

Summary of work activities

Luís Alves de Sousa
European Programme for Intervention
Epidemiology Training (EPIET), 2019 cohort

Background

ECDC's Fellowship Programme is a two-year competency based training course offering two paths: the field epidemiology path (EPIET) and the public health microbiology path (EUPHEM). After the two-year training course, the graduates will have extensive expertise in applying epidemiological or microbiological methods to guide public health interventions for communicable disease prevention and control.

Both curriculum paths provide training and practical experience through a 'learning by doing' approach at 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' which is why 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 Luís Alves de Sousa, cohort 2019 of the Intervention Epidemiology path (EPIET) at the Statens Serum Institut, Copenhagen, Denmark.

Pre-fellowship short biography

Luís Alves de Sousa graduated as a medical doctor (2010), obtained a Master of Public Health degree from Imperial College, London (2013) and is a qualified public health medical specialist recognised by the Portuguese Medical Association (2016). Prior to EPIET, Luís worked on epidemiological surveillance for transmissible diseases, outbreak investigation, health planning and health protection, both at local and regional public health units in Portugal.

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 and the summary and communication of scientific evidence and activities with a specific epidemiological focus.

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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, with the exception of those prohibited for reasons of confidentiality.

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 Manual¹.

1. Epidemiological investigations

1.1 Outbreak investigations

Campylobacter jejuni outbreak, Bornholm, Denmark, November 2019

Supervisors: Steen Ethelberg, Luise Müller, Laura Espenhain

On 28 November 2019, an unusually high number (14) of *Campylobacter* cases were reported on the Danish island of Bornholm. We initiated an outbreak investigation to identify the source and define control measures.

A case was defined as an individual with laboratory-confirmed *Campylobacter* spp. in November 2019, that had been living on Bornholm island during the incubation period (seven days before symptom onset) and not travelled outside Bornholm in the seven days before symptom onset. Initially, we assessed food consumption seven days before symptom onset by means of a trawling questionnaire, followed by an age-, sex- and residence-matched case-control study. We randomly selected controls from the Danish Civil Registration System. We analysed data with conditional logistic regression. We performed trace-back guided environmental investigation. Human isolates were sequenced with whole genome sequencing (WGS).

We identified 31 cases with an age range of 1–85 years; 21 of which were male (68%). Seven isolates were identically identified with WGS as type ST42. The matched case-control study included 25 cases and 75 controls. Cases were more likely to have consumed brand A milk (mOR 4.0; 95% CI 1.3 – 12; p=0.02). Brand A milk also presented a positive dose- and frequency-response association. No *Campylobacter* was isolated from raw or pasteurised milk samples collected from the dairy plant tanks or from packaged brand A pasteurised milk on retailers' premises. No *Campylobacter* was isolated from the water supply of the dairy plant. Dairy plant inspection did not identify a cause of contamination in pasteurisation.

Epidemiological and laboratory findings suggest brand A pasteurised milk as a probable source of this *Campylobacter* outbreak in Bornholm. We recommended reviewing the equipment and all stages of the process of pasteurisation/safe milk handling at the dairy production plant inspected.

Role and outputs: Principal investigator. During this outbreak investigation, Luís participated in the case definition work, and was responsible for the data extraction form, performing data entry, updating the outbreak line-list and performing data analysis. Luís also wrote an internal outbreak report and a final outbreak report for EPIET.

Campylobacter jejuni outbreak, Bornholm, Denmark, June 2020

Supervisors: Steen Ethelberg, Luise Müller, Laura Espenhain

On 31 May 2020, a remarkably high number (70) of *Campylobacter* cases were reported on the Danish island of Bornholm. We initiated an outbreak investigation to identify the source and define control measures.

A confirmed case was defined as an individual with laboratory-confirmed *Campylobacter* spp. diagnosed between 28 May and 9 June 2020, living on Bornholm and not having travelled during the seven days before symptom onset. Initially, we assessed food consumption seven days before symptom onset by means of a trawling questionnaire, followed by an age-, sex- and residence-matched case-control study. We randomly selected controls from the Danish Civil Registration System. We analysed data with logistic regression. We performed trace-back guided environmental investigation. Human isolates were sequenced with whole genome sequencing (WGS).

We identified 161 confirmed cases with an age range of 0–97 years; 97 of which were male (60%). Of 64 isolates analysed using WGS, 55 were identically identified as type ST50. A matched case-control study included 26 confirmed cases and 52 controls. Cases were more likely to have consumed brand B milk (mOR: 21.4; 95%CI: 2.8 - Inf). Brand B milk also presented a positive dose- and frequency-response association. We identified coliform bacteria contamination (200-2000 CFU/mL) in a pasteurised milk sample from brand B dairy producer. No *Campylobacter* was isolated from raw or pasteurised milk samples. Dairy plant inspection did not identify a cause of contamination in pasteurisation.

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>

Epidemiological and microbiological findings suggest brand B pasteurised milk as a probable source for this *Campylobacter* outbreak on Bornholm. We recommended reviewing the equipment and all stages of the process of pasteurisation/safe milk handling at the dairy production plant inspected.

Role and outputs: Principal investigator. During this outbreak investigation, Luís participated in case definition work, performed data entry and data analysis. Luís also submitted and presented (as an oral presentation) an abstract to ESCAIDE 2020, wrote an internal outbreak report and a final outbreak report for EPIET.

***Enterocytozoon bieneusi* outbreak in Denmark, 2020**

Supervisors: Steen Ethelberg, Luise Müller, Laura Espenhain

Microsporidia are rarely implicated as an aetiological agent for foodborne outbreaks. Here, we describe an outbreak of *Enterocytozoon bieneusi* at a workplace canteen in Denmark during November 2020.

A probable case was defined as any person using the canteen between 4 November and 13 December 2020 reporting at least one gastrointestinal symptom, whereas a confirmed case also had a positive stool sample for *E. bieneusi*. A web-based questionnaire was used to collect clinical, epidemiological and food exposure data. We performed a retrospective cohort study and microbiologically tested stool samples from affected individuals for bacterial, viral and parasitic pathogens, including *E. bieneusi*.

Altogether, 195 employees completed the questionnaire. We identified 52 cases (65% male; median age 45 years [range 25–65]). Diarrhoea (90%), fatigue (83%) and abdominal pain (79%) were the most commonly reported symptoms. Eight cases were laboratory-confirmed and all had *E. bieneusi* genotype C. The incubation period was between five and twelve days and PCR-detectable spore shedding occurred up to 43 days after symptom onset. Disease was associated with consuming food in the workplace canteen on 4 November 2020 (Relative Risk [RR], 2.8 [95% confidence interval [CI] 1.4–5.4]) and open lunch-box sandwiches (RR, 3.2 [95% CI 1.4–7.2]) served on that day.

This is the second documented foodborne outbreak of *E. bieneusi* worldwide. Epidemiological findings indicated lunch-box open sandwiches on November 4, 2020 as a likely source. *E. bieneusi* may be an under-reported cause of diarrhoeal outbreaks, and testing for it might be useful in foodborne outbreak investigations.

Role and outputs: Co-investigator. During this outbreak investigation, carried out as a partnership between an EUPHEM and an EPIET fellow, Luís participated in case definition work, performed data extraction, data cleaning and data analysis. Luís also wrote as a first co-author a manuscript submitted to the Clinical Infectious Diseases Journal. Additionally, Luís was a co-author of an abstract submitted and accepted for oral presentation at ECCMID 2021 and also a co-author of an abstract submitted and accepted for oral presentation at ESCAIDE 2021.

Training modules related to assignment/projects

Introductory Course – this introduced Luís to the main concepts of outbreak investigations, study designs and analysis. He became familiar with the 10 steps of outbreak investigations and how to practice outbreak investigations and analysis of data from outbreaks in case studies. Outbreak Investigation Module – this built on the Introductory Course and deepened the understanding of outbreak investigations. A core component of the course was a multi-day case study on a cohort study for an outbreak of gastroenteritis.

Multivariable Analysis Module – this built on the Introductory Course and helped to strengthen statistical skills. The module also provided added benefit for outbreak investigations as it allowed for a more in-depth analysis of any analytical studies done during outbreak investigations.

Rapid Assessment and Survey Methods (RAS) module – this covered aspects of (survey) sampling including spatial sampling, surveillance and response in (complex) emergencies risk assessment and risk communications. The module provided Luís with valuable skills and knowledge for outbreak investigations, particularly for outbreak investigations in emergency settings.

Educational outcome

Both the training modules of the Fellowship and the active lead role in investigating three food and waterborne outbreaks were excellent learning experiences for Luís and enabled him to think and work independently on all aspects and steps of an outbreak investigation. Luís found certain activities to be of great importance and value – these included interpreting and questioning of outbreak signals, setting up of a case definition, conducting hypothesis generating interviews and choosing/performing analytical studies. After participating in the aforementioned outbreak investigations, Luís has also developed his skills in the use of programming tools for analysis of outbreak data and the writing of outbreak reports and manuscripts. Finally, Luís has also gained first-hand experience with the challenges and considerations related to inter-institutional communication and the management of an outbreak.

1.2 Surveillance

Monitoring routine childhood vaccination uptake in Denmark, 2016–2020, using the Danish Vaccination Register

Supervisors: Palle Valentiner-Branth

The Danish Vaccination Register (DDV) is a national vaccination register including data on all vaccinations administered. It provides access for healthcare personnel to information on vaccinations, provides access for citizens to data on their own vaccinations and supports surveillance of vaccination coverage. The main objective of this study was to analyse vaccine uptake from the Danish Childhood Vaccination Programme (NCVP) vaccinations in Denmark between 2016 and 2020.

We conducted a descriptive nationwide register-based study of birth cohorts, describing the characteristics of vaccine doses included in the NCVP administered in Denmark from 2016 to 2020. We collected data on vaccination from DDV and socio-demographic data from the Danish Civil Registration System (CRS). We characterised vaccine recipients and aspects of vaccine uptake such as the time period and age at vaccination. We computed restricted mean survival time (RMST) for vaccine doses and estimated the average age at vaccination for vaccine dose included in the NCPV per birth cohort at 30 days after the defined age at vaccination. We compared these estimates between birth cohorts.

For all vaccine doses included in the NCVP, we observed a consistent uptake of total vaccines by birth cohort and sex. Looking at vaccine administration by time period and age at vaccination, specific vaccine dose patterns were also observed, although these were not consistent between birth cohorts. Regarding differences between birth cohorts by vaccine dose, we estimated that at 30 days after the recommended age for vaccination for a given vaccine dose, absolute differences in the average age at vaccination for vaccine uptake were consistently and significantly larger for most younger birth cohorts displaying earlier uptake of vaccines. The RMST metric also proved to be a useful tool for monitoring vaccine uptake and vaccine uptake differences for birth cohorts at different ages for vaccination. Finally, almost all reported vaccinations for the studied vaccine doses from the NCVP were reported to DDV by healthcare providers.

Role and outputs: Principal investigator. Luís was responsible for writing the protocol, collecting, cleaning and analysing surveillance data, and writing a final EPIET report. During this project, Luís has also created customised analytical scripts in order to semi-automate the process of data collection, cleaning and analysis for future use.

COVID-19 Surveillance in Denmark, March to August 2020

Supervisors: Steen Ethelberg

As Denmark adapted to the COVID-19 pandemic, the fellow was invited to participate in the COVID-19 dedicated team at SSI responsible for surveillance. For this reason and given the exceptional context of the epidemic, this activity was not defined as a formal surveillance project. Luís participated on a daily basis in the projects assigned to the COVID-19 team. The fellow worked in developing analytical tools and scripts describing the COVID-19 epidemic in Denmark. In particular, the fellow contributed to the epidemiological characterisation of COVID-19 testing, COVID-19 cases, hospitalisations and deaths, the epidemiological characterisation of COVID-19 by geographical area in Denmark, and the epidemiological characterisation of COVID-19 in specific settings, such as elderly care homes. The fellow was also an active participant in the initial computations of incidence and effective reproductive number metrics for Denmark. Overall, the fellow contributed to different aspects of COVID-19 surveillance in Denmark during the first months of the epidemic.

Role and outputs: Surveillance officer. Luís participated in daily meetings of the COVID-19 Surveillance team at SSI. For these meetings, Luís was involved in conceptualising and designing surveillance data outputs, such as tabular and graphical elements characterising the evolution of COVID-19 in Denmark. Luís collected data from the main COVID-19 surveillance line-list, analysed surveillance data, developed and maintained analytical scripts for report automation, and wrote daily internal reports.

Aberration detection for surveillance of enteric bacterial in Denmark, 2021, using the Register of Enteric Pathogens

Supervisors: Steen Ethelberg

In recent years, there has been increased data collection for routine surveillance of infectious diseases. Increased data availability has made it easier to apply statistical methods for aberration detection as they provide information on potential outbreaks and epidemiological signals.

The Register of Enteric Pathogens (TBR) is a laboratory-based surveillance register that contains information on all laboratory-positive test results for enteric bacteria tested in the Danish Regional Clinical Microbiology Departments (KMA). TBR is updated on weekly basis via electronic reporting from KMA. It contains a record of each identified serotype in an isolate, as well as information about the sample and the patient.

This project aimed to analyse and interpret surveillance data on TBR, to test the Farrington flexible algorithm for aberration (signal) detection on TBR data, and to develop a programming scrip to automate the weekly analysis and reporting of TBR surveillance data.

Role and outputs: Principal investigator. Luís collected and analysed surveillance data, prepared and revised analysis scripts to create tabular reports for specific enteric bacteria, and developed customised functions for the application of the Farrington Flexible algorithm for signal detection on surveillance data of enteric bacteria.

Training modules related to assignment/projects

The Introductory Course familiarised Luís with the core concepts in epidemiological surveillance. It covered the development and evaluation of a surveillance system, as well as key aspects of the analysis of surveillance data.

The Multivariable Analysis Module built on the Introductory Course and strengthened Luís' statistical skills. The module introduced a variety of regression methods that can be applied for surveillance data analysis.

During the Project Review Module fellows presented many projects and had interesting discussions. The module helped Luís to feel more comfortable using the theory learned during the other modules in real life.

The Vaccinology Module introduced Luís to vaccine types and effect in individuals (immunology). The module covered vaccination programmes and their impact on populations, evaluation of vaccination interventions in routine work, and methods to measure and improve vaccination coverage. It deepened the fellow's knowledge of barriers to vaccination uptake, and familiarised him with the steps and principles of decision-making for the introduction of new vaccines.

Educational outcome

For Luís, the three abovementioned surveillance projects represented a great learning experience. They contributed to his understanding of surveillance system structure and attributes, and how to gather, analyse, interpret and report surveillance data. Participating in the COVID-19 Surveillance team at SSI during the initial months of the pandemic was a great experience in this regard. During this period, Luís contributed to the generation of outputs that helped stakeholders and decision-makers decide upon specific public health measures. The activities with the Enteric Bacteria Register and with DDV also highlighted and enhanced his experience in dealing with surveillance data in large data environments. This pushed Luís to learn new technical and programming skills in order to deal with some of the requirements of this type of data system. Finally, all three surveillance projects contributed to a diverse exposure in terms of data sources and specific contexts. This was also a valuable learning experience, as Luís was able to reinforce his understanding of how to use surveillance data and how it is generated.

2. Applied public health research

Determinants of sporadic Shiga-toxin producing *Escherichia coli* (STEC) infection in Denmark, 2018–2020: a matched case-control study

Supervisors: Steen Ethelberg, Charlotte Kjelsø, Katrin Gaardbo Kuhn

Infection with Shiga-toxin producing *Escherichia coli* (STEC) is a growing problem in Denmark. Most cases are considered to be sporadic and approximately one third can be attributed to known sources of infection, such as food intake, animal contact and person-to-person infection. Here we describe an age and sex individually-matched case control study to identify sources of sporadic STEC infection.

From January 2018 to December 2020, we conducted a prospective nationwide case-control study among Danes for representative subgroups of adults and children. Participants were recruited through prospective and concurrent catchment of incident STEC cases and age and sex-matched controls. Controls were randomly selected according to matching variables from the Danish Civil Registration System (CRS). Participants were invited by email to complete an online questionnaire. Univariate and adjusted matched odds ratios (mOR) were computed using conditional logistic regression.

The study recruited 1 583 STEC cases (1 031 adults and 552 children), and 6 228 matched controls (3 980 adults and 2 248 children). A total of 658 cases (42%) were available to participate, of which 414 were adults (40%) and 244 were children (44%). A total of 2 155 controls (35%) were available to participate, of which 1 376 were adults (35%) and 751 were children (33%). For adults, after adjusting for area-level socioeconomic quintile, region of residence, urbanicity of residence, and seasonality, having consumed minced beef was associated (mOR 1.5 [95%CI 0.97 to 2.3]; $p = 0.068$) with a 50% higher risk of STEC infection. Looking at children, adjusted estimates showed that having consumed raw milk (mOR 14 [95%CI 1 to 190]), food at an outdoor grill (mOR 5 [95%CI 2 to 12]), and having a household member using diapers (mOR 2 [95%CI 1 to 4]) were associated with a higher risk of STEC illness.

Overall, the main findings of this study confirm that beef meat is an important risk factor for STEC infection. However, the results of this study also cast new light on whether sporadic STEC infections originate from more complex transmission routes, such as those from other food sources, food consumption related behaviour and environmental exposure. These findings will be used to guide additional research, promote public health action and improve national guidelines for prevention of STEC infection.

Role and outputs: Principal investigator. Luís revised the original research project idea, wrote the final version of the protocol, collected, cleaned and analysed data, and wrote a final report for EPIET. In addition, Luís will prepare a manuscript as first author to be submitted as an original research paper.

Training modules related to assignment/projects

The Introductory Course helped to familiarise the fellow with the core concepts of operational and applied research. It covered the development of study protocols and the drafting of aims and objectives relevant to a national public health institute, as well as data analysis and presentation for the other modules to build on.

The Multivariable Analysis Module built on the Introductory Course and strengthened the fellow's statistical skills. The module introduced a variety of regression methods that can be applied for data analysis and it also provided the basis for the Time Series Analysis module.

The Time Series Analysis Module built on the Introductory Course and the Multivariable Analysis Module. It provided a supplementary opportunity for Luís to explore more advanced analytical topics in time-series data.

Educational outcome

This research project allowed Luís to work in a field he had not previously been exposed to. It also provided Luís with the experience of writing a research project protocol, cleaning and managing a large dataset from an observational study, conducting descriptive and multivariable analysis, particularly for a matched design, identifying key recommendations based on the main findings, and writing research reports and manuscripts.

3. Teaching and pedagogy

Nordic Course in Infection Control and Prevention 2020

Supervisor: Anders Koch, Anne Kjerulf

This teaching assignment occurred on 30–31 January 2020 and 3–4 March 2020, a total of 20 hours of teaching. It took place in Västra Götaland region, Gothenburg, Sweden. The target audience were Nordic healthcare workers assigned to hospital infection prevention and control departments (31 participants).

This teaching assignment focused on basic infectious disease epidemiology and consisted of the presentation of lectures and the facilitation of practical exercise sessions on the following topics: i) Pitfalls in epidemiology - Confounding, chance and bias, ii) Critical appraisal of an article focusing on epidemiological pitfalls, iii) Study planning and design, iv) Presenting and Interpreting Results in Epidemiology, v) Descriptive statistics, vi) Comparing groups and statistical testing and vii) Data preparation and cleaning with Excel. The fellow revised and prepared all new lecture and practical materials for the aforementioned sessions.

Along with qualitative discussions and feedback at the end of the course, participants also answered a formal evaluation survey, which highlighted the overall good course structure and theoretical content.

Introduction to R programming

Supervisor: Tanja Charles, Steen Ethelberg

This teaching assignment took place on 15 October 2020 in the form of a three-hour long online session during the ECDC EPIET/EUPHEM Introductory Course 2020. The target audience were EPIET, EUPHEM, and PAE fellows from cohort 2020 (37 participants).

This teaching assignment consisted of presenting a lecture and facilitating a practical exercise session on the fundamentals of R programming and its applications to statistical and epidemiological analysis. Lecture and practical materials were revised and developed by the fellow from existing materials used on previous introductory courses.

Participants were required to answer a formal evaluation survey at the end of the module. Evaluation of this teaching assignment showed that participants considered it to be a well-structured and comprehensive session on R and they provided very positive feedback of the session.

Outbreak Investigation Module 2020

Supervisor: Tanja Charles, Steen Ethelberg

This teaching assignment took place on 7–8 December 2020, as an online session at the ECDC EPIET/EUPHEM Outbreak Investigation Module 2020 and totalled seven hours of teaching. The target audience were EPIET, EUPHEM, and PAE fellows from cohort 2020 (21 participants).

This teaching assignment involved facilitating a practical session entitled 'Copenhagen case-study' using the R programming language. In particular, this session focused on outbreak data management and inspection, descriptive statistical analysis, univariate analysis and non-significant hypothesis testing using R. Practical materials were based on existing materials used for previous editions of the Outbreak Investigation Module. At the end of the module, participants answered a formal evaluation survey, which gave very positive feedback on this session.

Multivariable Analysis Module 2021

Supervisor: Tanja Charles, Steen Ethelberg

This teaching assignment took place on 15-16 February 2021, as an online session at the ECDC EPIET/EUPHEM Multivariable Analysis Module 2021, totalling three hours of teaching. The target audience were EPIET, EUPHEM, and PAE fellows from cohort 2020 (33 participants).

This teaching assignment involved facilitating a practical session entitled 'Linear regression Case Study'. At the end of this session, participants were expected to understand the principles, identify analysis situations and perform and interpret the outputs of multivariable analysis, and linear multivariable regression. Practical materials were based on existing materials used during previous editions of the Multivariable Analysis Module. At the end of the module, participants answered a formal evaluation survey, stating that the facilitators were knowledgeable about both the statistical regression methods and the programming tools, and that they considered the practical session to be engaging and interesting.

Time Series Analysis Module 2021

Supervisor: Tanja Charles, Steen Ethelberg

This teaching assignment took place on 26–28 January 2021 as an online session at the ECDC EPIET/EUPHEM Time Series Analysis Module 2021, totalling six hours of teaching. The target audience were EPIET, EUPHEM, and PAE fellows from cohort 2019 (36 participants).

This teaching assignment involved presenting lectures and facilitating practical exercise sessions on the following topics: i) Time series and residual component and ii) Assessing the impact of interventions using surveillance data. At the end of this session, participants were expected to understand and be able to analyse trends, periodicity and autocorrelation in time-series data as well as to understand interrupted time-series, difference-in-difference, segmented time series regression, propensity score regression and synthetic control methods in assessing and interpreting the effect of a public health intervention using surveillance data. The fellow revised and developed lecture and practical materials from existing materials used during previous Time Series Analysis modules. Overall, participants gave positive feedback on the structure and content of both sessions.

Rapid Assessment & Survey Methods Module 2021

Supervisor: Tanja Charles, Steen Ethelberg

This teaching assignment took place on 5 May 2021 as an online session at the ECDC EPIET/EUPHEM Rapid Assessment & Survey Methods (RAS) module 2021, totalling six hours of teaching. The target audience were ECDC fellowship fellows and EPIET associated programme (PAE) fellows from cohorts 2019 and 2020 (36 participants).

This teaching assignment involved facilitating a practical session entitled 'Survey methods and spatial analysis in Complex Emergency Settings'. This teaching activity intended to provide knowledge of and practical experience in the handling of spatial vector and raster data with Geographical Information System (GIS) software, to conduct spatial random sampling and to build choropleth maps. Practical materials were based on existing materials used in previous editions of the RAS module by Epicentre (MSF). Participants were required to answer a formal evaluation survey at the end of the module. Overall, participants considered the practical sessions to be accessible and well-documented.

General and Statistical Programming with R

Supervisor: Steen Ethelberg

This teaching assignment took place regularly every two weeks from 30 September 2020 to 18 August 2021, as an internal online course at Statens Serum Institut (SSI). The course comprised a total of 26 hours of teaching. The target audience were SSI employees from the Infectious Disease Epidemiology and Prevention Department, from the Bacteria, Fungi and Parasites Department, and ECDC EPIET and EUPHEM Fellows (cohort 2019 and 2020) placed at SSI (52 listed participants).

This teaching assignment involved presenting lectures and practical sessions on the following topics: i) desktop application interfaces for R programming, ii) base R programming, iii) data import and export with R, iv) programming with the tidyverse syntax in R, v) R programming of dates and time, vi) static graphical visualisations with R and vii) statistical and epidemiological data analysis with R. Online lecture sessions were recorded and kept as a future learning material. In addition, a course notebook was created along with R scripts as support materials for the lecture sessions. All materials used on this course were prepared and revised by the fellow.

Participants provided qualitative feedback at the end of course. Overall, participants gave positive feedback on the structure and content of the course and notebook.

Training modules related to assignment/projects

The Introductory Course familiarised Luís with basic concepts of infectious disease epidemiology and surveillance. It also covered the basic elements of descriptive analysis in epidemiological data. This module also included a session on teaching and facilitating for non-teachers which was very useful for the fellow when preparing and conducting all the aforementioned teaching activities.

Educational outcome

These teaching activities were a good opportunity to review and refresh fundamental epidemiological and statistical concepts. In order to prepare for lecture sessions, Luís had to review and read about different topics in epidemiology and corresponding statistical methods, which allowed him to consolidate his knowledge in these areas. Facilitating practical sessions also enabled Luís to improve his skills in capacity building, explaining epidemiological topics, and providing valuable insight into how to adapt teaching methods to audiences with different professions and backgrounds. Luís also revised existing teaching materials and developed new ones, which allowed him to enhance his skills in planning and adapting theoretical and practical material for a specific audience. Two teaching activities were focused on the use of the R programming language, which represented a worthy opportunity to review and consolidate fundamental concepts and elements of the general and statistical methods of the R functional programming language. In order to prepare the lecture and practical sessions for this specific topic, the fellow had to review and read about several sub-domains of this programming language and its applications to statistical and epidemiological analysis. Overall, these teaching activities represented a significant step forward for Luís' personal learning process.

4. Communication

Publications related to the EPIET fellowship

1. Michlmayr D*, Alves de Sousa L*, Müller L, Jokelainen P, Ethelberg S, Vestergaard LS, Schjørring S, Mikkelsen S, Jensen CW, Rasmussen LD, Stensvold CR. Incubation period, spore shedding duration, and symptoms of *Enterocytozoon bieneusi* infection in a foodborne outbreak in Denmark, 2020. *Clinical Infectious Diseases*; 2021. [Manuscript submitted; * Equal contribution]
2. Duarte R, Furtado I, Alves de Sousa L, Carvalho C. The 2019 Novel Coronavirus (2019-nCoV): Novel Virus, Old Challenges. *Acta Médica Portuguesa*. 2020; 33(3):155-157.

Reports

1. Alves de Sousa L. *Campylobacter jejuni* outbreak, Bornholm, Denmark, November 2019. Infectious Disease Epidemiology and Prevention Department, Statens Serum Institut. EPIET Outbreak Investigation Report. 2020
2. Alves de Sousa L. Monitoring routine childhood vaccination uptake in Denmark 2016-2020 using the Danish Vaccination Register. Infectious Disease Epidemiology and Prevention Department, Statens Serum Institut. EPIET Surveillance Project Report. 2021
3. Alves de Sousa L. Determinants of sporadic Shiga-toxin producing *Escherichia coli* (STEC) infection in Denmark, 2018-2020: a matched case-control study. Infectious Disease Epidemiology and Prevention Department, Statens Serum Institut. EPIET Applied Research Report. 2020.

Conference presentations

1. Alves de Sousa L, Müller L, Espenhain L, Voss SS, Benedetti G, Schjørring S, Pedersen AF, Ethelberg S. A *Campylobacter jejuni* outbreak linked to contaminated pasteurized milk in Denmark, 2020: a matched case-control study. Oral presentation. ESCAIDE 2020. Virtual. 24 November 2020.

5. Other activities

International Assignment

Luís completed a six-week (October to December 2020) international assignment as a data management officer under the Ebola Virus Disease (EVD) Incident Management System (IMS) Team from WHO-GOARN. This assignment was carried out as remote work, and focused on the Ebola Virus Disease outbreak in Équateur Province, DRC, 2020.

The outbreak in Équateur Province, in western Democratic Republic of Congo (DRC), was the 11th registered Ebola outbreak. It was announced on 1 June 2020, after the reporting of 119 confirmed cases, 11 probable cases, 55 deaths and 75 people who had recovered. This outbreak was declared over on 18 November 2020. This assignment concerned two main activities: managing the incident databases for the outbreak and testing a model to combine epidemiological contact tracing data and phylogenetic data to estimate the outbreak transmission tree.

Department meetings

The fellow routinely participated in the activities of the Section for Zoonotic, Food and Waterborne Infections in the Department of Infectious Disease Epidemiology and Prevention (Statens Serum Institut).

The fellow also routinely participated and attended meetings of the Section for Vaccine Preventable Diseases in the Department of Infectious Disease Epidemiology and Prevention (Statens Serum Institut).

6. EPIET/EUPHEM modules attended

1. Introductory Course, 23 September – 11 October 2019, Spetses, Greece
2. Outbreak Investigation, 9–13 December 2019, Nicosia, Cyprus
3. Multivariable Analysis, 15–19 June 2020, virtual
4. Project Review 2020, 24–28 August 2020, virtual
5. Time Series Analysis, 25–29 January 2021, virtual
6. Rapid Assessment and Survey Methods, 4–6 May 2021, virtual
7. Vaccinology, 14–18 June 2021, virtual
8. Project Review 2021, 23–27 August 2021, virtual [excused from attendance]
9. ESCAIDE 2019, 27–29 November, Stockholm, Sweden
10. ESCAIDE 2020, 25–27 November, virtual.

7. Other training

1. Nordic Mini Project Review 2020, February 2020, Finnish Institute for Health and Welfare (THL), Helsinki.
2. Nordic Mini Project Review 2021, February 2021, virtual.
3. WHO, Health Emergencies Programme, GO Training 2.0, 18 October 2020, virtual training module.
4. WHO, Incident Management System (tier 1) - Introduction to Health Sector Emergency Response Management, 18 October 2020, virtual training module.
5. WHO, Incident Management System (tier 2) - Working in WHO's Incident Management System, 18 October 2020, virtual training module.
6. WHO, Health Emergencies Programme, Introduction to Go.Data – Field data collection, chains of transmission and contact follow-up, 18 October 2020, virtual training module.
7. WHO, United Nations GB UN Human Rights Responsibilities, 17 October 2020, virtual training module.
8. WHO, United Nations Multilingual Course on Prevention of Harassment, Sexual Harassment and Abuse of Authority, 17 October 2020, virtual training module.
9. WHO, United Nations GB UN To serve with Pride - Zero Tolerance, 17 October 2020, virtual training module.
10. WHO, United Nations Department of Safety and Security, BSAFE, 17 October 2020, virtual training module.

Discussion

Coordinator's conclusions

Luís entered the Fellowship already very skilled and experienced in most of the areas of public health and epidemiology covered. However, he managed to find suitable activities to further develop his competencies, which was especially noticeable in the areas of outbreak investigation and epidemiological research. He enthusiastically shared his broad knowledge by strongly supporting the teaching activities both for the institute and the Fellowship. For example, he developed and delivered extensive training courses in R. Furthermore, he used his advanced analytical and R skills to develop several scripts for use by colleagues in future epidemiological analyses. The COVID-19 pandemic and Luís' contribution to the national response, which was highly appreciated by the institute, had a large impact on his Fellowship. Nevertheless, he managed to react well to the unforeseen challenges and finish his projects and meet the demands of the Fellowship, maintaining an exceptionally high standard. It has been a real pleasure getting to know and working with Luís. I wish him all the best for his future career.

Supervisor's conclusions

I was the Danish national EPIET supervisor for Dr. Luís Alves de Sousa during his two years as EU-track EPIET fellow at the Department of Infectious Disease Epidemiology & Prevention at the SSI, where he was placed in Vaccine-Preventable Diseases Section.

During his fellowship, Luís showed himself to be a very good epidemiologist and it has been a great pleasure to host him. Luís' broad knowledge and work experience enabled him to quickly understand complex situations and to display his sound judgement in outbreak situations. In addition, Luís possesses an impressive theoretical knowledge of epidemiological methods and is at ease doing quite advanced statistical analyses. Even though Luís' fellowship took a different route than expected due to COVID-19, he has still managed to amass an impressive array of quite diverse projects during his two years at the SSI, producing some very good outputs. While working at the SSI, Luís had the chance to develop further in terms of skills, experience and network – but to be quite frank, I feel that the SSI has learned just as much if not more from Luís during his fellowship.

A good example here is the huge, yet seemingly effortless effort Luís put into sharing some of his expert knowledge of R within the SSI. As part of his EPIET teaching obligations (only one of several), Luís developed and taught a course in R internally at the SSI. This was highly appreciated, as at the SSI (similar to other EPIET host institutions) we have been struggling for some years to make the move to R from other types of software. Over the course of a full year Luís did weekly lectures and, in fact he even developed a complete text book for the course, a well-written and very instructive book amounting to many hundreds of pages. It was a quite amazing effort; highly appreciated by colleagues and a huge help for the SSI as an institution and I know that we will make good use of the teaching material and the recorded lectures in the years to come.

Luís also deserves a special thanks and gratitude for his contribution during the first part of the COVID-19 epidemic period. Because of his skills in coding and automation of data tasks using R, Luís was a tremendous help in the complex and, often somewhat uncoordinated work, in the building up of new surveillance and reporting tools during the early days of the pandemic. During this difficult time, Luís put his planned EPIET activities on hold for more than six months and instead threw all his energy into the COVID-19 tasks for most of his waking hours. In so doing, he really made a difference for the SSI, and we are truly grateful for this.

Luís is a person with many resources. Apart from his intellectual capacity, Luís is also a nice person - easy-going, always trying to help others and with an altruistic attitude in everything he does. I know that Luís will be very much missed by his colleagues at the SSI and we wish him all the best in his future carrier.

Personal conclusions of fellow

The EPIET Programme has been an outstanding opportunity to improve my skills in epidemiology, particularly within applied research and outbreak investigation, to widen my experience in public health at the European and international level, and to grow my personal and professional network. I consider these two years in Denmark and at SSI to have been an exceptional journey, both personally and professionally. Overall, I consider that my EPIET programme provided me with an exceptional training experience that met all my expectations.

Acknowledgements of fellow

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