AI could help fight the spread infectious disease around the world

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Communicable diseases represent a critical challenge for resource-strapped public health infrastructures worldwide. As evidenced by the outbreaks of severe acute respiratory syndrome (SARS) in 2003, influenza A H1N1 (or "swine flu") in 2009, Ebola and Middle East respiratory syndrome (MERS) in 2014, and the Zika virus in 2016, infectious diseases can spread rapidly within countries and across national borders. In China alone, the World Bank estimated the economic cost of SARS at $14.8 billion, and while both Europe and the United States were largely spared its ravages, the epidemic impacted global gross domestic product (GBP) by $33 billion. In an era of global air travel and densely concentrated, interconnected populations, most countries remain woefully underequipped to stem the tide of such infections.

Public health policymakers are tasked with deciding the nature and timing of appropriate courses of action to prevent, detect, and respond to an infectious disease outbreak. These challenges, along with rising care costs associated with infectious disease, are met with the concurrent emergence of artificial intelligence in health care. Through health care informatics, AI-based machine learning techniques are gaining prominence in public health planning, by translating large, heterogeneous, and often disparate datasets into effective public health management tools.

In September 2017, researchers from the Saw Swee Hock School of Public Health and the National Environment Agency's (NEA) Environmental Health Institute in Singapore developed an algorithm to forecast dengue outbreaks. The transmission dynamics of dengue, a mosquito-borne virus that infects approximately 400 million individuals annually, are closely related to climate variables such as precipitation and temperature. Marrying historic climate information with previous seasonal patterns of dengue has allowed the NEA to predict outbreaks up to four months in advance. The ability to produce accurate and actionable forecasts of communicable disease incidence and transmission across various time scales will facilitate targeted intervention and prevention strategies, such as increases in health care staffing or vector control measures. As the NEA's reservoir of data — the true lifeblood of AI — on dengue incidence trends expands, researchers can feed information through the learning algorithm to refine its accuracy and efficiency, while ultimately improving Singapore's public health response.

Researchers from the University of Southern California Viterbi School of Engineering have taken this concept further, developing an algorithm capable of slowing the spread of communicable disease while also accounting for limited resources and population dynamics over time. Given the complexity of disease dynamics, such an algorithmic approach will empower health planners to calibrate their responses and optimize policy ahead of time.

The study, published last month in the AAI Conference on Artificial Intelligence, incorporated epidemic disease trends and behavioral and demographic data to model the spread of disease in underlying population dynamics and contact patterns. Using computer simulations to test the program's feasibility, the team at USC, led by doctoral student Brian Wilder, explored two real-world cases: gonorrhea in the United States and tuberculosis in India. In both instances, the algorithm was more proficient in reducing disease incidence than current health outreach policies, by targeting information about each disease to those at greatest risk. Interestingly, the algorithm strategically allocated resources, concentrating on specific demographics, rather than merely apportioning greater support to groups with higher disease prevalence.

Wilder noted this may “indicate that the algorithm is leveraging non-obvious patterns and taking advantage of sometimes-subtle interactions between variables that humans may not be able to pinpoint.” To reflect underlying population dynamics, the algorithm accounted for factors such as birth, death, age, and movement. Such factors are key for policy planning, where researchers must divide resources between groups over many years to maximize long-term societal health. Disease infection incidences and transmission patterns differ significantly across age groups. To discern the optimal target groups and optimize resource allocation, researchers at USC utilized age-stratified data to discern the optimum demographics for targeted public health communications.

Considering the ballooning costs of care, the continued emergence of new infectious diseases, and the rise of antimicrobial resistance, AI will likely become an indispensable tool for public health policy planning. In the future, algorithms will facilitate more accurate and efficient intervention and prevention strategies, optimize the allocation of scarce resources, and ultimately curtail the spread of infectious disease.

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