Infectious disease epidemiology at the digital era in a global context

Health of populations everywhere in the world has dramatically improved in the past years. Child mortality halved in less than three decades. Life expectancy has increased in all countries and almost continuously since World War II, although large gaps still exist. However, one major threat for humanity remains for which we still don't have appropriate solutions: emerging infectious diseases (EID). We were collectively not very good in anticipating the last pandemic flu. We thought it would emerge from Southeast Asia, with an avian H5N1, when it came from Mexico, with a swine and avian strain of H1N1. We were not better in assessing the risk of Ebola in Western Africa, or Zika in Latin America and no one would dare to predict the evolution of the current outbreak in Democratic Republic of Congo (DRC).

This special issue of *JPHE* focuses on a carefully selected set of EID and aims to learn from intelligent approaches to help better understanding the conditions that promote their emergence. Two groups of emerging viral pathogens are of primary concern here: (I) airborne viruses, and (II) arboviruses (arthropod-borne).

The greatest threat of airborne viruses is due to the lack of measures to control airborne spread. Examples from the recent past highlight the pandemic potential of these viruses: the outbreaks of SARS-CoV in 2002/2003, the pandemic of influenza A/(H1N1)pdm09 in 2009 and the pandemic of MERS-CoV in 2012 with an unexpected international spread and a mortality rate of 40% (1). When a new respiratory pathogen emerges, immediate responses include increased surveillance, diagnostic assays to identify cases and *ad-hoc* mitigation strategies, like quarantining diseased persons. In the SARS-CoV outbreak, these measures eliminated the virus from the human population, but in the pandemic influenza A/(H1N1)pdm09, mitigation strategies had limited success and the virus quickly circulated around the globe. We are unlikely to ever been able to eradicate such viruses for which the human and animal reservoir is enormous. Therefore, continuing surveillance for local and imported cases and putative changes in virulence is essential.

Dengue virus, the most widespread arbovirus, threatens 40% of the global population and infects 390 million people a year (2). Zika is now causing high morbidity through congenital infections and neurological disorders in the Americas. The European Centre for Disease Control (ECDC) reported the largest outbreak of West Nile Virus ever recorded in Europe in 2018 (3). Emerging arboviruses have similar ecological and evolutionary patterns, originating from a sylvatic origin, and adapting to urban nearby environments before spreading to humans around the globe (4). Vectors expansion must be closely monitored to track and ultimately prevent this emergence. Clinically, arboviruses are hard to diagnose since they present as an unspecific febrile illness, with many mild forms.

Experts and leaders in global health and communities must join forces to detect, forecast, and contain these emerging outbreaks (5). We must do more than mitigate the impacts of outbreaks; we must get ahead of epidemics by combining traditional and innovative disease surveillance methods and leveraging new digital technologies, especially artificial intelligence (AI) (6).

Today, AI systems are increasingly capable of complex reasoning on vast banks of medical data as well as on the complexity of human behaviors and real-world environments. In 2011, the IBM Watson system has won the well-known TV show of Jeopardy (7) which involves a not only encyclopaedic recall, but also the ability to reason about convoluted and often opaque statements and their relationship to the real world. Since then, the system has been continuously evolving and is gaining more and more acceptance as a decision support tool in medicine (8). It is well within the capacity of such systems to leverage their medical knowledge and elaborate world models to solve problems like linking occurrence of microcephaly by infected individuals with Zika.

While the models which wrongly predicted a million cases of Ebola when actually less than 30,000 occurred, combining AI with modern simulation models can provide policy makers with a systematic, evidence-based assessment of the most probable effects of various measures. Such techniques allow us to consider complex multi-layered networks where each layer represents a particular strand of knowledge: core geography layer, epidemiological factors, biological factors, and social and economic factors. It is only through such multi-layered analysis and complex, that interweaved processes, such as disease spread, can be sustainably managed in today's complex world.

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The current vaccine hesitancy, both in high-income countries and in unstable regions of low-income countries, involves complex socio-economic and geo-political processes and attitude changes. Consequently, informing and engaging the general public is a key component of any public health strategy. The recent explosion of mobile communications and the expanding social media landscape has created new unprecedented possibilities for communicating with citizens and influencing public opinions and behaviors. A whole new related research field, so called "Persuasive Computing" (9), has recently emerged to study such strategies.

The increase of EID has been associated to the rapid global change of the Anthropocene. Climate change, the increase and variation in human migration patterns, population growth and movement, urbanization and land use changes are among the most significant factors of global change. Our era is also marked by the rapid technological development, particularly in the fields of data science and computing. Combining modern epidemiology with AI is vital in fully understanding and mitigating the influence of a multitude of these global-change factors on the risk of EID epidemics and pandemics.

AI based reasoning, data mining and machine learning are rapidly making inroads into medical diagnostics and decision support. Many of the actors involved in health security are interested in how bringing a quantitative way of quantifying the epidemic and pandemic risks in machine learning algorithms.

In summary, this special issue on precision infectious disease epidemiology shows how we are transforming the way prevention and control of epidemics are made, helping to mitigate the devastating consequences of pandemics. Towards this goal, the application of AI and associated big data technologies to the challenge of epidemic and pandemic threat prediction is currently a booming field as demonstrated by the promising papers included in this issue, or quoted in the scoping reviews included in this issue.

Acknowledgments

Funding: None.

Footnote

Provenance and Peer Review: This article was commissioned by the editorial office, *Journal of Public Health and Emergency* for the series "Precision Infectious Disease Epidemiology". The article did not undergo external peer review.

Conflicts of Interest: Both authors have completed the ICMJE uniform disclosure form (available at http://dx.doi.org/10.21037/jphe.2019.05.01). The series "Precision Infectious Disease Epidemiology" was commissioned by the editorial office without any funding or sponsorship. AF served as the unpaid Guest Editor of the series and serves as an unpaid editorial board member of *Journal of Public Health and Emergency* from April 2018 to March 2020. ODS served as the unpaid Guest Editor of the series. The authors have no other conflicts of interest to declare.

Ethical Statement: The authors are accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Received: 23 April 2019; Accepted: 15 May 2019; published: 05 June 2019.
doi: 10.21037/jphe.2019.05.01
View this article at: http://dx.doi.org/10.21037/jphe.2019.05.01

doi: 10.21037/jphe.2019.05.01
Cite this article as: Flahault A, De Santis O. Infectious disease epidemiology at the digital era in a global context. J Public Health Emerg 2019;3:9.