Summary of work activities

Sohvi Kääriäinen

The ECDC Fellowship Programme
Field Epidemiology path (EPIET), 2020 cohort

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.

Both curriculum paths provide training and practical experience using the 'learning by doing' approach in acknowledged training sites across European Union (EU) and European Economic Area (EEA) Member States.

According to Articles 5 and 9 of ECDC's founding regulation (EC No 851/2004) 'the Centre shall, encourage cooperation between expert and reference laboratories, foster the development of sufficient capacity within the community for the diagnosis, detection, identification and characterisation of infectious agents which may threaten public health' and 'as appropriate, support and coordinate training programmes in order to assist Member States and the Commission to have sufficient numbers of trained specialists, in particular in epidemiological surveillance and field investigations, and to have a capability to define health measures to control disease outbreaks'.

Moreover, Article 47 of the Lisbon Treaty states that 'Member States shall, within the framework of a joint programme, encourage the exchange of young workers.' Therefore, ECDC initiated the two-year EUPHEM training programme in 2008. EUPHEM is closely linked to the European Programme for Intervention Epidemiology Training (EPIET). Both EUPHEM and EPIET are considered 'specialist pathways' of the two-year ECDC fellowship programme for applied disease prevention and control.

This report summarises the work activities undertaken by Sohvi Kääriäinen, Cohort 2020 of the Intervention Epidemiology path (EPIET) at the Finnish Institute for Health and Welfare (Terveyden ja hyvinvoinnin laitos, THL).

Pre-fellowship short biography

Sohvi Kääriäinen, MD, PhD, has worked as an infectious disease specialist in the Infection Control Unit in Seinäjoki Central Hospital, Finland. She both trained as a medical doctor and completed her PhD in medicine (2012) in the University of Oulu, Finland. Her doctoral thesis focused on the epidemiology of hospital-associated infections in paediatric secondary care with a focus on viral infections and their prevention. She was clinically trained with a specialisation in Paediatrics (2015) in the University of Oulu, and further specialised in Paediatric Infectious Diseases in Tampere University, Finland (2020). In addition to the medical degrees, Sohvi holds a Master's degree in International Health (2009) from Tampere University. Sohvi has had a keen interest in epidemiology since the start of her medical studies, which led her to the EPIET fellowship programme.

Stockholm, November 2022

Methods

This report accompanies a portfolio that demonstrates the competencies acquired during the EPIET fellowship by working on various projects, activities and theoretical training modules.

Projects included epidemiological contributions to public health event detection and investigation (surveillance and outbreaks); applied epidemiology field research; teaching epidemiology; summarising and communicating scientific evidence and activities with a specific epidemiology focus.

The outcomes include publications, presentations, posters, reports and teaching materials prepared by the fellow. The portfolio presents a summary of all work activities conducted by the fellow, unless prohibited due to confidentiality regulations.

Results

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

1. Epidemiological investigations

Outbreak investigations

1.1 Salmonella Typhimurium outbreak associated with frozen tomato cubes at a lunch restaurant in western Finland, January–February 2021

Supervisor: Ruska Rimhanen-Finne

In late January 2021, gastrointestinal symptoms were reported after eating at a restaurant in western Finland. Two individuals were hospitalised and diagnosed with *Salmonella* Typhimurium infection. We conducted an outbreak investigation to discover the extent and source of the outbreak.

We did a retrospective cohort study, and exposed persons were asked to participate via a press release. We defined a case as a person who ate lunch at the restaurant during 27 and 29 January and developed stomach pain, vomiting or diarrhoea within seven days after the exposure and/or a laboratory-confirmed *Salmonella* Typhimurium infection between 27 January and 26 February. We collected faecal and food samples for PCR and culture, and conducted whole-genome-sequencing of positive samples and cluster analysis by core genome multilocus sequence typing (cgMLST).

During 27 and 29 January, 393 meals were sold and 101 persons, who ate 142 meals in total, participated in the study. Median age was 39 years (range, 16–77), and 39% were female. There were 49 cases (attack rate, 48.5%), including 23 laboratory-confirmed cases, with the onset of disease from 27 January to 4 February. Isolates from cases and frozen tomato cubes were closely related by cgMLST, based on analysis of 2 946 loci. Tomato cubes were used uncooked in salads that were served in the lunch buffet and consumed by 76% of the cases. No statistical association was found between eating the salads and being a case (risk ratio: 1.8; 95% confidence interval: 0.8–3.8; p-value 0.08), which may in part have been due to the small sample size.

Frozen tomato cubes were the most plausible source of the outbreak, all isolates clustered together in cgMLST. Epidemiological findings supported this conclusion since most cases consumed salads with frozen tomato cubes. A rapid withdrawal of the product was conducted on 12 February 2021. The manufacturer labelled the product with a recommendation to cook the frozen product before consumption.

Role: The outbreak investigation was done together with the local outbreak investigation team. Sohvi was the main investigator in THL and coordinated the work between the local and national teams. She performed the data analysis together with another fellow. The report was drafted by three fellows with different areas of responsibilities. Sohvi drafted and submitted a manuscript as a first author to *Eurosurveillance*, which was recently published (publication list reference 1). She orally presented this outbreak investigation at the European Scientific Conference on Applied Infectious Disease Epidemiology (ESCAIDE, 2021).

[1] European Centre for Disease Prevention and Control. European public health training programme. Stockholm: ECDC; 2020. Available from: https://www.ecdc.europa.eu/en/publications-data/ecdc-fellowship-programme-manual-cohort-2021

1.2 An outbreak caused by the SARS-CoV-2 Delta variant (B.1.617.2) in a secondary care hospital in Finland, May 2021

Supervisor: Outi Lyytikäinen

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) Delta variant of concern (B.1.617.2) was introduced to Finland in spring 2021. It caused an outbreak in a secondary care hospital, spreading from one patient to four wards in the hospital and to three primary care facilities in the Kanta-Häme healthcare district (population 171 000) in Finland. We investigated the outbreak to describe the extent of it.

The index cased was hospitalised due to COVID-19 in an isolation room. Six days after the discharge, two secondary cases were diagnosed in two wards, after which contact and droplet precautions were used in all patient care. We defined a case-patient or healthcare worker case (HCW-case) as a person with a positive SARS-CoV-2 RT-PCR test with a known exposure to a SARS-CoV-2 outbreak, either when admitted or working in one of the four healthcare facilities.

In total, 58 case-patients and 45 HCW-cases were detected in four healthcare facilities with median age 73 (range, 30–97) and 38 (range, 19–62) years, respectively. Eighteen case-patients died with median age 80 years (range, 62–96). Only 3% of case-patients were fully vaccinated, 72% had one dose and 24% were unvaccinated. Of the HCW-cases 40% were fully vaccinated, 13% had one dose, and 47% were unvaccinated. A few case-patients got infected despite being hospitalised in a single- or two-person room and cared for by fully vaccinated HCW with universal masking, which suggested transmission from vaccinated HCW-cases. We did not detect transmission from fully vaccinated asymptomatic HCW-cases (n=4). Thirty-six samples were sequenced and revealed Delta variant (B.1.617.2).

Breakthrough infections by the Delta variant via symptomatic and asymptomatic HCW occurred, despite full vaccination and universal masking of HCW causing nosocomial infections. We suggested that utilisation of FFP2/3 respirators while treating COVID-19 patients should be included in national guidelines.

Role: The outbreak investigation was done together with the local outbreak investigation team. Sohvi was a co-investigator and responsible for editing the manuscript during the whole writing process, facilitating communication between the authors and collecting data from different sources. She was the second author in the article published in *Eurosurveillance* (publication list reference 2). A report was also published in a national journal (in Finnish) for infection control (publication list reference 3), where Sohvi was the second author. During the outbreak investigation, the results were presented and discussed by Sohvi in two international meetings – the ECDC-World Health Organization (WHO) network call and WHO infection prevention and control-guideline development group (IPC-GDG) meeting in June 2021.

1.3 Outbreak of enterohaemorrhagic Escherichia coli in July–August 2021, Finland

Supervisor: Timothee Dub

An increasing number of enterohaemorrhagic *Escherichia coli* (EHEC) infections were noticed in summer 2021 across various data sources: a) cases notified in the Finnish National Infectious Diseases Register (NIDR); b) isolates sent to the national reference laboratory in the Finnish Institute for Health and Welfare (THL); and c) outbreak notifications in the National Registry for Food and Waterborne Outbreaks (RYMY). The aim of this project was to determine whether the increase in EHEC cases was due to an outbreak, and to describe the initial findings.

Data was available from NIDR (date of diagnosis, municipality, age, sex), from the laboratory line list (serotyping, Shiga toxin (*stx*) gene(s)), and from the interviews done for all EHEC cases by the local healthcare workers (possible exposures, symptoms and their severity, occupation). We had data until 12 August 2021 for the whole of Finland. We defined a case as person with a stool sample positive for EHEC of serogroup O103 or of unknown serotype, with a date of sample collection after 26 July 2021.

We identified 67 cases between 26 July and 12 August in 36 different municipalities and 12/20 healthcare districts across Finland. Among the 67 cases, 63% were female and the median age was 41 years (range, 2–96). A total of 37 cases were interviewed, although no common risk factor could be identified from the interviews. All cases were symptomatic, 70% had bloody diarrhoea, and 32% were hospitalised. No cases of haemolytic-uremic syndrome (HUS) were reported in the interviews, but two HUS cases were linked to the outbreak through other communications. The severity of symptoms was above what is usual for an *stx1*-carrying EHEC strain.

Based on our investigation, there was a strong suspicion of an ongoing EHEC outbreak requiring further investigation with more detailed questionnaires to discover the source of the outbreak.

Role: This outbreak investigation was carried out together with EUPHEM fellow Dafni Paspaliari. Sohvi was responsible for analysing the data from the NIDR and laboratory line list. The outbreak report was jointly written. This initial investigation was continued by other team members in THL after the confirmation of an existing outbreak.

1.4 Tap water as a source of Legionnaires' disease outbreak spread to several residential buildings and one hospital, March 2021, Finland

Supervisor: Outi Lyytikäinen

Legionnaires' disease (LD) is an important aetiology of atypical pneumonia and can be community-acquired or nosocomial. In March 2021, an increase in pneumonia cases caused by *Legionella pneumophila* serogroup 1 (Lp 1) was observed in a Finnish town (120 000 inhabitants), where single Legionnaires' disease (LD) cases are detected annually.

Microbiology laboratories notify *Legionella* findings and physicians LD cases to the National Infectious Diseases Register in Finland. We interviewed all the cases and obtained water samples from potential places of exposure as part of the enhanced surveillance for *Legionella*. Human and water *Legionella* isolates were compared by whole-genome sequencing (WGS). An LD case was defined as a patient with specimen positive for Lp 1 in UAG/PCR/culture from respiratory specimens, and as residential when at least one water sample from home was positive for Lp 1 or as nosocomial when a patient had stayed in the hospital, where Lp 1 was found in the water system, during the incubation period. A confirmation of the outbreak genotype was required from human and/or water isolate.

We identified 12 LD cases, nine living in different residential buildings and three nosocomial, linked to the outbreak by human and/or water isolate, two cases in 2020 and 10 during February–May 2021. Eleven were diagnosed by urinary antigen test; 10 by PCR and five by culture; age range 52–85 years; 50% were immunocompromised; and one died. Nine out of twelve water samplings at the cases' homes and 16 water samples from the hospital were positive for Lp 1, with concentrations up to 640 000 colony-forming units/L. Water samples from regional containers were negative. The positiveness at homes and the hospital suggested inadequate maintenance measures.

Enhanced surveillance combined with WGS was crucial in detecting this outbreak extending over a period of one year highlighting the importance of environmental sampling even when single LD cases occur. Repeated control measures were implemented to control the outbreak.

Role: The outbreak investigation was done together with the local outbreak investigation team. Sohvi was responsible for editing and reviewing the manuscript and is the second author for the manuscript that has been submitted to *Eurosurveillance* in August 2022 (publication list reference 4). The outbreak was presented orally at ESCAIDE 2021 by the first author; Sohvi was the second author for the abstract.

Training modules related to assignment/projects

EPIET/EUPHEM Introductory Course

The EPIET/EUPHEM Introductory Course introduced the concept of an outbreak investigation and presented the ten steps. The case studies were helpful in giving an understanding of the required skills in outbreak investigations and how the EPIET/EUPHEM training programmes meet these requirements.

Outbreak Investigation Module

The Outbreak Investigation Module provided in-depth epidemiological knowledge in outbreak investigations and introduced the basic skills in analytical epidemiology. Several case studies mimicked the real outbreak investigation giving lots of practical training in epidemiological investigation combined with microbiological investigation.

Multivariable Analysis Module

The Multivariable Analysis Module continued to provide skills needed in analytical epidemiology, especially the use of multivariable analysis in outbreak investigations. This module added to the contents of previous modules and was very useful and practical in giving the skills needed in the fellowship projects.

Educational outcome

During the four outbreak investigations, the fellow was able to gain experience and insight in different outbreaks caused by various pathogens and transmission methods. Sohvi was the main investigator for two outbreaks including a cohort study, and a co-investigator in the other two. These experiences gave the fellow skills both in analytical epidemiology and reporting outbreaks. Three of the outbreaks have been submitted to scientific journals providing excellent experience in scientific writing; Sohvi is the first author for one article and the second author for two.

2. Surveillance

2.1 Coronavirus disease 2019 (COVID-19) in different groups of healthcare workers, during 1 February 2020 – 30 June 2021, Finland

Supervisor: Outi Lyytikäinen

During the Coronavirus disease 2019 (COVID-19) pandemic, healthcare workers (HCWs) were a risk group for contracting COVID-19. We aimed at assessing the incidence, risk factors and outcomes of COVID-19 in HCWs using a retrospective register-based approach during February 2020 – June 2021 in Finland, in order to inform preventive measures in healthcare.

We combined the COVID-19 surveillance data from the National Infectious Diseases Register (NIDR) with professional registrations from the Register of Social Welfare and Healthcare Professionals (Terhikki), using national identity codes. COVID-19 cases were identified from NIDR notifications made by laboratories and physicians, and healthcare professionals from Terhikki. We categorised healthcare professionals into seven groups (dentist, dental nurse, dental hygienist, medical doctor, nurse, nursing assistant and all other HCWs). We calculated cumulative incidences using the Kaplan–Meier estimator during three periods (1 February – 30 June 2020, 1 July – 31 December 2020, and 1 January – 30 June 2021) for these groups. We identified risk factors for COVID-19 infection in a multivariable model using Cox's regression.

We identified 8 009 COVID-19-cases among HCWs, with cumulative incidence of 1.79% during the study period, 1 February 2020 – 30 June 2021; 83% were female, median age was 40.9 years (interquartile range, 31.2–51.6). Physician notification data was available for 6 113/8 009 cases (76.3%); 244/6 113 (4.0%) were hospitalised, 37/6 113 (0.6%) in intensive care, 4/6 113 (<0.1%) died. The incidence was higher (0.95%, 95% CI: 0.92–0.98%) during the latest period compared with the two former periods, 0.32% (95% CI: 0.31–0.34%) and 0.63% (95% CI: 0.60–0.65%). Most COVID-19-cases occurred in nursing assistants (53%) and nurses (17%), who had the highest cumulative incidences at 2.07% (95% CI, 2.01–2.13%) and 1.82% (95% CI, 1.73–1.91%), respectively. Risk factors were male sex (hazard ratio (HR) 1.2; 95% CI, 1.1–1.3), foreign native language (HR 2.5; 95% CI, 2.2–2.9) and foreign country of birth (HR 1.2; 95% CI, 1.1–1.4).

Nurses and nursing assistants, especially men, and professionals with foreign backgrounds, were at higher risk of COVID-19 among HCWs. This should be specifically addressed during training and implementing infection control measures.

Role: Sohvi was the main investigator in this project. She wrote the study protocol, and did the data management and analysis with the helpful assistance of a statistician from THL. Both the analysis and reporting were done by Sohvi. The report was written both in English and in Finnish (publication list reference 5), and the manuscript has Sohvi as the first author. An abstract about the project was submitted to ESCAIDE 2022 and accepted as an online poster.

Training modules related to assignment/projects

EPIET/EUPHEM Introductory Course

The EPIET/EUPHEM Introductory Course introduced the basic concepts of surveilling infectious diseases and the different ways of doing surveillance. To know the main goals of surveillance was important in planning projects and developing protocols.

Multivariable Analysis Module

The Multivariable Analysis Module gave a good insight and better understanding of using different multivariable models, especially logistic regression. It also gave possibilities to practise using STATA in regression modelling.

Educational outcome

The fellow was able to link the national surveillance data for COVID-19 together with the national register for healthcare professionals in order to analyse COVID-19 infections in healthcare workers. Using COVID-19 surveillance was a good learning experience for Sohvi on how the surveillance data can, and cannot, be used. Survival analysis and Cox regression were used in the data analysis for the cumulative incidence of COVID-19 and its risk factors. Thus, the project taught Sohvi many new analytical skills, including the use of multivariable analysis. Also, using large databases linked together taught her a lot about data management.

2.2 Coronavirus disease 2019 (COVID-19) surveillance in Finland (routine surveillance activities)

Supervisors: Outi Lyytikäinen and Emmi Sarvikivi

Sohvi was involved in the national COVID-19 surveillance during the fellowship. She collected and analysed the weekly data for COVID-19 contact tracing and helped in reporting the data nationally during the first six months of the fellowship. As part of this activity, she developed the questionnaire used for data collection and presented this work in three national COVID-19 meetings with healthcare professionals.

Sohvi also participated in planning an evaluation of COVID-19 surveillance in Finland, which was a shared project between the three fellows from Cohort 2020 in THL. This involved writing the protocol, including the plan of analysis for the evaluation together with the other fellows.

During the second year of the fellowship, Sohvi analysed the national data for children's COVID-19-related hospitalisations. This work is still ongoing and will be presented in a manuscript later in the year 2022.

Role: Sohvi worked with these surveillance activities alongside the main EPIET projects during the two years. She was the main investigator analysing the children's COVID-19 hospitalisation data.

Training modules related to assignment/projects

EPIET/EUPHEM Introductory Course

The EPIET/EUPHEM Introductory Course introduced the basic concepts of surveillance of infectious diseases. The knowledge this module provided was very useful when starting to work with COVID-19 surveillance. The Introductory Course provided the skills needed at the initial stages of the fellowship and enabled the fellow to contribute to the national COVID-19 surveillance.

Educational outcome

Participation in the routine surveillance work in the context of COVID-19 gave the fellow a nice experience of learning how the daily and weekly surveillance for COVID-19 was conducted in Finland, as well as teaching her to face challenges in infectious diseases surveillance. Writing the protocol for the evaluation of the surveillance system taught her a lot about how the COVID-19 surveillance was designed in Finland.

2.3 Surveillance of food- and waterborne outbreaks (routine surveillance activities)

Supervisor: Ruska Rimhanen-Finne

Sohvi worked closely with the team for food- and waterborne outbreaks in THL during January–February 2021. This work involved the surveillance of food- and waterborne outbreak notifications and risk assessment of the notifications. During this time, there were quite a few outbreaks that were investigated locally with the support of THL in a consulting capacity. Sohvi contributed to this work by contacting the local outbreak investigation teams, analysing the results together with the local investigators, cooperating with the Finnish Food Authority and evaluating the outbreak reports sent to THL and the Finnish Food Authority.

Role: Sohvi was an active part of the team during the two-month period. She took responsibility in the surveillance of outbreak notifications as well as facilitating communication between the different parties involved.

Training modules related to assignment/projects

EPIET/EUPHEM Introductory Course

The Introductory Course taught Sohvi the basic concepts pertaining to the surveillance of infectious diseases and outbreak investigations. These skills enabled Sohvi to contribute to the work done by the food- and waterborne surveillance team.

Outbreak investigation module

This module further deepened Sohvi's knowledge in analytical studies in outbreak investigations with various practical examples. She learnt a lot both concerning the different study designs as well as interpreting the results of outbreak investigation.

Educational outcome

The fellow learnt how the surveillance for food- and waterborne outbreaks is done in Finland, and gained invaluable experience through her participation in the collaborative work between THL and the Finnish Food Authority. Supporting local outbreak investigation teams helped Sohvi understand how outbreaks are investigated in a local setting and the kind of support these teams might need from THL.

3. Applied public health research

Risk of lymphoma increased after Puumala virus infection in Finland, 2009–2019: a retrospective register-based study

Supervisors: Outi Lyytikäinen and Timothee Dub

Puumala virus (PUUV) belongs to the rodent-borne *Orthohantavirus* genus and causes haemorrhagic fever with renal syndrome. An increased risk of lymphoma following PUUV infection has been reported in Sweden, with the highest risk soon after infection and decreasing over time. We aimed to estimate the risk of lymphoma following PUUV infection in a retrospective register-based study in Finland where PUUV is endemic with high incidence (31/100 000).

We linked data from the Finnish Cancer Registry, where lymphomas are reported by healthcare professionals, and the National Infectious Diseases Register, where PUUV infections are notified by microbiology laboratories. Laboratory notification for PUUV includes data on sex and region of residence. We linked registers for a period from 1 January 2009 to 31 December 2019 using national identity codes. We used time-dependent Cox regression models to evaluate the hazard of lymphoma within different follow-up periods after PUUV infection. The main time scale was age in the model, and we allowed for different baseline hazards. Sex, region (healthcare district), birth-year cohort (with five-year intervals) and PUUV infection during years 2004−2008 were added to the model. In addition to all lymphoma cases as one group, Cox regression was performed for groups of lymphoma using Haemacare classification for the categories where there were more than five cases of lymphoma after PUUV infection.

We identified 90 lymphoma cases among 16 075 PUUV-infected persons during 61 114 950 person-years of observation. Ten cases of lymphoma occurred within 3−12 months after PUUV infection, and 38 cases in the 1−4 years after PUUV exposure. The risk of lymphoma was increased in 3−12 months and 1−4 years after PUUV infection, with hazard ratio (HR) 2.0 (95% confidence interval (CI): 1.1−3.7) and HR 1.6 (95% CI: 1.2−2.3), respectively. There was no significant association between PUUV infection and lymphoma more than five years after the infection. Female sex decreased the risk of lymphoma development after PUUV infection with HR 0.67 (95%CI, 0.65−0.69; p-value<0.001). The association between the risk of lymphoma and PUUV infection was significant in the group of mature B-cell neoplasms for 3−12 months and 1−4 years after PUUV infection, HR 2.22 (95% CI, 1.15−4.26; p-value 0.017) and HR 1.80 (95% CI, 1.29−2.52; p-value 0.001), respectively. Other groups could not be reliably tested because of the low number of cases after PUUV infection.

The risk of lymphoma increased following PUUV infection in the Finnish population, supporting earlier findings in Sweden. The risk was related to lymphomas with B-cell origin. Further research is required to understand the physiopathological mechanisms behind this association and the public health impact.

Role: Sohvi was the main investigator in this project, starting with drafting the study protocol and seeking study permission. She did the data management and data analysis, wrote a report, drafted the manuscript as the first author, submitted an abstract for ESCAIDE (accepted as oral presentation), and coordinated the work between the co-authors. A report for the research project summarising findings has been approved, and a manuscript will be finalised during autumn 2022.

Training modules related to assignment/projects

Multivariable Analysis Module

The Multivariable Analysis Module covered the most common methods of multivariable models and gave possibilities to practise the building and usage of the models. The fellow was able to further develop these skills gained during the module in the research project.

Time Series Analysis module

The Time Series Analysis module with lectures and several practices was useful in understanding time series analyses and its methods. Even though time series analysis was not used in this project itself, the fellow was able to use the Puumala virus data during the Time Series Analysis module for the purposes of training.

Educational outcome

In this project, Sohvi was further able to train her skills in carrying out a research project, including planning of the project, writing the study protocol, conducting data analysis and reporting. Combining data from two national registers required careful planning in terms of terminology and classification of diseases. This project taught Sohvi a lot about register-based research and the options for study designs. She continued to develop her skills in Cox regression using a large database. As the research group had people from different institutions, good communication skills were also needed to carry out the project.

4. Teaching and pedagogy

4.1. Course: Essentials of Infectious Diseases Epidemiology

This course was organised by Prof. Ralf Reintjes from the University of Hamburg, and was targeted at Master's and PhD students in Public and Global Health in Tampere University. The fellows joined Prof. Reintjes for a whole week of teaching – giving lectures and facilitating case studies. Sohvi gave one lecture and facilitated several case studies. The lecture, 'Control measures against COVID-19', was built from the scratch. Materials for the case studies were already available. The course was organised online. The feedback collected by the fellows was very positive.

4.2. Lecture: How to measure the burden of hospital-associated infections

This lecture was given to nurses in a theoretical training for infection control at the Arcada University of Applied Sciences. The training material was developed based on the previous material used in this course. The duration of the lecture was 90 minutes and it was given online because of pandemic restrictions. Feedback was collected from the students after the lecture as part of the general feedback for the lecture series and was overall positive.

Training modules related to assignment/projects

EPIET/EUPHEM Introductory Course

The EPIET/EUPHEM Introductory Course introduced the basic concepts of epidemiology, including different study settings and measures of association. The case studies used in the course at Tampere University were very similar to those used in the Introductory Course, thus the experience of the Introductory Course was useful when facilitating the case studies.

Educational outcome

Sohvi gained valuable experience in the field of public health teaching during the fellowship by giving two lectures and participating in a week-long teaching activity at the Tampere University. For one of the lectures which did not have any previous teaching materials, Sohvi prepared content on infection control measures during COVID-19 pandemic and delivered the lecture. The experience of facilitating case studies was new for Sohvi, and she really enjoyed that. In doing this, she needed to take into account the background of participants, as they had different cultural and professional backgrounds, as well as the requirements set by the time allocated for case studies and the module taking place online due to pandemic precautions. Sohvi welcomed these challenges as important ways to develop her teaching skills.

5. Communication

5.1 Publications related to the EPIET fellowship

1. **Kääriäinen S**, Obach D, Paspaliari DK, Tofferi M, Nieminen A, Pihlajasaari A, Kuronen H, Vainio A, Rimhanen-Finne R. *Salmonella* Typhimurium outbreak associated with frozen tomato cubes at a restaurant in western Finland, January–February 2021. Euro Surveill. 2022;27(41):pii=2200316. https://www.eurosurveillance.org/content/10.2807/1560-7917.ES.2022.27.41.2200316

2. Hetemäki I, **Kääriäinen S**, Alho P, Mikkola J, Savolainen-Kopra C, Ikonen N, Nohynek H, Lyytikäinen O. An outbreak caused by the SARS-CoV-2 Delta variant (B.1.617.2) in a secondary care hospital in Finland, May 2021. Euro Surveill. 2021;26(30):pii=2100636. https://doi.org/10.2807/1560- 7917.ES.2021.26.30.2100636

3. Hetemäki Iivo, **Kääriäinen Sohvi**, Lyytikäinen Outi. SARS-CoV-2 deltavariantin aiheuttama sairaalaepidemia Kanta-Hämeen sairaanhoitopiirissä toukokuussa 2021. Infektioiden torjunta 2021;39:34–37. Article in Finnish. Not peer-reviewed.

4. Mentula S, **Kääriäinen S**, Jaakola S, Niittynen M, Airaksinen P, Koivula I, Lehtola M, Mauranen E, Mononen I, Savolainen R, Haatainen S, Lyytikäinen O. Tap water as a source of Legionnaires' disease outbreak identified by whole-genome sequencing spread to several residential buildings and one hospital. Manuscript submitted to *Eurosurveillance*.

5. **Kääriäinen S**, Harjunmaa U, Hannila-Handelberg T, Ollgren J, Lyytikäinen O. Koronavirusinfektiot (COVID-19) terveyden- ja sosiaalihuollon työntekijöillä Suomessa 1.2.2020–30.6.2021: Rekisteripohjainen kohorttitutkimus. Report in Finnish, published by THL. Available from: https://www.julkari.fi/handle/10024/144427

6. **Kääriäinen S**, Harjunmaa U, Hannila-Handelberg T, Ollgren J, Lyytikäinen O. Nursing assistants and nurses had the highest risk of Coronavirus Disease 2019 (COVID-19) among healthcare professionals during 1 February 2020 and 30 June 2021 in Finland. *Manuscript in preparation*.

7. **Kääriäinen S**, Dub T, Ollgren J, Laine O, Sinisalo M, Lyytikäinen O. Risk of lymphoma increased after Puumala virus infection in Finland, 2009–2019: a retrospective register-based study. *Manuscript in preparation*.

5.2 Reports

1. Surveillance project: Nursing assistants and nurses had the highest risk of Coronavirus Disease 2019 (COVID-19) among healthcare professionals during 1 February 2020 and 30 June 2021 in Finland

2. Applied public health research: Risk of lymphoma increased after Puumala virus infection in Finland, 2009–2019: a retrospective register-based study

3. Outbreak report: *Salmonella* Typhimurium outbreak associated with frozen tomato cubes at a lunch restaurant in western Finland, January—February 2021

4. Outbreak report: Outbreak of enterohaemorrhagic *Escherichia coli* in July–August 2021, Finland

5.3 Conference presentations

1. **Kääriäinen S**, Obach D, Paspaliari D, Tofferi M, Nieminen A, Pihlajasaari A et al. *Salmonella* Typhimurium outbreak associated with frozen tomato cubes at a lunch restaurant in western Finland, January–February 2021. Oral presentation in ESCAIDE 2021 (Fireside session, 16.11.2021).

2. Mentula S, **Kääriäinen S**, Jaakola S, Niittynen M, Airaksinen P, Koivula I et al. Tap water as a source of legionellosis outbreak spread to several residential buildings and one hospital. Oral presentation in ESCAIDE 2021, presented by S. Mentula.

3. **Kääriäinen S**, Harjunmaa U, Hannila-Handelberg T, Ollgren J, Lyytikäinen O. Nursing assistants and nurses had the highest risk of Coronavirus Disease 2019 (COVID-19) among healthcare professionals during 1 February 2020 and 30 June 2021 in Finland. Abstract accepted to ESCAIDE 2022, online poster.

4. **Kääriäinen S**, Dub T, Ollgren J, Laine O, Sinisalo M, Lyytikäinen O. Risk of lymphoma increased after Puumala virus infection in Finland, 2009–2019: a retrospective register-based study. Abstract accepted to ESCAIDE 2022, oral presentation.

5.4 Other presentations

Technical meetings:
- 11.06.2021 COVID-19 B.1.167.2 outbreak in healthcare, oral presentation in Regional Joint ECDC/WHO Europe COVID-19 Surveillance and Virology network call
- 24.6.2021 COVID-19 B.1.167.2 outbreak in healthcare, oral presentation in WHO COVID-19 IPC GDG meeting
- 31.8.2021 COVID-19 infections in healthcare workers in Finland, oral presentation in the National Immunisation Technical Advisory Group in Finland

Presentations in EPIET/EUPHEM modules:
- 07.12.2020 STEC and EPEC outbreak in 2016, oral presentation in Outbreak Investigation Module
- 23.03.2021 COVID-19 infections in healthcare workers in Finland, surveillance project protocol, oral presentation in Nordic Mini Project Review Module
- 23.08.2021 *Salmonella* Typhimurium outbreak, oral presentation in Project Review Module
- 08.03.2022 Puumala virus infection and the risk of lymphoma research project protocol, oral presentation in Nordic Mini Project Review Module

Local EPIET/EUPHEM meetings at THL:
- 03.12.2020 STEC and EPEC outbreak in 2016, oral presentation
- 25.02.2021 *Salmonella* Typhimurium outbreak, oral presentation
- 20.05.2021 *Salmonella* Typhimurium outbreak, oral presentation
- 17.06.2021 COVID-19 B.1.167.2 outbreak in healthcare, oral presentation
- 13.10.2021 COVID-19 B.1.167.2 outbreak in healthcare, oral presentation
- 04.11.2021 EHEC outbreak, oral presentation together with EU-EUPHEM fellow Dafni Paspaliari
- 03.03.2022 Puumala virus infection and the risk of lymphoma research project protocol, oral presentation

Other meetings at THL:
- 25.05.2021 *Salmonella* Typhimurium outbreak, oral presentation in THL Outbreak meeting
- 13.10.2021 COVID-19 B.1.167.2 outbreak investigation, oral presentation in Webinar 'COVID-19 implications for infection prevention and control in hospital settings'. Part of Thematic Programme for Health Promotion and Prevention: Nordic – Russian Cooperation on Antimicrobial Resistance (AMR) Containment, 2019–2020
- 03.03.2022 COVID-19 infections in healthcare workers in Finland, oral presentation in THL COVID-19 task force meeting, (uploaded in EVA)
- 29.03.2022 COVID-19 infections in healthcare workers in Finland, oral presentation in the COVID-19 national meeting between THL and healthcare providers

5.5 Other activities

1. Writing following chapters for the Annual Communicable Disease Report 2020 (https://thl.fi/documents/533963/7590511/Tartuntataudit+Suomessa+2020_28.9.2021.pdf/d9ac4a3b-c02f-e215-3e56-6e85f9ff6266?t=1632823785134)
   - Bacterial and fungal blood cultures and CSF cultures in adult population and in children
   - Group B Streptococcus blood culture positive infections in neonates

2. Writing following chapters for the Annual Communicable Disease Report 2021 (https://thl.fi/documents/533963/593236/Tartuntataudit+Suomessa+2021.pdf/fe3ebfd7-5dcd-16b5-d3fc-48bbef19881c?t=1655727852495)
   - Bacterial and fungal blood cultures and CSF cultures in adult population and in children
   - Group B Streptococcus blood culture positive infections in neonates

6. Other activities

1. Peer review of a *Eurosurveillance* manuscript under the guidance of the site supervisor Outi Lyytikäinen, who was invited to peer review by *Eurosurveillance*.

7. EPIET/EUPHEM modules attended

1. Fellowship Digital Introductory Course, 28.9.–16.10.2020, online

2. Inject days on Operational Research, 9.11.–10.11.2020, online

3. Outbreak Investigation Module, 7.12.–11.12.2020, online

4. Multivariable Analysis Module, 15.2.–19.2.2021, online
5. Inject day on Multivariable Analysis Module, 18.3.2021, online
6. Introduction Course part III, 26.4.–30.4.2021; 4.5.2021 and 7.5.2021, online
7. Rapid Assessment and Survey Methods module 5.5.–6.5.2021, online
8. Project Review Module, 23.8.–26.8.2021, online
9. Vaccinology Module, 14.2.–18.2.2022, online
10. Time Series Analysis Module, 3.4.–8.4.2022, Rome, Italy
11. Management, Leadership and Communication in Public Health, 13.6.–17.6.2022, hybrid
12. Project Review Module, Lisbon, Portugal, 29.8.–2.9.2022

8. Other training

1. Nordic Mini Project Review Module, 23.3.–24.3.2021, online
2. Nordic Mini Project Review Module, 7.3.–8.3.2022, hybrid
3. European Advanced Course in Clinical Tuberculosis (EACCTB), 6.6.–8.6.202, Helsinki, Finland

Discussion

Coordinator's conclusions

Emily White Johansson

Sohvi started her fellowship with strong clinical and epidemiological experience, including clinical work as an infectious disease specialist and research expertise in hospital-associated infections. During her two-year fellowship, Sohvi exceeded the number of projects to satisfy EPIET requirements, while producing high-quality outputs on diverse topics that expanded her competencies into new areas and methodologies.

Sohvi was involved in six field assignments including four outbreak investigations, one surveillance project and one research study, in addition to multiple routine surveillance activities. Sohvi's work resulted in seven manuscripts (first author on four manuscripts), four surveillance reports, and four conference presentations. There are numerous highlights from this portfolio including: a) four outbreak investigations spanning different pathogens and transmission modes using advanced epidemiological analysis and whole genome sequencing; b) surveillance of COVID-19 among healthcare workers by combining surveillance data with a professional registration database to highlight the disproportionate impact on nurses and nursing assistants; c) research on Puumala virus infection and lymphoma outcomes by combining surveillance data with cancer registry data, and using Cox proportional hazard models for analyses.

Through the fellowship, Sohvi developed new competencies, including practical experience in outbreak investigations, advanced registry-based research methods, and further experience in preparing research manuscripts and conference presentations. Sohvi showed perseverance through the two-year period marked by COVID-19 restrictions, remote working, and disruptions to in-person training and networking opportunities.

Sohvi is hard working, committed, competent, able to work independently and within teams; she is well respected by peers and supervisors. She received excellent supervision at THL that also drove her fellowship towards success. I am delighted that Sohvi will continue at THL and hopefully stay engaged with EPIET. Sohvi's strong competencies, combined with her personal characteristics, make her an exceptional field epidemiologist. I hope our paths cross again in the future, and I wish her only the best in what will undoubtably be a bright professional future ahead.

Supervisors' conclusions

Outi Lyytikäinen, Timothee Dub

During the two-year fellowship at THL, Sohvi has been involved in a variety of public health activities, including surveillance, outbreak investigations, descriptive and analytical epidemiology and research, as well as communication and teaching, as described in the core competencies of the EPIET programme.

The outcome of her work has been excellent, benefitting the department of health security as well as the international community. She has contributed to the development of Finnish surveillance systems by utilising data from different national registers. Sohvi was also involved in a very diverse set of outbreak investigations, which were conducted in multi-professional collaborations and led to new recommendations and guidelines.

Her project, 'COVID-19 in different groups of healthcare professionals' provided valuable information on issues to address when training healthcare workers on infection control measures. Her research project on risk of lymphoma after Puumala virus infection interestingly confirmed the earlier findings by Swedish colleagues and requires further research to understand the mechanism behind it and the public health impact.

During her fellowship, Sohvi increased her confidence in the field of infectious diseases epidemiology, especially in register-based linkage studies and advanced statistical methods. Her participation in the daily work of the department has made it possible for the supervisors to carry out projects that would have been impossible to accomplish otherwise. The fellow developed both personally and professionally during the fellowship and solved the given tasks in a highly competent way with a high and increasing degree of independence, but at the same time seeking assistance when necessary. A positive attitude towards challenges in the field of infectious diseases, and an open mind towards colleagues makes the fellow a very good team player. We are fortunate that Sohvi will be staying at THL after graduation. We are looking forward to having her involved in project supervision of fellows from the next batch of cohorts.

Personal conclusions of fellow

During my time as a member-state EPIET fellow at THL, Finland, I got to further develop my skills in the field of epidemiology. Before the fellowship I had had some experience in outbreak investigations as well as in epidemiological research. However, the fellowship offered me a great opportunity to learn more, deepen my knowledge and get a lot of practical experiences in these areas. Mostly I enjoyed learning to do register-based studies using national registers. Also, I got valuable experience in scientific writing and reporting outbreaks under the guidance of my site supervisor, Outi Lyytikäinen. As the pandemic was going on through the entire duration of my fellowship, I was able to follow closely and contribute to some of the work pertaining to the pandemic in THL. By doing this I gained a lot of insight on leadership and management during a crisis. Even though most of the fellowship modules were organised online, they were very helpful in bringing structure to the fellowship and providing possibilities to practise my skills in various scenarios in case studies.

Acknowledgements of fellow

I wish to express my deepest gratitude to my site supervisor, Outi Lyytikäinen, who guided me through the fellowship with her vast experience, professionalism and wisdom. She was always there to help me further my projects and created great opportunities for learning. I am also very thankful to my co-supervisor, Timothee Dub, who gave good guidance in her supervision and cared for the fellows' well-being. Thanks for helping me to keep my focus right. I also want to thank the statistician, Jukka Ollgren, my line manager, Emmi Sarvikivi and outbreak investigation supervisor, Ruska Rimhanen-Finne for your help and good collaboration during the fellowship. Many thanks belong to the whole team in THL.

I'm very grateful for my frontline scientific coordinators, Zaida Herrador Ortiz and Emily White Johansson. Your professional enthusiasm, guidance and encouragement were a great help and a source of inspiration for me. I also wish to thank the whole ECDC fellowship team, coordinators and supervisors and all those involved in delivering the modules.

During the fellowship I had a great opportunity to collaborate with local outbreak investigation teams across Finland – many thanks to you all for providing me these learning opportunities.

I wish to express my thankfulness for my co-fellows in THL, Dorothee Obach and Dafni Paspaliari. The fellowship would not have been the same without you. I am thankful for your friendship and support during the fellowship, and all the fun we experienced together. Also, many thanks to the other fellows in THL, Charlotte Hammer and Eveline Otte im Kampe. It has been great to get to know you both. Lastly, I am thankful for the EPIET/EUPHEM/PAE Cohort 2020, it has been great to work with you all.