Artificial Intelligence and Predictive Epidemiology: From Surveillance to Anticipating Public Health Risk

Fermas nafaa
Associate Professor, Faculty of Médicine, Epidemiology and Preventive Medicine, Farhat Abbas, University, Algeria

Bekakria Fatima zohra
Associate Professor, Faculty of Médicine, Epidemiology and Preventive Medicine, Farhat Abbas, University, Algeria

Abstract:

Introduction: The digital transformation of healthcare systems is leading to the increasing generation of health-related data. Artificial intelligence (AI) offers new opportunities to leverage these data and shift epidemiology from a descriptive and retrospective approach toward a predictive and proactive paradigm.Objective: To examine the main applications of AI in predictive epidemiology and its potential to strengthen public health surveillance and prevention.

Methods: A conceptual analysis of the applications of machine learning methods in epidemiology is presented. The areas considered include outbreak prediction, individual- and population-level risk stratification, early detection of unusual health events, predictive mapping, as well as surveillance of healthcare-associated infections and antimicrobial resistance.

Results and Discussion: The analysis highlights the growing potential of artificial intelligence (AI) to transform epidemiological surveillance from a predominantly descriptive and retrospective activity into a more predictive and proactive process. Machine learning models can integrate large volumes of heterogeneous data, including demographic, clinical, laboratory, environmental, behavioral, and geospatial information, in order to identify complex patterns and interactions that may not be readily detected using conventional statistical approaches. In outbreak surveillance, AI-based models may contribute to the early identification of abnormal temporal and spatial patterns and provide estimates of the probability and potential spread of emerging health events. Predictive risk stratification can also support the identification of individuals and populations at increased risk of disease, allowing prevention strategies and healthcare resources to be targeted more effectively. In addition, the integration of AI with geographic information systems can facilitate predictive mapping and the visualization of high-risk areas, thereby supporting geographically targeted interventions. In the field of healthcare-associated infections, AI may enhance the analysis of routine surveillance data by identifying unusual increases in infection rates, detecting potential transmission patterns, and supporting the early recognition of outbreaks. Similarly, predictive models applied to antimicrobial resistance surveillance could help identify populations, settings, or clinical situations associated with an increased probability of resistant infections. These applications could strengthen infection prevention and control programs and contribute to more timely public health decision-making.

Conclusion: The integration of AI into surveillance systems represents a promising avenue for developing predictive epidemiology focused on anticipation and prevention. Its implementation should be supported by rigorous methodological validation, appropriate governance, and robust data quality and protection frameworks.