UNIVERSITÀ DEGLI STUDI DI TORINO

Laurea Honoris Causa

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LECTIO MAGISTRALIS

“One Health, One World”

Aula Magna Campus Universitario Grugliasco
11 FEBBRAIO 2020

One Health, One World

Magnifico Rettore; Egregio Direttore di Scienze Veterinarie; chiarissimi professori e studenti; signore, signori, gentili amici e famiglia: grazie per questo grande onore e buongiorno.

One Health

Increasingly, we understand that people, animals and the environment are all essential parts of one healthy (or unhealthy) world. For infectious diseases in particular, studying the tight connections between human and animal public health and medicine are essential to understand transmission and design and apply effective interventions. The One Health approach is defined by the CDC as: “a collaborative, multi-sectoral, and transdisciplinary approach—working at the local, regional, national, and global levels—with the goal of achieving optimal health outcomes recognizing the interconnection between people, animals, plants, and their shared environment".

In a different way, as the naturalist and author, Gerald Durrell expressed it in his book about childhood in Corfù - we are all one family. Talking about families, I have to mention that I will not be the first one to receive a degree from l’Università di Torino. My dear aunt, Lotte Dann Treves, received her degree in medicine from the Istituto di Anatomia, more than 80 years ago, in 1938, working with Prof. Giuseppe Levi.

Ecology of Infectious Diseases

For several decades, with colleagues, students and post-docs, we have been studying the Ecology of Infectious Diseases. Students of infectious diseases have been leaders in incorporating ecological approaches into veterinary and medical research, integrating studies of pathogens, vectors, humans and animals in their ecosystems. The role of changing environments in the introduction, establishment, transmission, and impact of diseases has been receiving growing attention. It is an area where veterinary and human health researchers and practitioners have collaborated most, and where practical concerns about health have overlapped with the need to understand underlying transmission determinants. There is a long

history to an approach that considers the landscape when studying disease (an approach sometimes called medical geography), going back to the seminal work on zoonotic diseases in Russia by Eugeny Pavlovski in the first half of the 20th century. Zoonoses are diseases that are common to animals and people, typically transferred from vertebrate animals to humans (sometime through arthropod vectors). Teresio Balbo, here at the University of Torino, played a key role in bringing this approach into veterinary medicine.

Emerging Infectious Diseases (EIDs) and Anthropogenic Changes

Most EIDs are zoonotic, and either have an animal origin before becoming human diseases, or maintain a dependence on a reservoir host. If we look at most infectious disease news stories in the last 50 years, we see that nearly all share a link between wildlife, domestic animals and/or humans. They are also typically global phenomena, and, consequently are receiving increased attention (including a dedicated journal). Most recently, African Swine Fever (ASF) has been getting growing attention with a major epidemic in China, and wide concern about its emergence in Western Europe, following outbreaks in Eastern Europe and the growing and expanding wild boar population. Since the beginning of 2020, the new Corona virus outbreak in China and beyond, with its apparent origin in the Huanan seafood and live animal market in Wuhan has dominated the news. Its transmission pattern follows and exceeds the 2003 SARS outbreak; on January 30th it was declared a global health emergency by the WHO.

EID events are increasing mainly due to human activities and their impacts. We are in the Age of the Anthropocene, and among the manifestations of the Anthropocene, are the growing number and rate of emerging and re-emerging infectious diseases. An alternative title to this talk could have been: “One Health in a Changing World”, and indeed the anthropogenic changes in the environment and the accelerating disruption of the natural world are at the heart of the continuously evolving patterns of infectious diseases distribution and transmission. Key anthropogenic habitat changes are demographic (urbanization), agricultural (crops, water management and marketing), and the natural habitats (e.g., species extinction, deforestation, reforestation).

Urban population (and intensive farming) growth

Other than climate change, urbanization is possibly the most important manifestation of the Anthropocene: in less than 100 years we have shifted from a largely rural world to an urban one, with most of us (and increasingly more) living in cities. Similarly, the number of farms is declining with many small farms absorbed into large agricultural and animal-intensive production facilities. Not only do most of us live in cities now, but our cities are of an unprecedented (and growing) size, with many megalopolises of more than10 million people, mostly in low and middle income countries.

There are many changes associated with life in a crowded environment, with significant health, ecological and epidemiological implications; among them, the growing opportunities for unchecked disease transmission, given a high degree of contact between inhabitants. This is because monocultures (including megacities), with unprecedented numbers of conspecifics in crowded proximity, provide unique opportunities for the spread of pathogens. Veterinarians have been dealing with large outbreaks in confined livestock and poultry facilities for a long time. Rapid spread of pathogens and disease transmission can further be reinforced by reduced biodiversity (and loss of alternative hosts), growing antibiotic resistance, current agricultural practices, faster trade and travel, pollution and urban heat islands, and social inequalities (most notably, within cities and between the North and the South).

Movement of People and Animals

Another important anthropogenic change is the growing amount, distance and speed of movement of both humans and animals. We all can move between any two locations in the world in less than 24 hours, which, for example, renders quarantine, a traditional measure to control disease spread much less effective. Disease related movements include commerce (e.g., tires containing mosquitoes, live animals); refugees and mass migrations (due to war, climate change, environmental degradation, political oppression, and, historically, the slave trade); occupational, pilgrimage and leisure travel (e.g., migrant workers, the annual Hajj pilgrimage to Mecca and the Chinese New Year/Spring Festival travel in China).

Animal movement can be both natural and human induced, and the latter occurs at an unprecedented scale. Some two billion live animals were exported in 2017, with European countries among the biggest exporters (Denmark, the Netherlands, Canada, Germany) and the U.S, Saudi Arabia, Poland and Italy among the big importers. Furthermore, the illegal trade of animals and animal products is a huge problem both within countries and globally.

Invasion of pathogens, vectors and hosts

To understand, predict, prevent and control new and re-emerging diseases, we need to study the pathogens, the vectors and the hosts, and their movement patterns. Where do they come from and where will they go to? When and how do such movements occur? What is the role of anthropogenic effects? Will the invasion become successful (will the pathogens become established, and transmission take place)?

Some vectors and reservoir hosts have been very successful as invaders, becoming readily established in new areas. These synanthropic species include mosquitoes and the arboviruses they carry: *Cx. pipiens* – West Nile virus (WNv); *Ae aegypti* – dengue; Ae. *Albopictus* – Chikungunya, sandflies (leishmaniasis), ticks – Lyme disease, Tick-borne encephalitis (TBE), deer – hosts for ticks, carriers of Chronic Wasting Disease (CWD), rats (Plague, Typhus, leptospirosis) and wild boars – ASF. We need to pay special attention to these arthropods and vertebrates that have adapted so very well to the urban or disturbed rural environment.

Our work – mostly vector-borne diseases (VBDs)

Much of our research has centered on vector-borne diseases, primarily those carried by mosquitos and ticks. Many of these diseases have a global distribution (malaria, dengue, Lyme diseases, West Nile virus, leishmaniasis); some have extended their global reach recently (Chikungunya, Zika), while others are more endemic in the southern hemisphere (NTDs - Neglected Tropical Diseases, such as African trypanosomiasis, Chagas diseases). However, there is high degree of heterogeneity in the local transmission patterns of these global phenomena. Our field and laboratory research and analytical studies, have always been based on international collaborations, with an emphasis of training and mentoring of veterinarians, ecologists and human health professionals, and with strong commitment to

improved communication among disciplines, with the public and with health agencies. We conduct simultaneous studies of mammals (including humans), birds, arthropods and pathogens, use an eco-epidemiological approach to study heterogeneity, and apply tools such as GIS and spatial analysis. While we are pursuing innovative basic research, our attention has always been on the impact on public human and animal health, especially in vulnerable populations.

For transmission of vector-borne diseases and spillover to humans (or domestic animals), several things have to come together for the pathogen, vector, reservoir host, and animal/human of veterinary/medical importance. Namely, conditions have to be right for vector survival, presence of reservoir hosts, pathogen amplification and transmission, and opportunities for human (or domestic animal) exposure. Vector-borne diseases have received much attention with regard to the potential impact of climate change. Because many of them have a complex transmission cycle, it is hard to predict how climate change, especially changes other than global warming (e.g., rainfall, humidity, extreme events), will impact transmission and disease patterns.

Lyme disease and West Nile virus in the U.S. and Europe

To study a disease such as Lyme disease and WNv, we have to collect, analyze, integrate and interpret diverse data from the field, veterinary sources, human public health and medical records, satellite imagery and other environmental data sources. We apply Geographic Information Systems (GIS), spatio-temporal statistics and mathematical modeling in such studies. For our Lyme disease studies we have incorporated collections of questing and attached ticks, reservoir hosts studies (small and medium-size mammals, deer hunt check stations surveys, canine serology), human case data, environmental databases and satellite images. Using these data sources, we have developed a climate-based model for Lyme disease risk in the eastern U.S. Lyme disease (and TBE) have been expanding and becoming more common in parts of Europe and North America, and climate change may result in a changing distribution with simultaneous expansion (northward) and contraction (from the south). Studies in the Apennines and the Alps led by University of Torino researchers have shown that altitudinal expansion of ticks has occurred in both mountain ranges.

West Nile virus has become a major problem in the U.S. and parts of southern Europe. It is transmitted by the most common mosquito, *Culex pipiens*, which thrives in urban areas (as

well as rural ones). We have studied WNv extensively in the U.S., esp. around Chicago and Atlanta (but also a little in Italy), with participation of several Torino students and post-docs. As with Lyme disease studies, we have relied on diverse data sources and methods, including avian mist-netting and counts, adult and larval mosquito collections, avian and mosquito WNv isolation and confirmation, mosquito blood meal analysis, movement studies of birds and mosquitoes, and molecular genetic studies. In the greater Chicago area, we have demonstrated a well-defined spatial distribution and transmission risk based on urban landscape ecology, associating risk with demography, socio-economic factors, the built and natural environment, and aquatic sources. In Atlanta, we helped explain the much lower transmission of WNv by the mosquito feeding preference for Northern Cardinals, which are not good reservoirs for WNv.

Spillover of zoonoses and emergence of arboviruses into an urban transmission cycle

West Nile virus is one example of the spillover phenomenon, where zoonotic pathogens extend their host range from wild animals to domestic ones and to humans. Some of the best known arboviruses (arthropod borne viruses), and ones that have made the complete switch to humans, are Yellow fever, Dengue, Chikungunya and Zika. All of them have successfully moved from natural (sylvatic) habitats to urban ones, and crossed oceans from Africa or Asia to the Americas by ships (Yellow fever, dengue) and/or plane (Chikungunya, Zika).

We have a long-term collaborative study with universities, city health authorities and other research institutions in Salvador, the capital of Bahia, Brazil on the ecology of mosquito vectors, the transmission of arboviruses, and the epidemiological pattern of human disease. Salvador provides an excellent example of rapid (and often uncontrolled) urbanization, facilitating transmission of these arboviruses. In one neighborhood study, we have shown that *Aedes* mosquitoes can adapt to new non-traditional breeding habitats, which render classical surveillance activities less informative about risk for outbreaks. Thanks to strong collaboration with the city epidemiological surveillance unit, we were able to monitor the Zika outbreak from its inception and follow the resulting complications, first the neurological disorder (Guillain Barré syndrome – GBS) and then the congenital complications in newborns, particularly microcephaly. Using epidemiological curves, we were able to define the time lags between the Zika, GBS and microcephaly outbreaks in Salvador, and

demonstrate the temporal association between infection of the mother during the first month of pregnancy and the ensuing severe damage to the fetus.

In another extensive study of dengue, we studied the spatial patterns and mechanisms for geographic expansion of *Aedes aegypti* in the Peruvian Amazon. As part of this long-term collaborative study in Iquitos, Peru, we have been looking at movement of mosquitoes and patterns of spread of dengue at a range of spatial scales. In one study we have shown that the larger boats that move along the rivers, play a key role in introducing mosquitoes and dengue (and possibly other pathogens) to new areas, thus helping predict potential pattern of spread and areas at high risk.

By giving you a taste of some of our projects, I hope to have shown that vector-borne diseases epitomize the need to consider many components of the complex and heterogeneous transmission cycle, to apply a multi-disciplinary approach, which includes ecologists, veterinarians, statisticians, social scientists, epidemiologists, economists and many others, and to ensure effective communication among all parties.

Climate-induced vulnerability and pastoralist livestock marketing chains in Ethiopia

I want to say a few words about a very different collaborative study in southern Ethiopia, which looked at the impact of climate change (and other environmental and demographic changes) on pastoralists. This study involved anthropologists, veterinarians, animal scientists and epidemiologists. The underlying motivation for the study was to work with pastoralists, and help them deal with the drastic changes occurring in sub-Saharan Africa (specifically south Ethiopia and northern Kenya). The livestock marketing revolution finally hit the Horn of Africa, with export and price increases (US$ 1billion export), while food crisis/poverty remains. We want to: understand how markets can help producers/pastoralists and traders better cope with climate variability; contribute to policies and programs that build resilience in dryland/pastoralist areas, with a focus on the role that markets can play; and to do what universities do best – build knowledge (applied research), disseminate it through training, and put it in the hands of practicing partners (government, NGO’s, other practitioners, and, of course, the pastoralists themselves).

Pastoralists have to balance needs for water, food and access to markets. There are rainy season water sources, but droughts are becoming more frequent and longer, as rainfall is becoming less predictable. Mobile phones play a big role in allowing pastoralists to

communicate among themselves and with the emerging pastoralist/ bush traders, who collect market animals in remote areas. These traders also need to graze them in bush markets and collection points. Using mobile phones, the pastoralists can improve local bargaining/price and timing of sales, and help address feed problem. As part of this study, we published an article, titled: “Mobile Phones for Mobile People: The Role of Information Communication Technology (ICT) among Livestock Traders and Borana Pastoralists of Southern Ethiopia.” An interesting finding of our study was not only the increased reliance on mobile phones, but also the frequent sharing of this limited resource, especially within households, indicating the importance of maintaining societal integrity in face of drastic changes.

An important outcome of this study was the strengthening of Ethiopian institutions, and individual Ethiopian collaborators through training in Ethiopia and the U.S., and new collaborations that evolved with veterinary researchers [for example, studies on milk consumption (and a switch to camel milk) and nutritional outcomes among pastoralist children]. The growing hardships in rural sub-Saharan Africa (in part due to climate change and environmental degradation) are one of the reasons for the continuing growth in number of refugees trying to make it to Italy and other European Mediterranean countries, an issue that you are all too familiar with, and which impacts politics here, as well as there.

What’s next

So, what does the future bode? We do not have a crystal ball, and both dystopia and utopia are among the many possible faces of the future. Of course, when following the news and predictions about the dire consequences of climate change, species extinction, growing inequality, etc., it is easy to become depressed by this dystopic outlook. However, while the more positive prognosticators rarely envision a utopia, the opportunities for new technologies, alternative economic regimes and societal changes are exciting. Our main challenges remain the growing human population, the greatest single factor driving changes at all scales; how to address its needs in a more equitable fashion that takes into account the well-being of the rest of the world – its forests, animals, glaciers, rivers and soil; and how to communicate more effectively the challenges we are facing and the ways for a possible solution.

Future epidemics and the One Health Triad

Future epidemics will occur, caused by known players, by modified/adapted ones and by newcomers. In a 2015 WHO exercise, the human-animal interphase (including antibiotic resistance, animals as sentinels, and new zoonoses) was highlighted as a key factor. Collaborations of ecologists, veterinarians and human health professionals in a One Health approach are essential to address these ongoing and growing challenges. A complete understanding of host–pathogen interactions and how and where to intervene requires an ecosystem perspective that accounts for processes occurring at both macro- and micro-scales, including at the pathogen, host and environmental levels, as well as an integration of the effects of processes across these scales. Together with the impact of global trade and travel, EIDs exemplify the inter-connectedness of humans, animals and the environment, and demonstrate how human and animal ecology influence the global spread of disease.

A term that is gaining favor now is Planetary Health, defined by the Rockefeller Foundation–Lancet Commission on Planetary Health as: "the health of human civilization and the state of the natural systems on which it depends.” Regardless of terminology, the triad of healthy people, animals and environment is the core of a productive approach to study, understand, act and achieve a healthier world. We are getting better at it, and Veterinary Science in Torino in collaboration with other units of Università di Torino and other universities in Italy and abroad have been in the forefront of this approach in studies of domestic animals outbreaks, wildlife diseases, vector-borne diseases and antibiotic resistance. Only by working together, thinking outside the box, and mastering more effective communication strategies, can we hope to successfully prepare and address the upcoming challenges of infectious diseases in humans, animals and plants.