



Summary of work activities

Giulia Errico

European Public Health Microbiology Training Programme (EUPHEM), 2019 cohort

Background

According to the European Centre for Disease Prevention and Control (ECDC) Advisory Group on Public Health Microbiology ('national microbiology focal points'), public health microbiology is a cross-cutting area that spans the fields of human, animal, food, water and environmental microbiology, with a focus on human population health and disease. Its primary function is to improve health in collaboration with other public health disciplines, in particular epidemiology. Public health microbiology laboratories play a central role in detection, monitoring, outbreak response and the provision of scientific evidence to prevent and control infectious diseases.

European preparedness in responding to new infectious disease threats requires a sustainable infrastructure capable of detecting, diagnosing and controlling infectious disease problems, including the design of control strategies for the prevention and treatment of infections. A broad range of expertise, particularly in the fields of epidemiology and public health microbiology, is necessary to fulfil these requirements. Public health microbiology provides experts in all relevant communicable diseases at the regional, national and international level with the tools they need to mount rapid responses to emerging health threats. This enables them to plan appropriate prevention strategies, assess existing prevention disciplines, develop microbiological guidelines, evaluate/produce new diagnostic tools, assess risks from microbes or their products and provide pertinent information to policy makers from a microbiological perspective.

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 Giulia Errico, cohort 2019 of the European Public Health Microbiology Training Programme (EUPHEM) at Istituto Superiore di Sanità, Rome, Italy.

Giulia Errico completed a Masters degree in Biology Applied to Biomedical Research at the University of Roma Tre in 2009, with a thesis focused on *Pseudomonas aeruginosa* and iron uptake. In July 2015, Giulia also achieved her

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Medical Specialisation in Microbiology and Virology at Sapienza University of Rome, with a thesis on molecular diagnosis of Epstein Barr virus in central nervous system

diseases. During her specialisation training, Giulia had acquired professional diagnostic competences applied to medicine in the fields of microbiology, virology, mycology and parasitology, working many years in different hospitals in Rome. In 2014, Giulia started to work at Istituto Superiore di Sanità (ISS), the National Public Health Institute, in the Department of Infectious Disease in the field of molecular epidemiology of multidrug-resistant Enterobacterales and in laboratory diagnosis of diphtheria. Since February 2019, she has been working at ISS as a temporary researcher.

All EUPHEM activities aim to address different aspects of public health microbiology and underline the various roles of public health laboratory scientists within public health systems.

Methods

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

Projects included epidemiological investigations (outbreaks and surveillance); applied public health research; applied public health microbiology and laboratory investigation; bio-risk management; quality management; teaching and public health microbiology management and the summary and communication of scientific evidence and activities with a specific microbiological 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, 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 EUPHEM core competencies, as set out in the EUPHEM scientific guide¹.

1. Epidemiological investigations

1.1. Outbreak investigations

NDM-Klebsiella pneumoniae/Escherichia coli outbreak in the Tuscany Region, Italy, November 2018 - ongoing

Supervisors: *Annalisa Pantosti and Patrizio Pezzotti*

An increase in isolates of New Delhi metallo-beta-lactamase (NDM) producing carbapenem-resistant Enterobacterales (NDM-CRE) was reported in the north-western Tuscany, Italy, since November 2018. In March 2019, the Tuscany Regional Department of Health declared an outbreak situation.

Between November 2018 and 23 August 2020, 238 cases of bloodstream infections due to NDM-CRE affecting at least 20 hospitals in north-western Tuscany were reported, with a mortality rate of 25% for patients with sepsis. Between November 2018 and October 2019, a total of 1 645 NDM-CRE-positive samples were identified, being *K. pneumoniae* the most identified species. The core genome SNP-based phylogeny and the MLST analyses conducted on 51 invasive-isolates of NDM-*K. pneumoniae* revealed that the majority belonged to Sequence type (ST)147, harboured *bla*_{NDM-1}, and were closely related to each other.

The analysis conducted at Istituto Superiore di Sanità (ISS) on 20 NDM-*K. pneumoniae* isolates sent by hospital laboratories from three cities not in the Tuscany Region between January 2019 and June 2020 revealed that all the NDM-*K. pneumoniae* isolates were resistant to carbapenems and ceftazidime-avibactam; 75% were susceptible to colistin. Molecular characterisation revealed the presence of nine different STs with four isolates belonging to ST147-NDM-1, responsible for the Tuscany outbreak.

Several rapid actions were enhanced to contain the spread of NDM-CRE including mandatory screening on admission and during hospitalisation for all patients at risk; adoption of contact precautions; data collection using a

¹ European Centre for Disease Prevention and Control. European public health training programme. Stockholm: ECDC; 2013. Available from: <http://ecdc.europa.eu/en/publications/Publications/microbiology-public-health-training-programme.pdf>

regional database and obligatory notification of all cases to a centralised laboratory; development of guidelines for the clinical management of NDM positive cases; dedicated medical and nursing staff; educational meetings for all the professionals involved.

Giulia participated as part of the outbreak investigation team. She attended meetings with the Tuscany Region and the Ministry of Health in order to control the ongoing outbreak. She performed laboratory work on isolates sent to ISS, and analysis of the database of the National Surveillance of bloodstream infections due to carbapenemase-producing Enterobacterales (CPE) for the period 2016-2019. She also prepared the outbreak report (7).

Training modules related to the assignment/projects

The Introductory Course introduced the fellow to the 10 steps of an outbreak investigation as well as the basic concepts of outbreak investigation and epidemiological and microbiological analysis.

The Outbreak Investigation Module was an interactive course going through the 10 steps of outbreak investigation in depth. The fellow was trained in the use of different softwares; she practiced data collection, cleaning and management, as well as designing of questionnaires, descriptive and analytical data analyses.

The Multivariable Analysis Module provided a comprehensive understanding of the principles of statistical analyses through the use of different softwares (STATA or R) to investigate outbreaks.

Educational outcome

Giulia has applied microbiological and epidemiological knowledge in an outbreak situation, and developed her skills in management, team-leading, and communication with different stakeholders. She contributed to performing laboratory activity (confirmation of the presence of the *bla*_{NDM} gene, MLST) on isolates from other regions than Tuscany, and to analysing the database of the National Surveillance of BSI due to CPE. At the same time, she wrote the outbreak report (7).

1.2. Surveillance

1.2.1 National Surveillance of Healthcare-Associated (HA) methicillin-resistant Staphylococcus aureus (MRSA) bloodstream infections: drafting the protocol of a pilot project

Supervisors: Monica Monaco and Fortunato 'Paolo' D'Ancona

Staphylococcus aureus resistant to methicillin (MRSA) shows resistance to all beta-lactam antibiotics but can display combined resistance to other antimicrobial groups becoming a multidrug resistant organism and a major public health problem at global level. Infections due to MRSA are associated with higher mortality rates than infections caused by methicillin-susceptible *S. aureus* strains (MSSA), with increased lengths of hospital stays as well as healthcare costs.

In Italy, the percentage of MRSA-reported invasive infections is one of the highest in Europe since the 2000s. It decreased from 44.3% in 2000 to 34.1% in 2015, keeping high and stable at 34.0% in the period 2015-2019.

Since 2001, ISS has coordinated the National Antibiotic-Resistance Surveillance (AR-ISS), which collects and analyses data routinely produced by hospital laboratories on bacteraemia, including those caused by *S. aureus*. However, AR-ISS is essentially a laboratory-based surveillance that collects only antibiotic susceptibility data from hospitals participating in AR-ISS.

This pilot project aimed to draft the protocol for the establishment of the national surveillance of healthcare-associated (HA) MRSA bloodstream infections in Italy. This project contributed to collect clinical and demographic information on patients and possible risk factors (not currently collected in the AR-ISS surveillance system), and to develop and evaluate Infection Prevention and Control interventions which support safer patient care.

Giulia was involved in the revision of the literature on MRSA and on National Surveillance protocols of MRSA invasive infections in the European countries. She was in charge in drafting the Italian protocol (15) and the submission form collecting all clinical and demographic information on patients and possible risk factors. As part of the AMR team at ISS, she attended meetings with regional authorities and stakeholders.

1.2.2 Analysis of Enter-Net surveillance data from 2016 to 2019, Italy

Supervisors: Claudia Lucarelli and Luca Busani

The World Health Organization reports that unsafe food causes 600 million cases of foodborne diseases and 420 000 deaths each year worldwide, resulting in the loss of 33 million healthy life years (DALYs).

In Italy, ISS started a voluntary, passive, laboratory-based surveillance system for *Salmonella*, *Campylobacter*, *Yersinia*, and *Shigella* in 1994. This surveillance, named Enter-Net, participates into the Food-and Waterborne Diseases and Zoonoses Network of ECDC and consists of a network of 26 regional reference laboratories within the

National Health System, which send clinical and epidemiological data of human isolates and/or the bacterial strains for further analysis to ISS.

The aim of this project was to analyse surveillance data on enterobacteria causing human infection in Italy from 2016 to 2019 in order to provide an update of the pathogenic species under surveillance to different stakeholders and give recommendations for surveillance improvement.

For *Salmonella*, data from 15 188 human isolates were collected. The annual rate per 100 000 population remained constant, ranging from 7.8 in 2016 to 7.9 in 2019. *S. Typhimurium* monophasic variant (STYM), *S. Typhimurium*, *S. Enteritidis* and *S. Napoli* were the most frequently reported serotypes, representing 67.5% of all serotypes. A high proportion of strains was resistant to ampicillin (41.3%), sulphonamides (42.8%) and tetracycline (41.3%). Fluoroquinolone resistance was observed in 11.7%; third-generation cephalosporin resistance was 2.2%, and most isolates were *S. Infantis* (71.7%). Colistin resistance was 7.7%, and 77.7% of the strains were *S. Enteritidis*. 37.7% of strains were multidrug resistant (MDR); the most frequent MDR-profiles included at least Ampicillin-Sulfamethoxazole-Tetracycline (ASuT) and Ampicillin-Chloramphenicol-Sulfamethoxazole-Tetracycline (ACSuT).

For *Campylobacter*, data from 5 177 human isolates were collected, with the majority reported from children between 0-5 years. The annual rate per 100 000 population raised from 2.7 in 2016 to 4.1 in 2019. *C. jejuni* and *C. coli* were the most frequently reported species, with 78.7% and 9.4%, respectively. Antimicrobial susceptibility tests conducted on 241 *Campylobacter* spp. isolates (191 *C. jejuni* and 49 *C. coli*) showed that for *C. jejuni* 31.6% of the isolates were resistant to ciprofloxacin, 55.5% to ciprofloxacin and tetracycline, and 0.6% to ciprofloxacin, tetracycline and erythromycin. For *C. coli*, 48.8% was resistant to ciprofloxacin and tetracycline, and 25.6% to ciprofloxacin, tetracycline and erythromycin.

A total of 43 and 113 isolates of *Yersinia* spp. and *Shigella* spp., respectively, were reported in the study period.

This study confirmed the high level of resistance and MDR in human strains of *Salmonella* spp. and *Campylobacter* spp. in Italy. We recommend to continue monitoring antimicrobial-resistance and implement the surveillance within a One-Health approach to better understand their trends and related risks.

Giulia was in charge of analysing the microbiological and epidemiological data from clinical cases collected by the Enter-Net surveillance system, using Stata. In addition, the fellow was responsible for the drafting of the Italian report (16) to disseminate among stakeholders (reference laboratories, peripheral laboratories, Ministry of Health). She also wrote an abstract for ESCAIDE 2021, accepted as poster to (19).

1.2.3 The National Antibiotic-Resistance Surveillance (AR-ISS), 2019 data

Supervisors: Annalisa Pantosti, Monaco Monica, Patrizio Pezzotti and Fortunato 'Paolo' D'Ancona

The National Antibiotic-Resistance Surveillance, coordinated by ISS (AR-ISS) since 2001, is based on sentinel clinical hospital laboratories across the country, which send routine antibiotic susceptibility data for 8 selected pathogens from invasive infections: *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Enterococcus faecalis* and *Enterococcus faecium*, *Escherichia coli*, *Klebsiella pneumoniae*, *Pseudomonas aeruginosa* and *Acinetobacter* species.

For 2019, the analysis on AR-ISS data showed that the percentages of resistance to the main classes of antibiotics for the eight pathogens under surveillance remained high in Italy and in some cases, increased compared to previous years. For *E. coli*, the percentage of resistance to third-generation cephalosporins remained stable (around 30%), while a decreasing trend is observed for fluoroquinolones (from 44.4% in 2015 to 40.7% in 2019). An increasing trend in the percentage of *K. pneumoniae* isolates resistant to carbapenems was observed, from 26.8% in 2018 to 28.5% in 2019. The resistance to carbapenems was confirmed to be very low for *E. coli* (0.4%) and decreased in *P. aeruginosa* (13.7%) while it remained stable in *Acinetobacter* (79.2%). About 35% of *K. pneumoniae* isolates were multi-resistant (resistant to third-generation cephalosporins, aminoglycosides and fluoroquinolones), while resistance decreased to 11.7% for *E. coli*. For *P. aeruginosa* the percentage of resistance to three or more antibiotics, between piperacillin-tazobactam, ceftazidime, carbapenems, aminoglycosides and fluoroquinolones was 13.1%, while a particularly high percentage of multi-resistance (fluoroquinolones, aminoglycosides and carbapenems) was observed (77.3%) for *Acinetobacter*. For *S. aureus*, the percentage of methicillin-resistant isolates remained stable (around 34%), while significant increases were found for *E. faecium* isolates resistant to vancomycin, which was 21.3% in 2019. For *S. pneumoniae* there was a slight increase in both penicillin-resistant isolates (11.9%) and erythromycin-resistant isolates (22.4%).

The epidemiological monitoring in Italy is fundamental to evaluate the resistance to different classes of antibiotics particularly important in therapy for a specific pathogen, to study the spread of antibiotic-resistance nationally, and to follow its trend over time in order to put in place strategies to overcome the phenomenon.

Giulia, as part of the AMR team, attended meetings with regional authorities and stakeholders. She also contributed to the drafting of the report (8).

1.2.4 Analysis of the database of the National Surveillance of bloodstream infections due to carbapenemase-producing Enterobacterales for the period 2016-2019

Supervisors: Annalisa Pantosti and Patrizio Pezzotti

In February 2013, the Italian Ministry of Health (MoH) instituted the national surveillance of carbapenemase-producing Enterobacterales (CPE) through a circular letter, later revised in 2019, asking all the regional and the two provincial health authorities to report all cases of bloodstream infections (BSI) due to *K. pneumoniae*- or *E. coli*-resistant/intermediate to carbapenems and/or carbapenemase-producers.

In the framework of the NDM-outbreak investigation, the fellow conducted the analysis of the database of the National Surveillance of BSI due to CPE for the period 2016-2019. An increase in the number of NDM-*K. pneumoniae*/*E. coli* cases was observed, from seven cases reported in 2016 to 154 in 2019. Of note, every year about 30% of the reported isolates were not characterised, raising the possibility of an underestimation of the real number of NDM-CRE cases. In addition, an increase in the number of Regions reporting NDM-CRE cases from invasive infections was reported each year. In the last two years (2018-2019), most cases were reported from the Tuscany Region, where the NDM-outbreak occurred. We recommend continuing to monitor the spread of CPE infections and reinforcing surveillance in order to prevent and control antibiotic-resistant infections.

In the framework of the project of the NDM outbreak investigation in Tuscany, the fellow analysed the database of the National Surveillance of BSI due to CPE for the period 2016-2019. She also reported the results of this analysis in the outbreak-report (7), and data for 2019 were also included in the 'CPE: sorveglianza nazionale delle batteriemie da enterobatteri produttori di carbapenemasi. Dati 2019 (9)'.

Training modules related to the assignment/projects

The Introductory Course allowed the fellow to familiarise herself with various types and aspects of surveillance, focusing on the development, evaluation, and analysis of surveillance systems.

The Rapid Assessment and Survey Methods module gave the fellow an introduction to how to set up a surveillance system, interpret surveillance data, and set an alert and response system in complex emergency situations. The module also familiarised the fellow with the use of sampling strategies adapted to study populations.

Educational outcome

Giulia gained experience in data entry, handling and cleaning databases, description and analysis of surveillance data using software packages for statistical analysis. She further gained experience in formulating specific public health recommendations and writing surveillance reports using surveillance data. Findings were published in the communication section.

2. Applied public health research

2.1 Analysis of influenza vaccination response in elderly, season 2019-2020

Supervisors: Silvia Vendetti, Patrizio Pezzotti and Massimo Fabiani

The approach to influenza control typically aims to reduce severe influenza-related outcomes by vaccination of the elderly, who represents a category at highest risk. However, the vaccine effectiveness may vary among vaccine-recipients depending on several factors such as health status and age, which is associated with a decline in immune function leading to a reduced capacity of the immune system to respond to vaccination in the elderly compared with young healthy adults.

This project aimed to explore the response to influenza vaccination in the elderly compared to the general adult population and to understand better if a particular host factor could be implicated in a lower responsiveness.

In the 2019-2020 season, 77 participants were enrolled in the study by their general practitioners located in the area of Rome municipality. At the time of enrolment two different paper questionnaires were administered to study participants before the vaccination. Blood samples were collected before vaccination (t0) and at 28 days (t1) after flu vaccination (quadrivalent influenza or adjuvanted trivalent influenza vaccine).

Of 77 study participants, 57.1% were females, and 49.4% were elderly (≥ 65 years). The results of our analysis showed in general a higher seroconversion, seroprotection and of two-fold hemagglutinin antibody (HA) titer increase for H3N2, followed by H1N1, compared to influenza B viruses. These preliminary data showed that the elderly have a reduced antibody response to vaccination compared with adults (< 65), in particular for B-Phuket and H3N2. This lower responsiveness to influenza vaccination in elderly was more evident in terms of seroprotection. Our finding also showed a correlation between frailty and lower HA titer, and a correlation between comorbidities and lower HA titer.

Our preliminary results highlight the need for further data collection into the phenomenon of lower responsiveness in elderly, with the hope that such insights will eventually guide towards the development of a new and more immunogenic vaccine with enhanced protection in the elderly.

The fellow was in charge of the creation of the mask in Survey Monkey, filling in the questionnaires in the mask and in performing bivariate analysis (BVA) under the supervision of an expert biostatistician at ISS. In addition, Giulia was responsible for writing the research protocol (23) and the report of the project (14).

2.2 Laboratory management for SARS-CoV-2 detection: a user-friendly combination of the heat treatment approach and rt-Real-time PCR testing

Supervisor: Alessandra Ciervo

RNA purification is the gold standard for nucleic acid extraction of SARS-CoV-2 in swab samples, but it is dependent on the availability of chemical reagents. During the COVID-19 pandemic, worldwide demand for commercial RNA extraction kits, especially for robotic platforms, has increased enormously, creating a serious problem of shortage. In this study, we evaluated the heat treatment method without RNA extraction as a reliable option to nucleic acid purification in order to provide a feasible alternative to current method that requires chemical reagents.

For the purpose of this study, positive SARS-CoV-2 nasopharyngeal swabs were used to set up the method using different combination of temperature and time of incubation. The best combination, represented by the heat treatment method at 95°C for 10 min with a dilution of 1:10 of sample, was applied to 30 negative and 60 positive samples, distributed in different Cycle threshold (CT) ranges. At the same time, samples were also manually extracted and tested for the presence of SARS-CoV-2 by in-house rt-Real-time PCR (analysed for N1, N2 and RP genes) and the 2019-nCoV TaqMan RT-PCR Kit.

Compared with purified RNA (the reference method), the in-house protocol showed a 100% of sensitivity and specificity for heat treated samples, whereas the commercial Kit exhibited a 100% of sensitivity and specificity for extracted method and 86.7% of sensitivity and 100% specificity for the heat protocol. Compared to the extraction method, the heat treatment assay allowed the testing of clinical samples within a very short time (3–3.30 h vs. 5.30–6 h), representing an easy, rapid and most of all universally available alternative procedure. We suggested to apply this method for testing samples from patients with active infection during which high viral loads are expected: a low viral concentration could reduce its sensitivity and might not detect people with very low viral loads.

Giulia was involved in the laboratory activity during the first lockdown in Italy (March-May 2020) and in writing the manuscript accepted by *Emerging Microbes & Infection* (2).

Training modules related to the assignment/projects

The Introductory Course allowed fellows to familiarise with developing and presenting a research protocol. This three-week course consisted of lectures on epidemiology, on important concepts of laboratory-based standard microbiological techniques including concepts of phylogenetic analysis and interactive case studies.

The Outbreak Investigation Module gave the fellows the opportunity to acquire skills and competencies in the practical aspects of data management and analysis during outbreak investigations. The course also familiarised the fellows on methods of WGS and next generation sequencing, mapping, phylogeny and epidemic intelligence through lectures.

The Multivariable Analysis Module provided a more comprehensive understanding of the principles of statistical analyses through the use of different softwares (STATA or R) to investigate outbreaks. The module abled the fellow to manage and analyse data from surveillance systems.

The Rapid Assessment and Survey methods (RAS) module focused on field surveys and investigations, teaching on sampling methods to study populations, on how to set up a surveillance system, to interpret surveillance data and to set an alert and response system in complex emergency situations.

The Management, Leadership and Communication trained fellows in different aspects of management, leadership, collaboration and communication. This module included exercises in groups on project management, risk assessment, and communication with different authorities in the field, as well involvement in different outbreak-scenarios.

Educational outcome

Giulia familiarised with all stages of conducting a public health research project: writing a study protocol, understanding laboratory methods, analysing data, identifying limitations and writing the activity's report. She also conducted a research activity on the heat treatment method without RNA extraction as a reliable option to nucleic

acid purification during the first lockdown in Italy, being involved in the lab activity and in the draft of the manuscript.

3. Applied public health microbiology and laboratory investigations

3.1 Chikungunya virus (CHIKV): viral and antibody kinetics in patients of the Italian 2017 outbreak, and evaluation of serological and molecular tests for the diagnosis of infection

Supervisor: Giulietta Venturi

Chikungunya virus (CHIKV), a mosquito-borne alphavirus mainly transmitted by *Aedes aegypti* and *Aedes albopictus*, represents a major public health problem in tropical and subtropical regions. The project aimed to evaluate the performances of two commercially available diagnostic ELISA systems (system 1 IgM/IgG and system 2 IgM/IgG) for CHIKV on a collection of serum samples of patients of the 2017 Italian-CHIKV outbreak, and to evaluate the cross-reactivity of CHIKV toward Mayaro virus MAYV, a closely related emerging alphavirus.

For the first aim, serum samples from 118 patients were tested on the two IgM/IgG ELISA systems, giving the following positive results: 95/118 in system 1-M, 83/118 in system 2-M, 67/118 in system 1-G, and 65/118 in system 2-G. When tested by PRNT (Plaque reduction neutralisation test), 95/118 patient sera presented positive results and RT-PCR results were available for 79 of 118 patients, of which 23 were positive. Applying the ECDC's case definition criteria, 77 patients were confirmed as CHIKV-infected, 21 as probable CHIKV-cases and 20 as non-infected (negative) cases. The sensitivity and specificity of the CHIKV-ELISA systems 1-M and 2-M were: 94.8%, 90.0% and 84.7% and 100.0%, respectively. The sensitivity and specificity of the CHIKV-ELISA systems 1-G and 2-G were: 68.4%, 100.0% and 63.3%, 85.0%, respectively, lower than IgM.

The evaluation of the cross-reactivity of CHIKV toward MAYV was carried out on a subset of 86 samples selected: CHIKV positive confirmed cases, both autochthonous (n=43) and imported (n=14), and CHIKV negative with a diagnosed of DENV or ZIKV or WNV infection (n=15), or negative for all tested arboviruses (n=14). Samples of CHIKV confirmed cases showed high levels of cross-reactivity toward MAYV, particularly when tested by an anti-MAYV ELISA IgM system and by PRNT for MAYV, highlighting the difficulties to perform differential diagnosis of closely related viruses using serological tests.

The rapid and accurate laboratory diagnosis of arboviral infections applying the appropriate diagnostic methodologies is essential for patient management, and implementation of measures for outbreak control. Availability of commercial serological tests is of great importance for a reliable diagnosis, however their performances in different context need to be carefully evaluated in comparison with reference gold standard methods.

Giulia was involved in the laboratory activity at the Reference Laboratory for Arboviruses (NRLA) at the Italian National Institute of Health (ISS) performing laboratory activity (ELISA tests and PRNT under Biosafety level 3, BSL3) on the 118 patients belonging to the CHIKV-outbreak and on selected specimens for MAYV. Her task also included the analysis and interpretation of serological and molecular data. The fellow was also in charge in the analysis of results of the laboratory tests performed for the diagnosis of CHIKV infection by NRLA at ISS in the period November 2015-December 2020. In addition, the fellow presented these results during the 2020-PRM (22) and was in charge of the manuscript drafting as first author (6).

3.2 Molecular confirmation of SARS-CoV-2 infection on clinically positive samples sent to the National Reference Laboratory at Istituto Superiore di Sanità

Supervisors: Giulietta Venturi and Alessandra Ciervo

On 9 January 2020, the Chinese authorities identified a new type of coronavirus, named 2019-nCoV. Italy reported its first confirmed coronavirus cases on 30 January with two Chinese tourists coming from Wuhan, the epicentre of the epidemic. On 20 February 2020, a severe case of pneumonia due to SARS-CoV-2 was diagnosed in the Lombardy province of Lodi in an Italian 38-year-old man with no apparent direct epidemiological link with China. Many other cases of COVID-19 were diagnosed in the surrounding area and in the region of Veneto, which borders Lombardy. On 9 March 2020, the government of Italy imposed a national lockdown. As early as January 2020 the Circular n. 1997, issued by the Ministry of Health, established that all samples from all the Italian hospitals found to be positive had to be sent to the ISS in order to carry out confirmatory tests for SARS-CoV-2 infection.

The fellow, as part of the group involved in the COVID-activity, was in charge of performing the molecular confirmation of about 600 clinical positive samples sent to ISS in the period March-May 2020. All samples were subjected to manual RNA extraction in BSL3. Extracted RNA was tested for presence of SARS-CoV-2 and analysed for N1, N2, N3 and RP genes by in-house reverse transcriptase Real-Time PCR (rt-Real-time PCR) using the protocol

from CDC (Division of Viral Diseases, Centers for Disease Control and Prevention-USA). The molecular analysis showed that 99% of the clinical samples processed by the fellow and the group were confirmed to be positive by the National Reference Laboratory at ISS.

The fellow was in charge of performing the molecular confirmation of clinical positive samples sent to ISS as part of one of several working groups that worked simultaneously to face this pandemic, during the first lockdown in Italy (March-May 2020). She was responsible of writing the report (10).

3.3 Confirmation of identification and diphtheria toxin gene detection on a suspected *Corynebacterium diphtheriae* isolate by phenotypic method and molecular technique

Supervisors: Annalisa Pantosti and Monica Monaco

Diphtheria is an acute vaccine-preventable infectious disease affecting the upper respiratory tract, and occasionally the skin caused by toxigenic *Corynebacterium diphtheriae* and, rarely *Corynebacterium ulcerans* and *Corynebacterium pseudotuberculosis*. There are four biovars of *C. diphtheriae* that can be distinguished by biochemical properties: *gravis*, *intermedius*, *mitis* and *belfanti*.

A rapid and accurate microbiological diagnosis of each suspected case is essential for the treatment of the case and the management of close contacts, helping to influence vaccination policies and also ensuring that diphtheria antitoxin is distributed appropriately.

Reporting toxigenic isolates of *C. diphtheriae*, *C. ulcerans* or *C. pseudotuberculosis* is mandatory in the European Region and all suspected isolates should be sent to a reference laboratory for confirmation of identification and toxigenicity testing.

In March 2020, a suspected *C. diphtheriae* isolate from bronchoalveolar lavage from a 17-year-old Somali patient was sent to the National Reference Laboratory for Diphtheria at ISS for the confirmation of the species and for investigating the presence of the diphtheria toxin gene (*toxA*). The isolated was confirmed to be a non-toxigenic *C. diphtheriae* var. *belfanti* that colonised the upper respiratory tract of an anapyretic and asymptomatic patient. Non-toxigenic *C. diphtheriae* carriage in healthy individuals is not unusual.

The fellow was in charge of performing all the laboratory investigation from culture to biochemical test for the identification of the species, as well as molecular assay (PCR) for the detection of the *toxA* gene. The fellow was responsible to immediately communicate the results to the hospital laboratory. Giulia was also in charge of writing a report of the activity (11).

3.4 The changing epidemiology of carbapenemase-producing *Klebsiella pneumoniae* in Italy: toward polyclonal evolution with emergence of high-risk lineages

Supervisors: Monica Monaco and Maria Del Grosso

According to estimates elaborated by the ECDC, over 200,000 infections and nearly 11,000 deaths due to antibiotic-resistant bacterial pathogens occurred in Italy in 2015, with a large proportion of the total burden caused by carbapenem- or colistin-resistant Gram-negative.

During the past decade, carbapenem-resistant *K. pneumoniae* (CR-KP) emerged and spread worldwide as a major antibiotic-resistant threat, causing infections associated with high mortality rates, and becoming endemic in many countries across Europe.

In Italy, the proportion of CR-KP among invasive isolates rose dramatically from 1% in 2009 to 15% in 2010 and to 34% in 2016, with a slight decrease (27%) in 2018. In the early phases, the CR-KP epidemic observed in Italy was found to be mostly associated with the expansion of high-risk clones of ST512 and ST258, included in the clonal group (CG) 258, producing KPC-type carbapenemases. Later epidemiological studies have shown the emergence of other KPC-producing high-risk clones, such as ST307, outcompeting CG258 in some geographical areas.

We characterised a panel of 157 consecutive non-replicate clinical isolates of invasive CR-*K. pneumoniae* collected from 24 out of 30 enrolled hospital laboratories participating to the National Antibiotic-Resistance Surveillance.

Out of 157, 156 were confirmed as *K. pneumoniae sensu stricto* by WGS and found to carry at least one carbapenemase-encoding gene, corresponding in most cases (96.1%) to *bla*_{KPC}. MLST- and SNP-based phylogeny revealed that 87.8% of the isolates clustered in four major lineages: CG258 (47.4%), CG307 (19.9%), ST101 (15.4%) and ST395 (5.1%). This study revealed a close association between lineages and antibiotic-resistance phenotypes and genotypes, virulence traits and capsular types. Colistin resistance was common in all major lineages except ST395, and mainly associated with *mgrB* mutations.

This study represents the first implementation of WGS for the surveillance of CR-KP in Italy, an action compliant with the high-priority recommendations of the ECDC for public health surveillance. This study showed a significant evolution in the epidemiology of KPC-KP, from a predominance of the hyperepidemic CG258 towards a polyclonal population structure with the emergence of CG307 and ST101, providing a snapshot of the evolution of CR-KP in Italy and can be considered as a baseline for future WGS-based surveys in Italy and on a wider scale.

During the fellowship, the fellow was in charge of analysing data and writing the manuscript as first author (1).

Training modules related to the assignment/projects

The Introductory Course introduced the fellows to microbial characterisation methods and their relevance in public health laboratories. The fellows learned how to choose appropriate laboratory methods for suspected pathogen characterisation.

The Outbreak Investigation Module gave a highly comprehensive lecture on outbreak investigation, training the fellows in the basics of WGS and next generation sequencing, phylogenetic and epidemiological analysis. The fellows were also trained in the use of different softwares: STATA, EpiData.

The Multivariable Analysis Module aimed to provide participants with basic definitions and concepts for the different types of regression models, including linear regression, simple and multivariable logistic regression, conditional logistic regression, Poisson and Cox regressions.

The Rapid Assessment and Survey methods (RAS) module focused on field surveys and investigations, teaching on sampling methods to study populations, on how to set up a surveillance system, to interpret surveillance data and to set an alert and response system in complex emergency situations.

The Management, Leadership and Communication in Public Health Module covered different topics such as management, communication, and trained the fellows on how to deliver an efficient presentation according to target audiences.

Biorisk and Quality Management Module was cancelled

The Vaccinology module provided participants with knowledge and skills to understand how to apply and undertake projects and routine work in the field area of vaccine preventable disease epidemiology, including vaccination programmes, evaluation of vaccination interventions, methods to inform vaccine programme decision making and improvement of vaccination coverage.

The Project Review Module provided information on how to improve conference contribution on scientific projects.

Educational outcome

The fellow deepened her public health microbiology knowledge especially in the field of virology. She had the opportunity to improve her knowledge in virological diagnosis, applying new techniques such as ELISA and PRNT performed in BSL-3 and also WGS. She strengthened her ability to work within a laboratory team, especially in a pandemic situation, during the first few months when little was known about COVID-19.

The fellow wrote reports and manuscripts.

4. Biorisk management

4.1 Certificate BSL-3 Biosafety and Biosecurity training

Supervisor: Giuletta Venturi

The training consisted of a three-week intensive training given by the co-supervisor Giuletta Venturi at the BSL-3 of the Department of Infectious Diseases, Istituto Superiore di Sanità. The training included both didactic and practical courses, covering reviewing of biosafety principals and levels, risk assessment, and management and waste management, laboratory management, safety procedures, emergency management, biosafety cabinet practices and procedure, biosecurity.

4.2 Chikungunya virus (CHIKV): viral and antibody kinetics in patients of the Italian 2017 outbreak, and evaluation of serological and molecular tests for the diagnosis of infection

Supervisor: Giuletta Venturi

In the framework of the laboratory investigation project 'Chikungunya virus (CHIKV): viral and antibody kinetics in patients of the Italian 2017 outbreak, and evaluation of serological and molecular tests for the diagnosis of infection' the confirmation of positive ELISA IgM results for CHIKV and MAYV was carried out by PRNT, the gold standard test.

As part of the project, the fellow worked under BSL-3 conditions participating in performing PRNT for CHIKV and MAYV.

Training modules related to the assignment/projects

The fellow was trained by the Istituto Superiore di Sanità, achieving a BSL-3 training certificate issued by ISS. Biorisk and Quality Management Module was cancelled.

Educational outcome

Giulia was trained to understand the importance of biorisk management, to identify and mitigate risks, to use personal protective equipment, perform waste management and safe handling of infectious.

5. Quality management

Proficiency Testing (PT) for detection of Trichinella spp. larvae in pork-meat intended for human consumption according to the EC Regulations 2020/1478 and 2015/1375

Supervisors: Patrizia Rossi, Alessia Possenti and Gianluca Marucci

Human trichinellosis is a zoonotic disease acquired by the consumption of infected raw or improperly cooked meat from pigs, horses, wild boars and other game animals. According to the Commission Implementing Regulations (EU) 2020/1478 and 2015/1375, all animals, which are potential carriers of *Trichinella* spp. larvae, intended for human consumption in the EU market shall be systematically tested for *Trichinella* spp. by laboratories performing official controls.

One of the tasks of the European Union Reference Laboratory for Parasites (EURLP) at ISS is to organise PTs for National Reference Laboratories (NRLs) for Parasites of the member states and for public and private laboratories in order to assess their competence and to improve laboratory performance in detecting *Trichinella* spp. larvae in meat.

A PT on detection of *Trichinella* larvae in meat samples took place in November 9th 2020 at the EURLP, with the participation of 26 attending laboratories (23 public laboratories and three private laboratories). Participants had to complete the PT, analyse the items by one of the approved digestion methods following the ISO18743:2015 and submit results in the restricted area of the EURLP website within five days of the date of sample preparation. According to current EU Regulation (2020/1478), evaluation of the results was only qualitative and a final report on the performance of all laboratories participating in a single round was issued.

The PT performed on November 9th demonstrated a high competence of the 26 participating laboratories to detect *Trichinella* larvae in meat: all the laboratories passed the PT; no 'false positive' or 'false negative' was reported. The analysis of the results for the period 2016-2020 showed that all the laboratories have kept stable and high their performance on *Trichinella* inspection.

The use of standardised methods for the detection allows the harmonisation and the mutual recognition of test results performed by laboratories, and of particular relevance, for those laboratories performing official controls. The increasing global requirements for reliable diagnostic and control methods of foodborne parasites to ensure food safety makes quality assurance in laboratory testing of crucial importance for effective diagnostic and control programs.

The fellow was involved in all the steps of a PT: (i) PT organisation; (ii) sample preparation; (iii) packing of samples and delivery; (iv) result analysis and feedback to the customer laboratories. The fellow was also involved in the item preparation, packing and delivery for other two PT rounds organised on 21 September and 23 November, respectively. The fellow was in charge of writing a report (12).

Training modules related to the assignment/projects

The fellow was trained by the EURLP at the Istituto Superiore di Sanità, Rome, Italy.

Biorisk and Quality Management Module was cancelled.

Educational outcome

By participating in the organisation of a PT, the fellow learnt about quality management regarding all aspects. She became familiar with all the steps of a PT, understood the principles and practice of quality assurance, analysed the results from the PT and wrote the activity report.

6. Teaching and pedagogy

The phenomenon of antibiotic-resistance and the Italian and European situation

The fellow was involved in the organisation of the online course 'The phenomenon of antibiotic-resistance and the Italian and European situation' organised by ISS and uploaded on the EDUISS platform. This course aimed to promote basic knowledge of antibiotic-resistance and strategies for its contrast. The course was targeted to all the medical and health workers. The task of the fellow was to prepare all the material uploaded on the platform: tutorial, reading material, bibliography, sitography. She also wrote the reflective note (24-26).

Syphilis? No, thanks!

The fellow, supervised by Anna Colucci and Rosa Dalla Torre of the 'Unità Operativa Ricerca psico-socio-comportamentale, Comunicazione, Formazione' at ISS, worked in order to provide information about syphilis to adolescents by a video for the IGTV (Instagram Television) to be disseminated through the most popular channels consulted by adolescents. In particular, the fellow was in charge to take care of the video scientific contents writing a concise script for the video using an appropriate language for adolescents. The task of Giulia was also to prepare a report activity (13).

Training modules related to the assignment/projects

EPIET/EUPHEM Introductory Course introduced the fellow with basic knowledge on preparation and an efficiently delivering of teaching presentation through lectures on pedagogics and teaching.

Educational outcome:

The fellow gained experience in different stages of teaching, from outlining course objectives, defining learning objectives and developing learning materials, understanding the importance of using an appropriate language depending on the target. At the end of this experience, the fellow wrote a reflective note and a report of the activity.

7. Public health microbiology management

7.1 Management during outbreak investigation and other projects

Public health microbiology management (PHMM) was an integral and essential component of outbreak investigations as well as part of all projects and activities throughout the fellowship. This included time-management, working in multidisciplinary teams, communicating to different stakeholders, setting up meetings and teleconferences, team building and coordination, and research collaboration. The fellow worked with different National Reference Laboratories at ISS within the CHIKV, COVID-19, *C. diphtheriae* and the AMR-projects, and collaborated with the Epidemiology unit especially for the outbreak investigation, surveillance and research projects. She also collaborated with the 'Unità Operativa Ricerca psico-socio-comportamentale, Comunicazione, Formazione' at ISS. During the fellowship, the fellow improved her skills in oral and written communication and problem-solving.

7.2 Presentation to the ECDC Director and Chief Scientist

During the Management, Leadership and Communication module in Stockholm, the fellow and her group had the oral presentation 'Improving the ECDC fellowship - Visions from the fellows', to discuss with the highest authorities of ECDC, including the ECDC Director (21).

7.3 Management of Peer - Review processes

During the fellowship, Giulia was invited and accepted to be a peer reviewer for a scientific manuscript sent to Journal of Global Antimicrobial Resistance (28).

Training modules related to the assignment/projects

Management, Leadership and Communication in Public Health Module trained the fellow in how to best lead, manage and communicate in the Public Health working environment with different stakeholders through many lectures and interactive sessions.

Vaccinology trained the fellows in how to apply and evaluate appropriate control strategies in response to vaccine preventable disease outbreaks.

Educational outcome

Giulia strengthened her abilities in management, leadership, networking, and team building. She increased her skills in communication with scientific experts from a multidisciplinary background, authorities, the public and the media. She also improved communication through scientific writing and oral presentations.

8. Communication

Publications related to the EUPHEM fellowship

1. Di Pilato V*, **Errico G***, Monaco M, Giani T, Del Grosso M, *et al.* The changing epidemiology of carbapenemase-producing *Klebsiella pneumoniae* in Italy: toward polyclonal evolution with emergence of high-risk lineages. *J Antimicrob Chemother.* 2021 Jan 19; 76(2):355-361. doi: 10.1093/jac/dkaa431. PMID: 33188415. ***shared first authorship**
2. Mancini F, Barbanti F, Scaturro M, **Errico G**, Iacobino A, *et al.* Laboratory management for SARS-CoV-2 detection: a user-friendly combination of the heat treatment approach and rt-Real-time PCR testing. *Emerg Microbes Infect.* 2020 Dec; 9(1):1393-1396. doi: 10.1080/22221751.2020.1775500. PMID: 32552549; PMCID: PMC7473159
3. Fattorini L, Creti R, Palma C, Pantosti A; Unit of Antibiotic Resistance and Special Pathogens*; Unit of Antibiotic Resistance and Special Pathogens of the Department of Infectious Diseases, Istituto Superiore di Sanità, Rome. Bacterial coinfections in COVID-19: an underestimated adversary. *Ann Ist Super Sanità.* 2020 Jul-Sep; 56(3):359-364. doi: 10.4415/ANN_20_03_14. PMID: 32959802. ***Errico G is mentioned in the Unit of Antibiotic Resistance and Special Pathogens**
4. Iacchini S, Bellino S, D'Ancona F, Del Grosso M, Camilli R, **Errico G**, *et al.* National surveillance of antibiotic-resistance AR-ISS: first six months of 2020 data. *Boll Epidemiol Naz* 2020; 1(2):46-50
5. Lötsch F, Albiger B, Monnet DL, Struelens MJ, Seifert H, Kohlenberg A; European Antimicrobial Resistance Genes Surveillance Network (EURGen-Net) carbapenem-resistant *Acinetobacter baumannii* capacity survey group*; EURGen-Net carbapenem-resistant *Acinetobacter baumannii* capacity survey group. Epidemiological situation, laboratory capacity and preparedness for carbapenem-resistant *Acinetobacter baumannii* in Europe, 2019. *Euro Surveill.* 2020 Nov; 25(45):2001735. doi: 10.2807/1560-7917.ES.2020.25.45.2001735. PMID: 33183407; PMCID: PMC7667627. ***Errico G is mentioned in the EURGen-Net carbapenem-resistant *Acinetobacter baumannii* capacity survey group**
6. **Errico G***, Amendola A*, Fortuna C, Marsili G, Benedetti E, Fiorentini C, Venturi G *et al.* Diagnosis of Chikungunya virus (CHIKV) infection at the Italian National Reference Laboratory for Arboviruses, in the period November 2015 - December 2020. (in preparation) ***shared first authorship**

Reports

7. **Errico G.** NDM-*Klebsiella pneumoniae*/*Escherichia coli* outbreak in the Tuscany Region, Italy, November 2018-ongoing.
8. Bellino S, Iacchini S, Monaco M, Del Grosso M, Camilli R, **Errico G**, D'Ancona F, Pantosti A, Pezzotti P, Maraglino F, Iannazzo S. AR-ISS: sorveglianza nazionale dell'Antibiotico-Resistenza. Dati 2019. Roma: Istituto Superiore di Sanità; 2020. (Rapporti ISS Sorveglianza RIS-1/2020 rev).
9. Iacchini S, D'Ancona F, Bizzotti V, Giannitelli S, Monaco M, **Errico G**, Bellino S, Pezzotti P, Pantosti A, Iannazzo S. CPE: sorveglianza nazionale delle batteriemie da enterobatteri produttori di carbapenemasi. Dati 2019. Roma: Istituto Superiore di Sanità; 2020. (Rapporti ISS Sorveglianza RIS-2/2020).
10. **Errico G.** Molecular confirmation of SARS-CoV-2 infection on clinically positive samples sent to the National Reference Laboratory at Istituto Superiore di Sanità.
11. **Errico G.** Confirmation of identification and diphtheria toxin gene detection on a suspected *Corynebacterium diphtheriae* isolate by phenotypic method and molecular technique.
12. **Errico G.** Proficiency Testing (PT) for detection of *Trichinella* spp. larvae in pork-meat intended for human consumption according to the EC Regulations 2020/1478 and 2015/1375.
13. **Errico G.** Syphilis? No, thanks.
14. **Errico G.** Analysis of influenza vaccination response in elderly, season 2019-2020.
15. **Errico G.** National Surveillance of Healthcare-Associated (HA) methicillin-resistant *Staphylococcus aureus* (MRSA) bloodstream infections: drafting the protocol of a pilot project.
16. **Errico G.** Analysis of Enter-Net surveillance data from 2016 to 2019, Italy. In preparation.

Conference presentations

17. ECCMID 2020. Accepted as poster. Camilli R, Del Grosso M, D'Ambrosio F, Monaco M, Pimentel de Araujo F, **Errico G** *et al.*, 'Trends in invasive pneumococcal disease in Italy, 2010-2018'. The conference has been cancelled due to the COVID-19 outbreak. Abstract published in the Abstract Book 2020 (Abstract number: 6587).
18. ECCMID 2020. Accepted as poster. Monaco M, Bellino S, Iacchini S, Del Grosso M, Camilli R, **Errico G** *et al.*, 'Antimicrobial resistance in Italy: data from the National Surveillance System AR-ISS over 7-year period, 2012-2018'. The conference has been cancelled due to the COVID-19 outbreak. Abstract published in the Abstract Book 2020 (Abstract number: 4795).
19. ESCAIDE 2021. **Errico G**, Villa L, García-Fernández A, Owczarek S, Fortini D, Dionisi A M, Arena S, Busani L, Lucarelli C. Antimicrobial-resistance in human strains of *Salmonella* spp: data from Enter-Net surveillance system 2016-2019, Italy. Accepted as poster.

Other presentations

20. Oral Presentation of the EUPHEM/EPIET Programme to the Department of Infectious Diseases at ISS, October 2019.
21. Oral Presentation at the MLCPH module entitled 'Improving the ECDC fellowship – visions from the fellows', Presentation to the ECDC Director and Chief Scientist during the Management, Leadership and Communication module, 14/02/2020, Stockholm.
22. Oral Presentation at the PRM entitled 'Evaluation of commercial serological tests for the diagnosis of Chikungunya virus (CHIKV) and Mayaro virus (MAYV) infection in patients of the Italian 2017 outbreak'. Online. August 2020.

Other activities

23. **Errico G**. Analysis of influenza vaccination response in elderly, season 2019-2020. Research protocol.
24. **Errico G**. The phenomenon of antibiotic-resistance and the Italian and European situation. Reflective note.
25. Pantosti A, Monaco M, **Errico G**. The phenomenon of antibiotic-resistance and the Italian and European situation. Tutorial (teaching activity).
26. **Errico G**, Monaco M, Pantosti A. Inquadrare il fenomeno dell'antibiotico resistenza a livello nazionale ed europeo. Reading Material (teaching activity).
27. **Errico G**, Monaco M, Pantosti A. Book chapter 'La resistenza agli antibiotici: meccanismi, determinanti, epidemiologia, come superarla' from the book 'Gli antibiotici spiegati bene'. Edited by Silvio Garattini. Published by Lswr Editor, February 2020.
28. Paper Revision for Journal of Global Antimicrobial Resistance. November 2020.

9. Other activities

During the fellowship, the fellow was involved in writing a chapter of a book dealing with antibiotics. In particular, the book chapter was focused on antibiotic-resistance (27).

10. EPIET/EUPHEM modules attended

1. Introductory course, 23/09/2019 - 11/10/2019, Spetses, Greece
2. Outbreak investigation, 09-13/12/2019, Nicosia, Cyprus
3. Management, Leadership and Communication in Public Health, 10-14/02/2020, Stockholm, Sweden
4. Multivariable analysis, 12-18/06/2020, online and 18/03/2021 online
5. Project Review Module 2020, 24-28/08/2020 online
6. Rapid assessment and survey methods, 27/04, 5-6/05/2021 online
7. Vaccinology, 14-18/06/2021, online

11. Other training

1. Lecture: 'Computer security', 30/10/2019, Rome, Italy
2. Lecture: 'The PRIVACY impact on new technologies in healthcare', 21/10/2019, Rome, Italy
3. Online course with certificate: 'Vaccini e vaccinazioni: strategie e strumenti per la prevenzione delle malattie infettive', 3/11/2019, online, EDUISS platform
4. Online course with certificate: 'Vaccini e malattie prevenibili da vaccinazioni, basi immunologiche e nuovi approcci', 6/11/2019, online, EDUISS platform

5. AMR Event organised by Ministry of Health, 22/11/2019, Rome, Italy
6. The European Scientific Conference on Applied Infectious Disease Epidemiology (ESCAIDE), 27-29/11/2019, Sweden, Stockholm
7. The Public Health Alliance Central Eastern Europe (PHACEE) Summit, 18/12/2019, Rome, Italy
8. Online course on EVA with certificate: 'Cross-border sharing of public health data e-learning', 28/02/2020, online
9. Online scientific seminar with certificate: 'Gli italiani e gli antibiotici: informazione, utilizzo e consapevolezza del fenomeno dell'antimicrobico resistenza', 18/11/2020, online
10. The European Scientific Conference on Applied Infectious Disease Epidemiology (ESCAIDE), 24-27/11/2020, Sweden, online
11. Lecture: 'Corso sulla Privacy' with certificate, 11/12/2020, online
12. Lecture: 'Legal Epidemiology and the Path to Better Health Law and Policy', 21/01/2021, online
13. Online course on EVA with certificate 'Antimicrobial Stewardship e-learning course', 22/03/2021
14. BSL3-training certificate, 18/02/2021, Dep. Infectious diseases, Istituto Superiore di Sanità, Rome, Italy
15. Online course with certificate 'The Global Outbreak Alert and Response Network' by GOARN, 22/03/2021
16. Online course with certificate 'Working with GOARN in the field (the deployment process) by GOARN', 22/03/2021
17. Online course with certificate 'The public health emergencies and humanitarian architecture and landscape' by GOARN, 23/03/2021
18. On-line course with certificate 'Working in an international multidisciplinary outbreak response team' by GOARN, 23/03/2021
19. On-line course with certificate 'Personal well-being for deployment' by GOARN, 23/03/2021
20. UN BESAFE certificate by GOARN, 24/03/2021
21. On-line course with certificate 'SARS-CoV-2: diagnosi, varianti, vaccini', 26/03/2021
22. Lecture: 'Le Malattie Batteriche Invasive prevenibili da vaccinazione in era COVID-19', 19-20/05/2021, online
23. On-line training course 'Isolation of *Bacillus anthracis* spores from soil in contaminates site' by SHARP, 25/06/2021

Discussion

Coordinator's conclusions

One of the main goals of the EUPHEM programme is to expose fellows to diverse and multidisciplinary public health experiences and activities, thus enabling them to work across different disciplines. This report summarises all activities and projects conducted by Giulia Errico during her two-year EUPHEM fellowship (cohort 2019) as an MS-track fellow at the Istituto Superiore di Sanità in Rome, Italy.

Giulia joined the fellowship to widen her skills in Public Health Microbiology and over the past two years she responded to the challenges associated with the COVID-19 pandemic by undertaking an impressive array of projects at ISS. Her strengths are clearly in the area of surveillance of AMR, but I was very impressed by her hard work and dedication to all the projects she undertook. In particular, I was very pleased to see her follow the guidance of her superb supervisory team when undertaking the quality management competence with a project to produce a PT on detection of *Trichinella* larvae in meat for human consumption, from production of the panel to participant's data analysis. Understanding the importance of suitable PT panels and quality management is key in a time when countries need laboratory public health professionals able to organise surge laboratory capacity and diagnostic tools at short notice. Giulia is part of the new generation of public health microbiologists who will be able to collaborate within networks that integrate human and animal health with data from the environment, to manage, control, and prevent future zoonotic threats. It is very rewarding to have contributed to mentoring such a solid Public Health Microbiology professional.

Supervisor's conclusions

Giulia, the third MS-track fellow at ISS, started the EUPHEM fellowship as an experienced microbiologist.

Giulia has shown a remarkable capacity to meet the challenges of changes in supervisor and the COVID-19 pandemic. She immediately offered her support to The National Reference Laboratory at ISS in charge of carrying out all confirmatory testing for SARS-CoV-2, in the first pandemic phase. Giulia was responsible for performing the molecular confirmation of clinical positive samples sent to ISS between March and May 2020 and participated in a research project on COVID-19 diagnosis.

She has shown a great degree of versatility and flexibility, and managed to complete most tasks at a high level and within set timeframes.

She approached her tasks with great enthusiasm and scientific rigour that led to interesting discussions with his colleagues, supervisors, and EPIET fellows, thus creating a mutual learning experience, in the spirit of the EUPHEM programme. Giulia was instrumental to the preparation of the first protocol of National Surveillance of Healthcare-Associated (HA) methicillin-resistant *Staphylococcus aureus* (MRSA) bloodstream infections and investigation of an NDM-*Klebsiella pneumoniae*/ *Escherichia coli* outbreak.

In this two-year programme Giulia has broadened her understanding of public health microbiology and epidemiology and the capacity to deal with stressful situations. We have no doubt that Giulia will continue to do an excellent work and contribute as a public health microbiology specialist at national and international level.

Personal conclusions of fellow

I have known of the EUPHEM programme for years and had met all the EUPHEM fellows based at ISS, including collaborating with them on different projects. When I decided to apply myself, I felt it would be a unique and rewarding opportunity, both on professional and personal levels, an exceptional opportunity that enriches personal and professional experience. This fellowship has given me the chance to improve my expertise in microbiology, and to strengthen interdisciplinary collaborations and promoting networking between epidemiologists, public health microbiologists and other healthcare specialists in Europe. It has provided an exceptional opportunity to be involved in outbreak investigations and in surveillance of infectious disease, and deepened my expertise within bacteriology, virology and parasitology, and epidemiology.

The programme also strengthened my ability to multitask, manage stress and work in a team, especially in the particular circumstances of the COVID-19 pandemic. The programme has represented a great challenge in the context of an emergency in which certain projects had to be reduced or have progressed slowly and our face-to-face modules had to be switched to online versions.

Acknowledgements of fellow

First, I would like to express my sincere gratitude to my first main EUPHEM supervisor at ISS, Annalisa Pantosti, and EUPHEM co-supervisor, Loredana Ingrosso, for introducing me to the first year of the fellowship through their excellent support in interesting projects and activities. Thank you also to Roberta Creti for being part of my supervisor's team in the first year, with her expertise and availability.

I would like to deeply thank my current main supervisor, Claudia Lucarelli, and co-supervisor, Giulietta Venturi, for making the fellowship such a fantastic experience despite the difficulties related to the pandemic. Thank you for encouraging me, for being so flexible and helpful, and for giving me the opportunity to collaborate with you in valuable projects.

I would like to thank the head of the 'Antibiotic resistance and special pathogens Unit' at ISS, Dr Lanfranco Fattorini, all my colleagues, and all my project supervisors. A big thanks also to Antonello Amendola and Sauro Sisi; it was fun and constructive working with you.

I am especially grateful to my frontline coordinator Aura Andreasen, always present with her constant and constructive supervision. I could not have hoped for a better frontline coordinator. A warmest thank you also to Aftab Jasir for her deep dedication to the programme and to her fellows.

A special thanks to all EPIET/EUPHEM Cohort 2019 fellows, particularly to Martina Del Manso and Alberto Mateo Urdiales.

Last but not least, my biggest thanks go to my family, as always.