# Roberto Croci

The European Programme for Intervention Epidemiology Training (EPIET), Cohort 2023
**Statens Serum Institut (SSI), Denmark**

# Background

The ECDC Fellowship Programme is a two-year competency-based training with two paths: the field epidemiology path (EPIET) and the public health microbiology path (EUPHEM). After the two-year training, EPIET and EUPHEM graduates are considered experts in applying epidemiological or microbiological methods to provide evidence to guide public health interventions for communicable disease prevention and control. The Administrative Decisions ECDC/AD/2022/16 Rev.01 and ECDC/AD/2023/06 govern the European Union (EU)-track and Member State (MS)-track, respectively, of the ECDC Fellowship Programme, field epidemiology path (EPIET) and public health microbiology path (EUPHEM), Cohort 2023.

Both curriculum paths provide training and practical experience using the 'learning-by-doing' approach at acknowledged training sites across the European Union/European Economic Area (EU/EEA). This final report describes the experiences and competencies the fellow acquired by working on various projects, activities, theoretical fellowship training modules, other modules or trainings, and international assignments or exchanges during the fellowship.

# Pre-fellowship short biography

Roberto Croci is a medical doctor who graduated from the University of Milan (2019), with a specialisation in public health medicine (2023). After working at a university hospital in Milan, he gained experiences in applied research and communicable disease surveillance as a fellow at the Italian National Institute of Health (Istituto Superiore di Sanità) in Rome, as a trainee in the surveillance section at ECDC in Stockholm, and as an intern in the public health team at the Organisation for Economic Co-operation and Development in Paris. He is interested in health policy analysis, communicable disease epidemiology, and epidemiological studies, particularly those with a modelling component. In September 2023, he moved to Copenhagen to start his EPIET fellowship at the SSI.

# Results

The objectives of the core competency domains were achieved partly through project and activity work, and partly by participating in the training modules. Results are presented in accordance with the EPIET/EUPHEM core competencies, as set out in the ECDC Fellowship Manual[1].

[1] European Centre for Disease Prevention and Control (ECDC). Manual for the ECDC Fellowship Programme EPIET and EUPHEM paths. Stockholm: ECDC; 2025. Available at: https://www.ecdc.europa.eu/en/publications-data/ecdc-fellowship-programme-manual

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# 1. Epidemiological investigations

## 1.1. Outbreak investigations

### *1.1.1. Outbreak of psittacosis in Denmark, December 2023 to March 2024*

**Supervisors:** Laura Espenhain (SSI), Luise Müller (SSI), Frederik Trier Møller (SSI), Christian Holm Hansen (SSI), Steen Ethelberg (SSI)

**Category:** Respiratory diseases

**Aim:** To investigate sources of exposure, assess disease severity, test the hypothesis of air-borne transmission from dried bird droppings, and inform public health action.

**Methods:** In January 2024, following a marked nationwide increase in *Chlamydia psittaci* detections and atypical pneumonia notifications, the Danish Patient Safety Authority conducted hypothesis-generating interviews with initial cases. Based on these, we designed a case–control study to test the hypothesis that indirect environmental exposure to bird droppings was associated with infection. We matched cases with population controls from the Danish Civil Registration System by age, sex, and region. Exposure data were collected via telephone interviews administered by trained personnel. We estimated adjusted odds ratios (aOR) and 95% confidence intervals (CI) using multivariable conditional logistic regression, with adjustment sets guided by a directed acyclic graph.

**Results:** From December 2023 to March 2024, 27 laboratory-confirmed cases were reported, spanning four out of five Danish Regions. Outbreak cases were significantly older than historical cases (median age: 75 vs. 62 years; p<0.001). Hospitalisation occurred in 81% outbreak cases (22/27) vs. 38% historical cases (p<0.001); 30-day all-cause mortality was 15% (4/27) vs. 2% (p=0.008). Between 13 March and 10 April 2024, we interviewed 19 surviving cases and 57 matched controls. Owning a bird-feeding board (aOR: 2.8; 95% CI: 0.9–9.3, p=0.08) and cleaning bird-contaminated areas (aOR: 3.6; 95% CI: 0.7–18, p =0.12) were more common in cases. Importantly, the study was underpowered to detect effects with statistical significance.

**Public health implications/Conclusions:** Findings supported indirect environmental transmission. We recommended using personal protective equipment (PPE) when cleaning outdoor surfaces exposed to bird activity.

**Role:** Roberto designed the study, collected and analysed the data, and co-led the interpretation. He reported on the outbreak response at the SSI internal preparedness meetings, drafted an outbreak report which was disseminated to the SSI leadership, and is presently contributing – alongside an EU-track EUPHEM fellow at the SSI – to a research paper collating results from the epidemiological, microbiological, and environmental investigations of this nationwide outbreak.

### *1.1.2. Outbreak of gastrointestinal illness linked to pork tenderloin, Capital Region of Denmark, October 2024*

**Supervisors:** Stine Nielsen (SSI), Pernille Kold Munch (SSI)

**Category:** Food- and waterborne diseases

**Aim:** To identify the cause of a gastrointestinal illness outbreak among employees who ate food from a common catering company, and propose control measures.

**Methods:** Between 4–8 November 2024, we conducted a retrospective cohort study using an online questionnaire. Our case definition included any person experiencing one or more gastrointestinal symptoms (diarrhoea, abdominal pain, nausea, or vomiting) within 72 hours of consuming food on 25 or28 October from the catering company. We calculated food item-specific attack rates (AR) and relative risks (RR), using Fisher's exact test to assess associations with illness.

**Results:** Of 588 employees, 138 responded (23%) to the questionnaire; 15 met the case definition. Twelve reported symptoms after lunch on 28 October, and everyone had eaten pork tenderloin. This item showed a 19% AR and a significant association with illness (p =0.03). RR was incalculable due to 100% exposure. Median incubation was 14 hours (interquartile range (IQR): 12–19). Illness lasted a median of two days (IQR: 1–3.25). Symptoms were mostly abdominal pain and diarrhoea (10 cases, respectively). Vomiting was reported by one case. No one was hospitalised or submitted stool samples. Food samples tested negative for *Clostridium perfringens* and *Bacillus cereus*, but clinical and epidemiological features were consistent with *Clostridium perfringens* enterotoxicosis.

Separately, a company – in which the questionnaire was not distributed – reported 30 out of 70 employees fell ill after eating pork tenderloin, which the caterer linked to a malfunctioning oven.

**Public health implications/Conclusions:** We recommended oven repair or replacement, and stricter cooling procedures to prevent spore-forming bacterial growth.

**Role:** Roberto contributed to the outbreak response coordination, designed the study, collected and analysed the data, drafted and circulated the outbreak report, and contributed to the formulation of the recommendations.

## 1.2. Surveillance

### *1.2.1. A quantitative evaluation of the psittacosis surveillance system, Denmark, 2010–2024*

**Supervisors:** Stine Kjær Lefèvre (SSI), Steen Ethelberg (SSI)

**Type of project:** Evaluating a surveillance system

**Aim:** To describe the psittacosis surveillance system in Denmark and assess sensitivity, positive predictive value (PPV), timeliness, and data completeness.

**Methods:** A prior qualitative evaluation (2023) addressed simplicity, acceptability and One Health alignment of the psittacosis surveillance system. We complemented it with a structured system description and a quantitative analysis using two national databases containing clinical notifications and laboratory results. We performed a capture-recapture analysis to estimate total cases and sensitivity, with 95% CI from log-linear models. We calculated PPV, assessed completeness for key variables (e.g. symptom onset, occupation, infection source), and compared notification delays before and after the implementation of electronic reporting.

**Results:** The psittacosis surveillance system operates as a coordinated, stimulated passive surveillance mechanism across human and veterinary sectors. Capture-recapture estimated 361 human cases (95% CI: 355–368). Sensitivity was 77% for clinical notifications (82 missed cases; 95% CI: 77–90) and 94% for laboratory detections (23 missed cases; 95% CI: 18–31). PPV improved from 58% (2010–2012) to 99% (2018–2022), with a modest decline to 85% during the 2023–2024 outbreak. Notification delays decreased from seven days (IQR: 5–11) to three (IQR: 2–5) post-automation ($p<0.001$). Overall, data completeness exceeded 85% and symptom onset completeness rose from <1% to 86%. Documentation of infection source improved (25% to 46%), while occupational exposure reporting remained limited (33%).

**Public health implications/Conclusions:** The psittacosis surveillance system reliably detects cases and reports them quickly. Further improvement in One Health integration could be achieved through structured fields for exposure information, interoperable storage of case interviews, and regular joint reporting across sectors.

**Role:** Roberto developed the evaluation using the predefined EPIET template, analysed the data, drafted the full report, shared it with internal stakeholders, and discussed findings and future implementations of the recommendations with the training site supervisor.

### *Routine surveillance activities*
### *National surveillance of food-borne outbreaks in Denmark, 2023–2025*

**Activities and role:** As an active member of the SSI's outbreak team, Roberto attended internal meetings twice weekly, as well as the weekly joint laboratory-epi coordination sessions. Regular activities included supporting routine outbreak data management, producing customised analyses (e.g. multi-year outbreak trend visualisations), and helping the development and improvement of R scripts to automate and standardise epidemiological reporting.

### *National surveillance of psittacosis in Denmark, 2023–2025*

**Activities and role:** Roberto was responsible for the management of psittacosis at the SSI, initially under supervision and subsequently in full autonomy. He validated clinically notified cases, liaised with laboratory colleagues and the Danish Patient Safety Authority to collect and store patient interview data, and created a dynamic report in R markdown to ease visualisation of case occurrence and clinical/epidemiological characteristics.

### *Standard data project: improving interoperability for food-borne diseases, 2023–2025*

**Activities and role:** This activity aimed to generate a standardised pipeline to harmonise disease surveillance data across five population registries, collating data on the cases' mortality, residence, laboratory-confirmed infection records, hospital contacts, and clinical notifications. Roberto autonomously built the data pipeline for six notifiable pathogens: *Shigella spp.*, *Campylobacter*, *Chlamydia psittaci*, *Yersinia spp.*, *Leptospira spp.*, and hepatitis A virus. Under the supervision of an epidemiologist at the SSI, he improved data consistency across pathogens, aligning the project's outputs with existing case definitions, and supported automated extraction and analysis processes for public health reporting.

### *National HIV surveillance in Denmark, 2023–2025*

**Activities and role:** Roberto significantly enhanced HIV surveillance outputs by creating comprehensive and interactive R Shiny visualisations (tables and plots). Additionally, Roberto helped streamline data by creating an algorithm which automated the classification of variables which were previously coded manually, such as migrant status and late presentation (combining CD4 count and infection date). These contributions currently support routine validation workflows and may inform future annual updates published on the SSI's website.

# 2. Applied public health research

## *2.1. HIV continuum of care estimates in Danish nationals and international migrants, Denmark, 2023*

**Supervisors:** Maarten Nauta (SSI), Maria Wessman (SSI)

**Aim:** To assess Denmark's progress towards the Joint United Nations Programme on HIV/AIDS (UNAIDS) 2025 target of ≥95% of people living with HIV (PLHIV) being aware of their status, and to produce estimates stratified by migrant status to inform targeted interventions.

**Methods:** We used national surveillance data (1983–2023) and population denominators to calculate notification rates. We applied the ECDC HIV Modelling Platform tool to generate PLHIV estimates, and reported rates, proportions and 95% CI derived from parametric bootstrap analyses.

**Results:** Denmark's awareness estimate for 2023 was 96.3% (95% CI: 95.5–96.6), exceeding the UNAIDS target. HIV notification rates were higher among migrants (11.7/100 000) than Danish nationals (0.6/100 000), but cumulative prevalence of undiagnosed HIV was lower among migrants (0.8 vs. 4.2/100 000).

**Public health implications/Conclusions:** These findings support Denmark's progress toward HIV elimination and indicate effective migrant-targeted testing. Model uncertainty remains due to surveillance data limitations, particularly underreporting death due to incomplete linkage of historical AIDS cases due to anonymous testing and structural model assumptions, such as unaccounted outmigration.

**Role:** Roberto wrote the research protocol, performed data analysis, liaised with the ECDC HIV Modelling Platform tool creators for further model specifications, presented findings at the Project Review module in 2024 and subsequently at the European Scientific Conference on Applied Infectious Disease Epidemiology (ESCAIDE) 2024 (oral presentation). A peer-reviewed publication was planned and subsequently deferred, pending surveillance data improvements.

## *2.2. Influenza vaccination attenuates acute myocardial infarction (AMI) and stroke risk following influenza infection: a self-controlled case-series study, Denmark, 2014–2025*

**Supervisors:** Christian Holm Hansen (SSI), Hanne-Dorthe Emborg (SSI), Palle Valentiner-Branth (SSI), Steen Ethelberg (SSI)

**Aim:** To quantify the short-term risk of first-time AMI or stroke following laboratory-confirmed influenza and assess whether vaccination attenuates it.

**Methods:** We conducted a nationwide self-controlled case-series study using Danish health registries from 2014 to 2025. We included individuals aged ≥40 years with a first-ever hospital admission for AMI or stroke within ±365 days of a polymerase-chain reaction-confirmed influenza infection. We defined days 1–7 after specimen date as risk period and excluded a 14-day pre-exposure period to reduce reverse causality. We linked testing, hospitalisation, vaccination and mortality data deterministically via unique personal identifiers. We estimated incidence rate ratios (IRRs) with conditional Poisson regression.

**Results:** Among 1 221 individuals with a first-ever hospital admission for AMI (n=429, 35%) or stroke (n=792, 65%) within ±365 days of 1 231 influenza episodes, the median age was 75 years (IQR: 66–82) and 561 (46%) were female. After calendar month adjustment, the pooled IRR for cardiovascular events during days 1–7 from specimen date was 3.5 (95% CI: 2.6–4.7). It was higher for AMI [4.7 (3.1–7.4)] than stroke [2.9 (2.0–4.2)]. Prior influenza vaccination, recorded in 610 (50%) episodes, reduced the event rate during the risk period by 49% (IRR: 0.51, 95% CI: 0.29–0.91) from 2.97 to 1.57 per person-year (interaction p=0.020).

**Public health implications/Conclusions:** Influenza infection conferred a transiently increased risk of first-time AMI and stroke. Vaccination substantially attenuated this risk, supporting its role in preventing cardiovascular complications after breakthrough infection.

**Role:** The project was initiated by a former EPIET fellow, who drafted a project proposal, formulated the research question and performed the initial data linkage. Roberto continued the work, conceived the study design, led the data linkage across registries and analysis, co-developed the statistical model and validated it with the SSI's statisticians, and drafted the manuscript for publication.

# 3. Teaching and pedagogy

### *Data analysis in R for public health professionals, SSI, 2025*

Roberto developed and delivered two lectures (three hours) aimed at fellow epidemiologists at the SSI. He created teaching materials (slides, datasets, solution scripts) and included a data wrangling and live coding demonstration. In addition, he took part as co-facilitator in pre-existing weekly drop-in clinics (six hours total) supporting real-time troubleshooting of participant-submitted data challenges. These activities were delivered face-to-face. Training needs were assessed pre-course, and the clinics were evaluated post-hoc. Overall, feedback indicated increased autonomy among participants, but also pacing challenges due to differences in learners' baseline level in R.

# 4. Communications related to the EPIET/EUPHEM fellowship

## 4.1. Manuscripts published in peer-reviewed journals

- **Croci R**, Young J, Emborg H, Ethelberg S, Branth PV, Hansen C. Influenza vaccination attenuates acute myocardial infarction and stroke risk following influenza infection: results from a self-controlled case-series study, Denmark, 2014 to 2025. [Submitted to *Eurosuveillance* in September 2025]

## 4.2. Other reports

- Psittacosis outbreak in Denmark, December 2023–March 2024: results of the case–control study [internal report shared with the Statens Serum Institut], 27 March 2024
- EU Health Task Force Mission report, 'Mpox response support in the Democratic Republic of the Congo', 4 September to 15 October 2024 [internal report circulated to the ECDC and EU Health Task Force members]
- Outbreak linked to catered pork tenderloin [internal report shared with the Statens Serum Institut and the Danish Veterinary and Food Administration], 12 November 2024
- Western Bahr el Ghazal State Ministry of Health, 'Cholera outbreak situation report, n. 07', 11 April 2025 [co-written together with South Sudan colleagues at the WHO Country Office (WCO)]
- Global Outbreak Alert and Response Network (GOARN). End of mission report. GOARN Request for Assistance, Cholera, South Sudan, 28 April 2025 [end of mission report shared with the WHO Country Office and GOARN]
- A quantitative assessment of Denmark's psittacosis surveillance system [internal report shared in May 2025].

## 4.3. Conference presentations

- **Croci R**, Nauta M, Eves C, Wessman M. Are we reaching the HIV targets? Modelling-based estimates to assess the first UNAIDS goal, Denmark, 2023 (oral presentation). Presented at ESCAIDE; 22 November 2024; Stockholm, Sweden.
- **Croci R**, Emborg HD, Branth PV, Ethelberg S, Hansen C. Influenza vaccination attenuates acute myocardial infarction and stroke risk following influenza infection: a registry-based, self-controlled case series study, Denmark, 2014–2025 (oral presentation). Presented at ESCAIDE; 21 November 2025; Warsaw, Poland.

## 4.4. Other presentations

- Increase in psittacosis cases: epidemiological overview and actions planned, internal SSI preparedness meeting, 14 February 2024
- Investigating determinants of solving food-borne outbreaks in Denmark: an exploratory analysis of outbreak surveillance data, Nordic Mini Project Review Module, 1 March 2024
- Experiences and lessons learnt: EPIET international assignment – mpox response support in the Democratic Republic of the Congo (DRC), SSI's Tuesday meeting (entire department), 7 January 2025
- My experience as an EPIET-fellow at the SSI: integration within the SSI workforce and deployments, SSI Polymorfien Talk (entire SSI), 2 April 2025 [delivered asynchronously via video]
- Time-series analysis of oral cholera vaccination campaigns and daily trends in cases, WHO's weekly Emergency Preparedness and Response learning session, South Sudan, 10 April 2025

# 5. EPIET/EUPHEM modules attended

- Introductory Course, 25 September–13 October 2023, Spetses, Greece
- Study Protocol and Scientific Writing, 26–27 October and 7–8 November 2023, virtual
- European Scientific Conference on Applied Infectious Disease Epidemiology (ESCAIDE) 2023, 22–24 November 2023, Barcelona, Spain
- Multivariable Analysis, 19–23 February 2024, Berlin, Germany
- Vaccinology, 4–8 March 2024, virtual
- Qualitative Research, 19 and 22 March 2024, virtual
- Rapid Assessment and Survey Methods, 15–19 April 2024, Dublin, Ireland
- Public Health Microbiology II – Biorisk and Quality Management, 21–23 May 2024, virtual
- Public Health Microbiology I – Basic phylogeny, 17–18 June 2024, virtual
- Project Review Module, 26–30 August 2024, Lisbon, Portugal
- European Scientific Conference on Applied Infectious Disease Epidemiology (ESCAIDE) 2024, 20–22 November 2024, Stockholm, Sweden
- Time Series Analysis, 9–13 December 2024, Utrecht, the Netherlands
- One-Health, 12–15 May 2025, virtual
- Public Health Microbiology III – Whole Genome Sequencing, 23–27 June 2025, Vienna, Austria
- Project Review Module, 25–29 August 2025, Lisbon, Portugal
- Public Health Leadership, 1–3 September 2025, Lisbon, Portugal.

# 6. Other training

- BSAFE - security awareness training by the United Nations Department of Safety and Security (UNDSS), 12 April 2024, online
- Public Health Preparedness for Mass Gathering Events, 12 April 2024, online
- Epidemiology in Healthcare Settings, 3–5 July 2024, Berlin, Germany (in-person training by the Robert Koch Institute (RKI) and the United Kingdom Health Security Agency (UKHSA))
- Prevention of sexual exploitation and abuse, 22 August 2024, online
- United to Respect: Preventing sexual harassment and other prohibited conduct, 24 August 2024, online
- WHO's New Policy and Strategy on Preventing and Addressing Sexual Misconduct, 25 August 2024, online
- Mpox: Introductory course for African outbreak contexts offered by the WHO Health Emergencies programme, 1 September 2024, online
- Mpox and the 2022–2023 global outbreak, 1 September 2024 offered by the WHO Health Emergencies programme, online
- Danish Ministry of Economics, 'Introduction to data handling', online, 6 January 2025 [On Danish GDPR/data minimisation]
- Danish language exams (acquired level: B1)

# 7. International assignments

## *Mpox surveillance support, EU Health Task Force deployment, Kinshasa, Democratic Republic of the Congo (DRC), 4 September–15 October 2024*

Deployed through the European Union Health Task Force (EUHTF), hosted by the Directorate-General for European Civil Protection and Humanitarian Aid Operations, and supervised by the ECDC colleague, Vivian Leung, Roberto supported the Ministry of Health of the Democratic Republic of the Congo (DRC), working with international partners including the World Health Organization (WHO), the United States Centers for Disease Control and Prevention (US CDC), and the United Nations Children's Fund (UNICEF) in strengthening mpox surveillance. He worked on cleaning and restructuring subnational line list data, standardising outbreak indicators, and proposing a hotspot definition based on reporting and test-positivity rates.

He co-developed a Shiny application, now hosted on a WHO server (https://worldhealthorg.shinyapps.io/mPoxDRC_completude/), for tracking data completeness across provinces. He also helped modularise existing R scripts, managing 23 different surveillance data formats to facilitate updates and longer-term use. He also contributed to weekly briefing notes for national authorities, supported the review of contact tracing and vaccination tools, and prepared detailed handover documentation for incoming deployees.

### *Cholera outbreak response support, GOARN (Global Outbreak Alert and Response Network) deployment (as epidemiologist), South Sudan, 25 February–22 April 2025*

Roberto was part of an EPIET/EUPHEM roster of deployees supporting the South Sudan Ministry of Health and WHO Country Office (WCO) in cholera surveillance during the country's largest recorded outbreak. He was deployed alongside another EU-track EPIET fellow. During four weeks at the WCO in Juba, he helped reactivate the national cholera dashboard (https://worldhealthorg.shinyapps.io/cholera_dashboard/ ), adding metadata tabs to clarify indicators. He produced a codebook to ensure consistency in variable interpretation. In a field deployment in Wau, in the Western Bahr el Ghazal state (two weeks), he offered task-based capacity building in R analysis tools, supported the local WCO team in validating subnational line lists and developing an enhanced situation report with mapped case occurrence and severity indicators. During a final two-week phase of remote work, he conducted and presented a subnational-level time-series analysis of daily case trends and oral cholera vaccine campaign timing, proposed monitoring treatment adequacy metrics aligned with WHO standards, and prepared handover materials for his successor.

## 8. Other activities

- Contributed to SSI's strategic preparedness initiatives by actively collaborating with the Secretariat for Infectious Preparedness and One Health. Activities included outbreak update delivery on psittacosis (March–April 2024), participation in the mpox coordination group and early mpox outbreak intelligence and case mapping support during the worldwide clade Ib mpox outbreak, including contributions to the public information on SSI's website.
- Organisation of the weekly SSI EPIET and EUPHEM forum meetings
- Active participation in bi-monthly section surveillance meetings.

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