
b) Supplementary to EU-regulations.
c) See Table A32 for explanation of the herd levels.
d) 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 referral of isolates, individual and laboratory notifiable human diseases presented in this report, 2023

Microorganism	Notification type[a,b,c]	Referral of isolates or biological material to SSI[a]	Portion (%) of cases recevied as isolates or biological material
Bacteria			
Brucella spp.	Laboratory	Mandatory[d]	NA[f]
Campylobacter spp.	Laboratory	Voluntary[d]	11.4
Chlamydophila psittaci (Ornithosis)	Laboratory and clinical notification	Mandatory	NA
Listeria monocytogenes	Laboratory and clinical notification	Mandatoryd	96.3
Leptospira spp.	Laboratory and clinical notification	No	-
Mycobacterium bovis/ tuberculosis	Laboratory and clinical notification	No[e]	-
Coxiella burnetii	Laboratory	No	-
Salmonella spp.	Laboratory	Mandatory[d]	85.3
Shigella spp. and EIEC[g]	Laboratory and clinical notification	Voluntary[d]	28.5
STEC[h]	Laboratory and clinical notification	Mandatory from patients with HUS, all other voluntary[d]	31
Yersinia enterocolitica	Laboratory	Voluntary[d]	39.4
Parasites			
Cryptosporidium spp.	Laboratory	Mandatory when outb-reak suspected	NA
Echinococcus multilocularis	Laboratory	Mandatory	NA
Echinococcus granulosus	Laboratory	Mandatory	NA
Trichinella spp.	Laboratory	No	-
Viruses			
Lyssavirus (Rabies)	Laboratory and clinical notification	No[e]	-
Prions			
BSE/Creutzfeld Jacob	Laboratory and clinical notification	No	-

a) According to the Danish Order no. 260 of 27/10/2023.
b) The regional microbiological laboratories report confirmed cases.
c) The physician report individually notifiable infections.
d) Only isolates
e) All diagnostics are carried out at SSI, therefore there is no requirement for further submission
f) Not applicable, implemented by November 1, 2023
g) The diagnostic PCR assays target the IpaH-gene shared by both *Shigella* spp. and enteroinvasive *Escherichia coli* (EIEC) species
h) Shiga toxin-producing *Escherichia coli* (STEC)

Source: Statens Serum Institut

Table A27. Overview of notifiable and non-notifiable animal diseases presented in this report, 2023

Pathogen	Notifiable	EU legislation	Danish legislation
Bacteria			
Brucella spp.	1920[a]		
Cattle	OBF in 1979[b]	Regulation (EU) 2021/620	Order no 1152 of 25/07/2022
Sheep and goats	ObmF in 1995[c]	Regulation (EU) 2021/620	Order no 1152 of 25/07/2022
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. 1341 of 27/11/2023
Mycobacterium bovis/ tuberculosis	1920a		
Cattle	OTF in 1980[d]	Decision 2003/467/EC	Order no. 1290 of 10/11/2023
Coxiella burnetii	2005	-	Order no. 1341 of 27/11/2023
Salmonella spp.	1993[e]		
Cattle		-	Order no. 1493 of 06/12/2022
Swine		-	Order no. 597 of 29/05/2023
Eggs for consumption		-	Order no. 499 of 23/03/2021
Hatching eggs		-	Order no. 1247 of 23/10/2023
Poultry for slaugther		-	Order no. 1819 of 02/12/2020
STEC	no	-	-
Yersinia enterocolitica	no	-	-
Parasites			
Cryptosporidium spp.	no	-	-
Echinococcus multilocularis	2004	Regulation (EU) 2016/429	Order no. 1341 of 27/11/2023
Echinococcus granulosus	1993	Regulation (EU) 2016/429	Order no. 1341 of 27/11/2023
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, 2023*

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 m^2 in total) or swab samples (>1 m^2 in total). Analysed as one pool	5 transport crates from one delivery: crate liners (>1 m^2 in total) or swab samples (>1 m^2 in total). Analysed as one pool
1st & 2nd week[b, c]	Per unit	-	2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample of 60 g
4th week[a,b,c]	Per unit	5 pairs of boot swabs (analysed as two pooled samples), or 1 faeces sample consisting of 2x150 g	2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample of 60 g
8th week[a,b,c]	Per unit	2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample of 60 g	2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample of 60 g
2 weeks prior to moving[a,c,d]	Per unit	5 pairs of boot swabs (analysed as two pooled samples), or 1 faeces sample consisting of 2x150 g	2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces 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 pooled samples), or 1 faeces sample consisting of 2x150 g	5 pairs of boot swabs (analysed as two pooled samples), or 1 faeces 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 DanishOrder no. 782 of 02/06/2020 and 1247 of 23/10/2023
d) Samples collected by the Danish Veterinary and Food Administration.
e) Sampling requirements set out by Danish Order no. 782 of 02/06/2020 and 1247 of 23/10/2023.
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, 2023*

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, laboratorium 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, 2023*

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 pooled sample)
4, 8 and 10 weeks old and 1 week before moving[a,b]	Per flock	5 pairs of boot swabs (analysed as two pooled samples) or 5 faeces samples of 60 gram
2 weeks before moving[a,c]	Per flock	5 pairs of boot swabs (analysed as two pooled samples) or 5 faeces 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 pooled sample) or 1 faeces sample consisting of 2x150 g. 250 ml (100 g) dust or a dust sample by a cloth of min. 900 cm^2
Every 2 weeks from age 20 weeks[a,b,d,]	Per flock	2 pairs of boot swabs (analysed as one pooled sample) or 1 faeces sample consisting of 2x150 g.
After positive serological findings[c]	Per flock	5 pairs of boot swabs (analysed as two pooled samples) 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, 2023*

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, 2023*

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, depending on whether the heifers are owned by a single or several owners	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. 1493 of 06/12/2022. 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 af 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 programmea for the pig production, 2023

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[f]	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[g]	Swab samples from 4 designated areas after 12 hours chilling (4x100cm^2)	Slaughterhouses slaughtering more than 30,000 pigs per year
5 samples every second month	Swab samples from 4 designated areas after 12 hours chilling (4x100cm^2)	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 (4x100cm^2)	Slaughterhouses slaughtering 1,000 or more pigs and less than 10,000 pigs per year
No sampling		Slaughterhouses slaughtering less than 1,000 pigs per year

a) Sampling requirements set out by Danish Order no. 1079 of 01/06/2021 replaced by Danish Order no. 597 of 29/05/2023.
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) Centrally coordinated study (Table A24).
g) If 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 analysis with 5 samples in each.

Source: Danish Veterinary and Food Administration

Table A34. Typing methods used in the surveillance of foodborne pathogens in Denmark, 2023

Methods	Human[a]	Food	Animal
Salmonella enterica			
Serotyping	All isolates by WGS and a subset phenotypically tested	All isolates (by WGS)[b]	All isolates (by WGS)[b]
Antimicrobial resistance testing	All isolates by WGS and most phenotypically tested	Almost all isolates	Isolates for DANMAP and EFSA
WGS (ST and cluster analysis)	All isolates	All isolates[b]	All isolates[b]
Campylobacter coli/jejuni			
Antimicrobial resistance testing	All isolates by WGS and phenotypically tested.	Isolates for DANMAP and EFSA	Isolates for DANMAP and EFSA
WGS (ST and cluster analysis)	All isolates	40% of positive isolates (isolates primarily from chilled chicken meat)[b]	None
STEC[c]			
Serotyping	All isolates by WGS and a subset phenotypically tested	All isolates (by PCR & WGS)	All O157 isolates
Virulence profile	All isolates by WGS and a subset by PCR	All isolates (by PCR & WGS)	All O157 isolates
Antimicrobial resistance	All isolates by WGS and a subset phenotypically tested		
WGS (ST and cluster analysis)	All isolates	All isolates[d]	None
Listeria			
WGS (ST and cluster analysis)	All isolates	Selected isolates (ST typing and outbreak investigations)	None
Yersinia enterocolitica			
Serotyping	All isolates	None	None
WGS (ST and cluster analysis)	Outbreaks investigations, research	None	None
Shigella/EIEC[e]			
Biochemical separation of *Shigella* spp. and EIEC	All isolates	None	None
Species designation and serotyping	All isolates	None	None
Antimicrobial resistance (*Shigella* spp. only)	All isolates phenotypically tested	None	None
WGS (ST and cluster analysis)	Outbreaks investigations, research	None	None

a) All isolates include the isolates referred to SSI for surveillance as outlined in table A26
b) Other commercial laboratories have been used for some centrally coordinated studies. Alternative methods (not listed here) may have been used for these samples.
c) Shiga toxin-producing *Escherichia coli* (STEC)
d) No STEC isolates were isolated from food in 2023.
e) The PCR assays target the IpaH-gene shared by both *Shigella* spp. and enteroinvasive *Escherichia coli* (EIEC) species.

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

Population and slaughter data

Table A35. Human population, 2023

Age groups (years)	Males	Females	Total
0-4	158,614	150,195	308,809
5-14	325,518	308,785	634,303
15-24	368,088	353,385	721,473
25-44	762,790	739,758	1,502,548
45-64	775,262	777,855	1,553,117
65+	565,054	658,841	1,223,895
Total	2,955,326	2,988,819	5,944,145

Source: Statistics Denmark, 1 July 2023

Table A36. Number of livestock establishments, livestock and animals slaughtered, 2023

	No. of establishments	Livestock (capacity)	Number slaughtered
Slaughter pigs	7,359	13,190,683	14,511,599
Cattle	14,823	1,480,218	427,500
Broilers	274	20,101,367	102,735,700
Layers (excl. barnyard)	142	4,317,530	-
Turkeys	36	320,844	1,800
Sheep & lambs	6,046	132,550	65,400
Goats	3,164	18,171	-
Horses	-	-	462

Source: Statistics Denmark and Danish Veterinary and Food Administration - the Central Husbandry Register, May 2023

Table A37. Number of establishments, flocks and livestock capacity in the broiler production, 2023

	No. of establishments	No. of flocks	Livestock (capacity)
Rearing period (grandparent)	2	2	50,000
Adult period (grandparent)	4	9	84,500
Rearing period (parent)	19	80	680,300
Adult period (parent)	50	129	1,098,200
Hatcheries	5	0	0
Broilers	274	660	20,101,367

Source: Danish Veterinary and Food Administration, April 2024

Table A38 Number of establishments, flocks and livestock capacity in the table egg production, 2023

	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	28,800
Adult period (parent)	8	7	61,400
Hatcheries	6	0	0
Pullet-rearing	32	53	1,335,620
Layers (excl. barnyard)	142	212	4,317,530

Source: Danish Veterinary and Food Administration, April 2024

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Contributing institutions:

National Food Institute
Technical University of Denmark
Henrik Dams Allé
Building 204
DK - 2800 Kgs. Lyngby
Tel: +45 3588 7000
E-mail: food@food.dtu.dk
www.food.dtu.dk

Statens Serum Institut
Artillerivej 5
DK - 2300 København S
Tel: +45 3268 3268
E-mail: serum@ssi.dk
www.ssi.dk

The Danish Veterinary and Food Administration
Stationsparken 31-33
DK - 2600 Glostrup
Tel: +45 7227 6900
E-mail: fvst@fvst.dk
www.fvst.dk

Danish Agriculture and Food Council
Axelborg, Axeltorv 3
DK - 1609 Copenhagen V
Tel: +45 3339 4000
E-mail: info@lf.dk
www.lf.dk

National Food Institute
Technical University of Denmark
Henrik Dams Allé, Building 204
DK - 2800 Kgs. Lyngby

T: 35 88 70 00
F: 35 88 70 01
www.food.dtu.dk

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