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Campylobacter Outbreak Investigations in Denmark: Turning Cross-Sector WGS Data Sharing into Action

Science Meets Policy: From Regulation to Practice – Turning WGS into Action for Foodborne Outbreak Investigation, Rome, September 2nd 2026

Agenda

- *Campylobacter* a Foodborne Public Health Challenge
- Danish National Action Plan on *Campylobacter*
- Sampling and Use of WGS in Denmark
- Communication and Data Sharing with Industry
- Case – Two Large National *Campylobacter* Outbreaks in 2025
- Perspectives

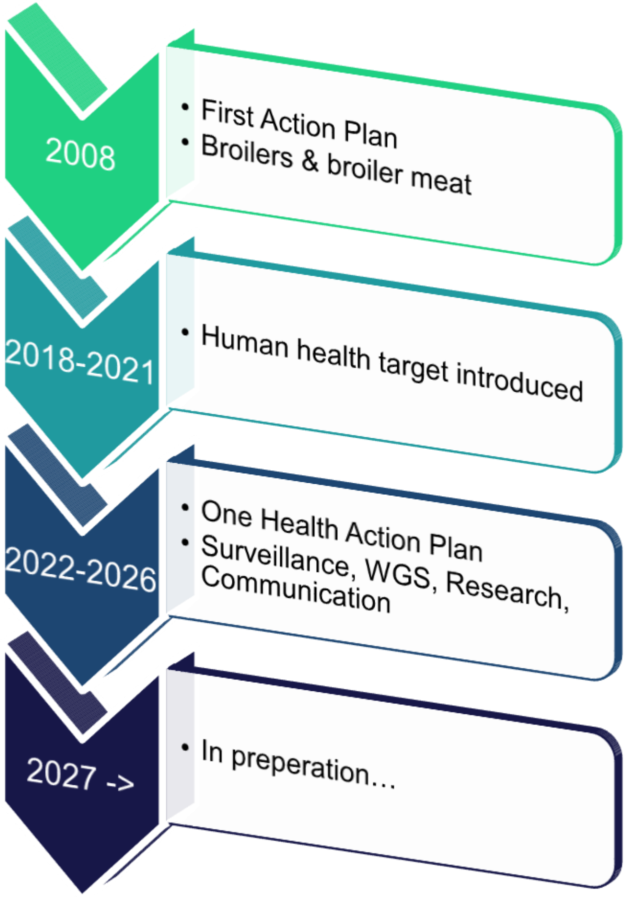
Campylobacter remains a major public health challenge

- *Campylobacter* illness in humans
  - Denmark
    - 5,714 reported *Campylobacter* cases in 2025 (95.2 cases pr. 100,000 inhabitants)
    - *Campylobacter* remains the most common bacterial foodborne infection in Denmark
  - European Union
    - 168,396 reported human campylobacteriosis cases in 2024
    - *Campylobacter* was the most frequently reported zoonosis in the EU in 2024
  - The number of cases is not declining in DK or EU, despite the stricter process hygiene criteria for broiler carcasses in 2018, 2022, and 2025
    - Slight decline seen after introduction in 2018
    - However; Denmark (2015-2022): Gradual shift from culture to PCR diagnostics increased reported *Campylobacter* incidence; PCR detected an estimated 43% more cases than culture
- Poultry remains an important source of human infection
- Whole genome sequencing supports source attribution and outbreak detection across humans, food and animals
- Continued One Health action is needed to reduce the burden of disease

Danish National *Campylobacter* Action Plan

- Prepared by Danish Veterinary and Food Administration (DVFA) in collaboration with
  - Industry (Danish Agriculture and Food Council, Confederation of Danish Industry, Danish Butchers Association FoodDenmark, large slaughterhouses)
  - Research (DTU Food)

- Long-standing national commitment
  - National Action Plans since 2008
  - Originally focused on broiler production and broiler meat
  - Gradually expanded into a One Health approach integrating surveillance, outbreak investigation, research and risk communication
  - The current Action Plan (2022-2026) builds on more than 15 years of coordinated control efforts.



Danish National *Campylobacter* Action Plan 2022-2026

- Objective:
  - Reduce the number of human *Campylobacter* cases through coordinated One Health actions across the food chain

- Elements:
  - Targets for poultry production (conventional and organic/free-range flocks)
    - Goal: max. 15% in conventional flocks
    - Goal: max. 65% in organic/free-range flocks
  - Slaughterhouse-specific reduction targets based on prevalence and concentration
  - Continued surveillance of poultry flocks, meat and retail products
  - One Health outbreak detection through WGS (since 2019) and source attribution
  - Research, source attribution, and consumer communication

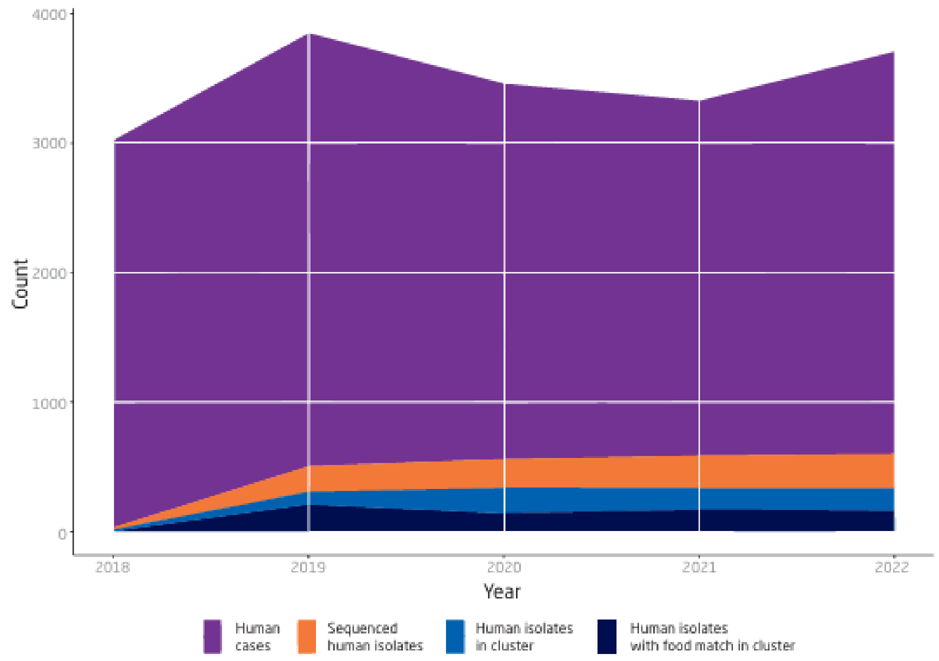
- The Action Plan is dynamic and can be adjusted as new evidence emerges and production systems evolve

Use of WGS in the *Campylobacter* Action Plan

Goals:

- About 6-15 % of human *Campylobacter* cases are typed using Whole Genome Sequencing
- Ongoingly matched to food isolates
- WGS of *Campylobacter* food isolates from official surveillance samples
  - ~ 40-100% of positive samples, primarily from chilled broiler meat
  - To a lesser extend cattle & imported broiler meat
- Clusters are registered at ≥5 human cases (within a 3-month period)

Figure 5.1. Registered human cases with Campylobacter *infections (with no history of travel, pink), Denmark (2018-2022). Sequenced human isolates (C. jejuni and C. coli, orange), human isolates in clusters (≥2 human isolate, light blue), human isolates in clusters with a detected food match (dark blue)*

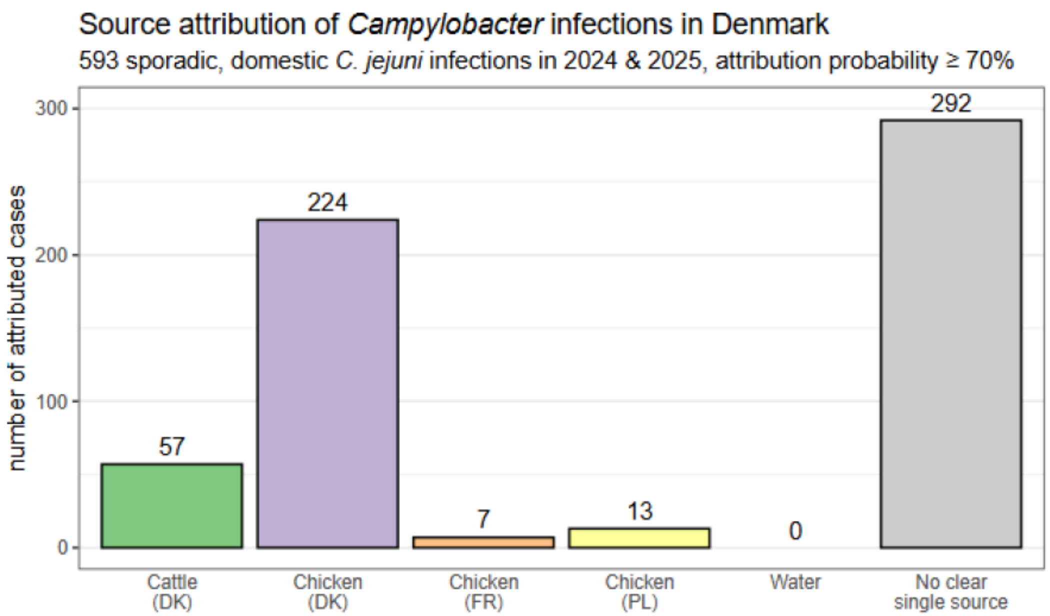


[Annual Report on Zoonoses in Denmark 2022]

Use of WGS in the *Campylobacter* Action Plan (continued)

Goals (cont.):

- Use of WGS to identify *Campylobacter* contamination sources at farm and slaughterhouse level
- Establish which data (and how) can be shared between poultry slaughterhouses and authorities to enable rapid trace-back of contaminated flocks/outbreaks
- Source attribution: Increase the use of WGS and industry data integration to improve identification of transmission routes and support targeted interventions across the broiler production chain
- Enable rapid outbreak detection
- Support targeted *Campylobacter* control measures



Rules and Sampling for *Campylobacter*

- Comprehensive national surveillance in broilers in Denmark
  - cloacal swabs at slaughter – flocks (industry sampling, national rules)
  - routine sampling of broiler meat batches (leg skin) at slaughterhouses (official sampling), incl. WGS of 40-100% of positive samples
    - Due to possible cross-contamination, outbreaks linked to leg skin samples is supported by additional sampling & epidemiological investigation

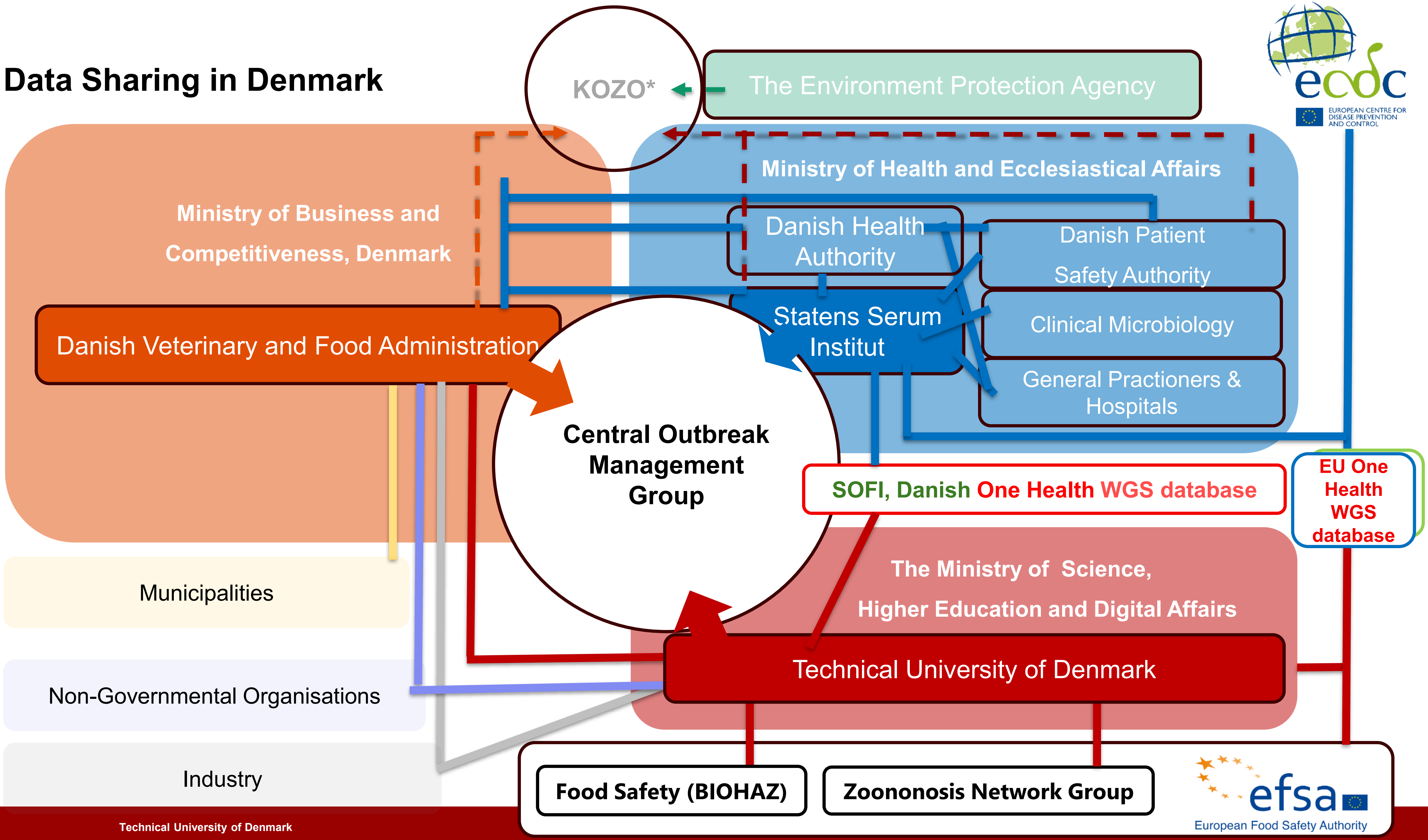
- EU Reg. 2073/2005 on Microbiological criteria
  - *Campylobacter* testing of neck-skin samples at slaughter – process hygiene
  - Exceeding the criterion does not automatically lead to a recall, but triggers corrective actions

- From August 2026, EU Reg. 2025/179 requires sharing outbreak-related *Campylobacter* WGS-data between authorities, laboratories and EFSA
  - not a requirement to sequence all isolates
  - only those associated or suspected to be associated with a foodborne outbreak investigation

▼M1

	Food category	Micro-organisms	Sampling plan (1)		Limits (2)		Analytical reference method (3)	Stage where the criterion applies	Action in case of unsatisfactory results
			n	c	m	M			
	2.1.8 Meat preparations	*E. coli* (8)	5	2	500 cfu/g or cm^2	5 000 cfu/g or cm^2	ISO 16649-1 or 2	End of the manufacturing process	Improvements in production hygiene and improvements in selection and/or origin of raw materials
▼M8	2.1.9 Carcases of broilers	*Campylobacter* spp.	50 (5)	c = 20 From 1.1.2020 c = 15; From 1.1.2025 c = 10	1 000 cfu/g		EN ISO 10272-2	Carcases after chilling	Improvements in slaughter hygiene, review of process controls, of animals' origin and of the biosecurity measures in the farms of origin

Data Sharing in Denmark



Data Sharing with Industry

Current situation in Denmark

- *Campylobacter* data are generated from multiple sources:
  - Official control samples and WGS (DVFA surveillance programme)
  - Slaughterhouse testing and process hygiene monitoring (own-control programmes)
  - Human surveillance and WGS (SSI)

- Data are shared through:
  - *Campylobacter* action plans
  - Bilateral meetings between authorities and industry
  - Outbreak notifications and briefings
  - Dissemination of monitoring results
  - Industry and authority working groups

Case: Two Large National *Campylobacter* Outbreaks in 2025

- Two concurrent ***C. jejuni* outbreaks (ST49 and ST52)** caused a large increase in *Campylobacter* infections during summer and autumn 2025 in Denmark

- Only a small proportion of *Campylobacter*-positive samples were sequenced, but outbreak is estimated to affect around **900 cases in total**

- WGS matching (cgMLST) between human isolates and isolates from national surveillance, identified **Danish broiler meat as the source** of both outbreaks

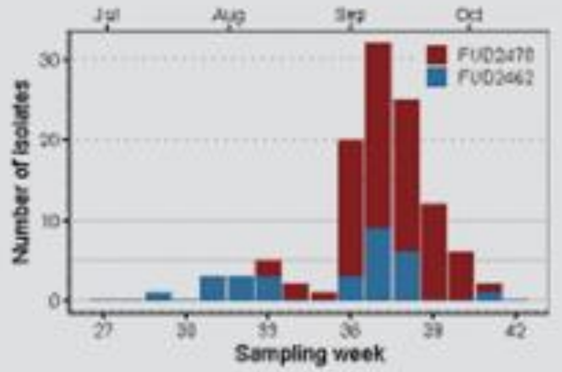


Figure 1.3 Number of Campylobacter jejuni isolates in FUD2470 and FUD2462 in Denmark by week of sampling, July 1st - October 15th, 2025

Annual Report on Zoonoses in Denmark 2025 [Zoonosis - Annual Reports]

Public Health Impact – Two Large National *Campylobacter* Outbreaks in 2025

- The two outbreaks were associated with more severe disease than typically observed for *Campylobacter* infections

- Approximately 40% of identified cases required hospitalization, and 14% had positive blood cultures

- Rapid identification and control of ”high-risk” clones may have significant public health impact

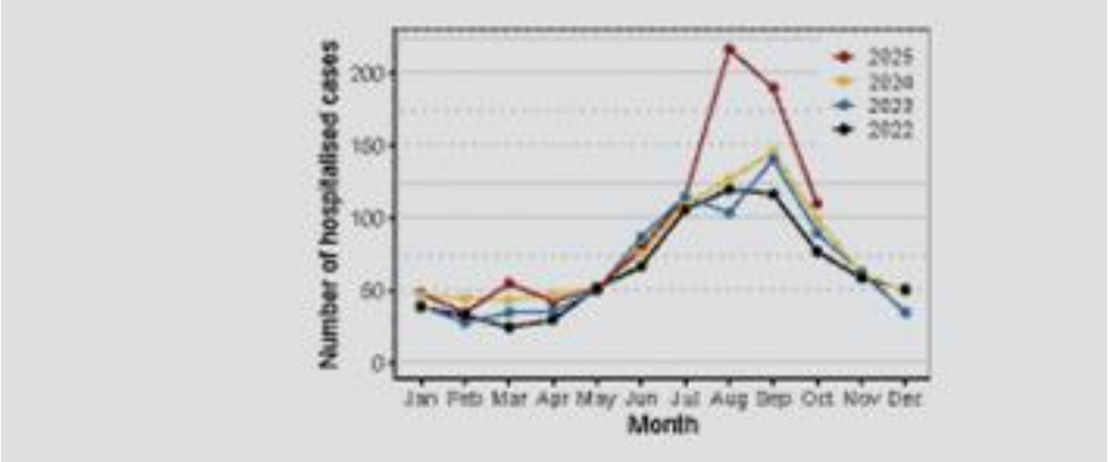


Figure 1.4 Total number of hospitalised Campylobacter cases by month of sampling, 2022-October 2025

Annual Report on Zoonoses in Denmark 2025 [Zoonosis - Annual Reports]

Lessons Learned – Two Large National *Campylobacter* Outbreaks in 2025

The two outbreaks involved multiple farms and slaughterhouses, illustrating how presence can be spread widely through the broiler production chain

Routine *Campylobacter* monitoring in broiler meat provided the microbiological evidence needed for source attribution

Timely sharing of genomic data across authorities enabled rapid outbreak response and targeted interventions

Lessons Learned – Two Large National *Campylobacter* Outbreaks in 2025

What worked well

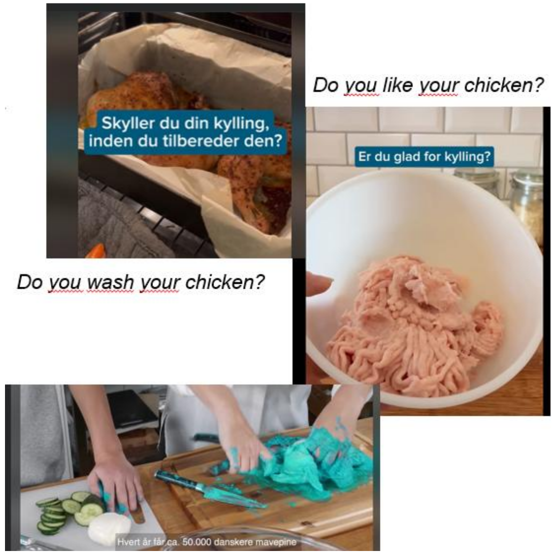
- WGS linked human cases to Danish broiler meat on farm/slaughterhouse level
- Existing national *Campylobacter* surveillance generated food isolates that could be compared with human isolates
- One Health collaboration

Effective response relied on

- Intensified slaughter hygiene measures,
- Official follow-up testing of implicated farms (caecal samples at slaughter),
- Industry engagement, and
- Consumer risk communication on safe handling and cooking of broiler meat

Challenges observed

- Difficult to ”stop” the outbreak
- Outbreak strains appeared across multiple farms and slaughterhouses
- No straightforward legal basis existed for market withdrawal of products solely because *Campylobacter* was present
- Evidence accumulated after much of the implicated meat had already been consumed
- Unclear expectations regarding industry's role during ongoing genomic investigations



Perspectives – Communication & Data Sharing with Industry

What value can industry get from WGS?

- Early identification of recurring (*Campylobacter*) clones within production chains
- Better understanding of whether contamination originates from:
  - specific farms,
  - transport,
  - slaughter processes,
  - or wider dissemination
- Evaluation of the effect of interventions and hygiene measures
- Risk-based prioritization of farms or supplier groups
- Documentation of control efforts towards customers and authorities
- Potential benchmarking across time rather than relying only on prevalence

Possible limitations?

- Different expectations between authorities and industry
- National measures beyond EU requirements may challenge competitiveness and create uneven playing field
- The value proposition of WGS may not be sufficiently clear
  - WGS outputs may be perceived as surveillance information rather than actionable production information
  - Limited regulatory obligations to respond to genomic findings
  - Uncertainty about how industry can or should use outbreak-related genomic information
- The nature of *Campylobacter* transmission pathways – detection at a farm can vary over the year: neg. – neg. – neg. – pos. – neg. –neg. - neg.

Perspectives on *Campylobacter* WGS Official Implementation

- Despite substantial advances in surveillance and control, *Campylobacter* occurrence in broilers remains challenging to reduce

- Future possibilities(?)
  – Enhanced patient interviews to guide targeted food-chain sampling (when needed)
  – Retention of routine broiler samples/isolates for retrospective WGS analysis
  – Continued collaboration and data sharing with industry partners
  – Clear EU guidance on managing WGS-detected *Campylobacter* outbreak strains

- WGS will likely increase the number of detected and resolved *Campylobacter* outbreaks
  – How should industry and competent authorities respond when WGS identifies recurring outbreak strains, but targeted prevention measures remain limited?

Thank you for you attention!

Appendix

Table A9 Occurrence of Campylobacter *in broiler flocks, 2015-2025*[a]

	Cloacal swabs at slaughter		Neck skin samples at slaughter[b]	
	N (Flocks)	% pos	N (Batches)	% pos[c]
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
2024	3,694	28.2	1,065	9.4
2025	3,701	28.3	1,140	12.5

a) See Table A29 for description of the surveillance programmes. In 2014 the sampling method changed from boot swabs collected in the stable 7-10 days before slaughter to cloacal swabs at slaughter according to Danish Order no. 1512 of 13/12/2013
b) In 2018, additional sampling of neck skin began at the slaughterhouses according to Regulation (EC) 2073/2005, see Table A29 for further description
c) Percent positive samples >1,000 cfu/g
d) Corrected from 2022 report

Source: Danish Agriculture and Food Council and Danish Veterinary, Food, Agriculture and Fisheries Agency

Data source: Annual Report on Zoonoses in Denmark 2025 [Zoonosis - Annual Reports]

Data source: Annual Report on Zoonoses in Denmark 2025 Zoonosis - Annual Reports

		N (samples)	% pos	N (samples)	% pos[c]	N (samples)	% pos[c]
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
2024	Conventional	1,233	30.4	762	11.0	33	63.6
	Organic/free-range	97	50.5	143	23.1	33	75.8
2025	Conventional	1233	28.4	772	13.5[d]	30	40.0[f]
	Organic/free-range	97	49.5	92	27.2[e]	25	72.0[g]

a) Centrally coordinated studies (see Table A24 and section 7.4 for description). Limit of quantification: 10 cfu/g
b) Leg-skin samples

1.3 *Campylobacter* outbreaks

During summer and autumn, a marked increase in *Campylobacter* cases was observed compared with previous years. This increase was primarily driven by two large outbreaks caused by *Campylobacter jejuni* ST49 and ST52 (FUD2470 and FUD2462) (see box). A total of 11 *Campylobacter* outbreaks were registered in Denmark in 2025, which was at a similar level to 2024, when 10 outbreaks were registered. All outbreaks were national and caused by *Campylobacter jejuni*. For nine outbreaks, the source was identified as Danish chicken meat, based on whole genome sequencing (WGS) matches between human isolates and food isolates from the same time period.

Two severe *Campylobacter* outbreaks traced to Danish chicken meat

From July to December 2025, Denmark experienced two unusually large, concurrent outbreaks caused by *Campylobacter jejuni* ST49 and ST52 (FUD2470 and FUD2462) (Figure 1.3). In the two outbreaks, 89 and 31 cases were identified, respectively. Under the current national surveillance system, only 10-15% of positive *Campylobacter* samples are sequenced. Using a probability-based approach, the true number of laboratory-confirmed outbreak cases was therefore estimated to be approximately 900 cases in total.

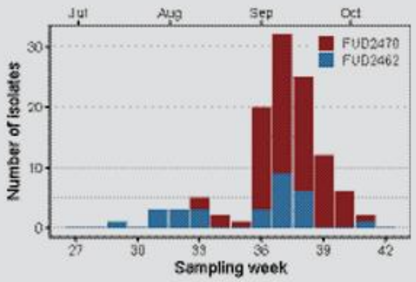


Figure 1.3 Number of Campylobacter jejuni *isolates in FUD2470 and FUD2462 in Denmark by week of sampling, July 1st - October 15th, 2025*

The outbreaks affected people across the country and were associated with more severe clinical outcomes than typically observed for *Campylobacter* infections. Overall, 45 cases (40%) required hospitalisation and 16 cases (14%) had a positive blood culture [3]. Possible contributing factors to the increased severity include higher exposure doses from contaminated products, clone-specific virulence, and/or wider dissemination within the food chain, as multiple slaughterhouses and farms were implicated.

WGS-based matching between human isolates and isolates from Danish chicken meat, identified through the DVFAFA monitoring, established Danish chicken meat as the source of both outbreaks. Control measures included increased focus on slaughter hygiene among broiler producers and at slaughter, follow-up testing of implicated farms to ensure that the specific *Campylobacter* types did not persist, and several consumer-targeted social media campaigns emphasising safe handling and thorough cooking of chicken meat.

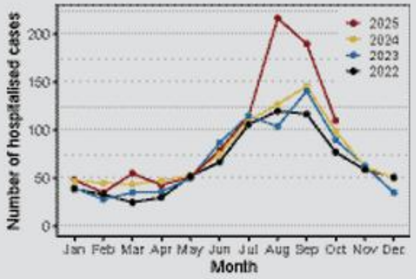


Figure 1.4 Total number of hospitalised Campylobacter *cases by month of sampling, 2022-October 2025*

Data source: Annual Report on Zoonoses in Denmark 2025 [Zoonosis - Annual Reports]

Table A1 Zoonoses in humans, number of laboratory-confirmed cases, 2020-2025

	Incidence per 100,000 inhabitants	Reported no. of cases					
Zoonotic pathogen	2025	2025	2024	2023	2022	2021	2020
Bacteria							
Brucella abortus/melitensis[a,b]	0.0	2	1	1	1	1	1
Campylobacter	95.2	5,714	5,546	5,186	5,142	3,740	3,742
Chlamydia psittaci	0.3	16	35	17	16	25	27
Leptospira spp.	0.2	14	25	13	6	10	14
Listeria monocytogenes	1.4	84	61	54	86	62	43
Mycobacterium bovis	0.0	1	0	2	0	0	0
Salmonella total	17.5	1,051	1,266	1,207	899	692	614
S. Enteritidis	4.3	255	274	384	251	114	117
S. Typhimurium[c]	3.7	223	310	174	208	205	149
Other serotypes	7.1	427	470	649[d]	344	301	302
Shigella/EIEC[e]	13.4	803	728	709	-	-	-
Shigella[f]	2.2	134	140	139	-	-	-
EIEC	1.2	73	82	63	-	-	-
STEC total[g]	17.5	1,049	1,269	1,431	1,330	927	448
O157	0.5	30	32	38	47	32	39
Other O-groups or non-typeable	3.0	183	310	375	394	376	198
HUS cases[h]	0.0	3	13	18	11	12	10
Yersinia enterocolitica total[i]	21.1	1,269	1,296	1,199	747	454	413
Yersinia enterocolitica (Biotype 2, 3, 4 and 5)	1.6	95	99	118	174	137	106

Appendix – Changes in *Campylobacter* human diagnostics

The effect of changing diagnostic method from culture to PCR on the number of episodes of human campylobacteriosis in Denmark: a retrospective study (2015–2022)

Authors: Guido Benedetti, Christian Holm Hansen, Anna Tølbøll Svendsen, Katrine Grimstrup Joensen, Gitte Sørensen, Anne Line Engsbro, Mia Torpdahl, Eva Møller Nielsen, Steen Ethelberg | AUTHORS INFO & AFFILIATIONS

https://doi.org/10.1128/spectrum.03418-23 • Check for updates

TABLE 2 Estimated number (and relative increase) of episodes of human campylobacteriosis in Denmark from January 2018 to December 2021 in a hypothetical scenario where only PCR methods were used (Table view)

	2018	2019	2020	2021
Number of DCMs using PCR at the end of the year, out of nine DCMs	3/9	3/9	3/9	5/9
Analyzed episodes[a]	4,482	5,324	3,680	3,645
PCR effect applied (base model)	5,418	6,388	4,425	4,248
Relative increase	*+21%*	*+20%*	*+20%*	*+17%*
DCM-specific PCR effect applied (model-2)[b]	5,571	6,616	4,608	4,412
Relative increase	*+24%*	*+24%*	*+25%*	*+21%*

[a] The number of episodes here reported does not correspond to the yearly number of registered episodes of campylobacteriosis in Denmark.

[b] This model measured DCM-specific PCR effects. The PCR effect of the base model was applied to the weekly observations from DCMs that did not introduce PCR methods during the entire study period.