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IM - COMMENTARY

Progress and prospects for artificial intelligence in clinical practice: learning from COVID-19

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Commentary

Machine learning, deep learning, and artificial intelligence are terms that have made their way into nearly all areas of medicine. Whereas these methods have accelerated progress in several areas of medical imaging, their role in other fields of medicine has not been as well established [1].

The vast amount of data generated from patients hospitalized for COVID-19 is offering an opportunity to substantiate the true potential of machine learning—a subset of artificial intelligence—in clinical medicine and medical practice.

In this issue of *Internal and Emergency Medicine*, Casillas and colleagues have examined the application of machine learning to investigate possible clinical parameters that could help to predict disease severe and mortality risks in hospitalized COVID-19 patients [2], with possible direct implications on clinical decisions and therapeutic management.

Artificial intelligence is a wide-ranging scientific field concerned with making machines able to mimic human intelligence and perform tasks commonly associated with problem-solving and decision-making [1–3]. Specifically, machine learning uses historical data of a phenomena into statistical algorithms and software applications to discover and extrapolate patterns, which is acquiring increasing practical relevance by virtue of the impressive results achieved in handling huge volumes of data, especially with the recent advent of the deep learning paradigm (i.e., the use of network to simultaneously learn optimal data representation and models [1, 4, 5]. A truly universal analytic approach, machine learning already has many effective uses to predict outcome values in health and healthcare sectors, from industry to clinical practice [4, 6], and growing evidence is highlighting its potential role for COVID-19 [2, 7–10]. Whereas the pandemic crisis imposed structural changes in healthcare organization and patient management [11, 12], these challenges have also turned into opportunities to minimize the burden of COVID-19.

Casillas and colleagues executed the valuable scientific step of exploiting COVID-19 datasets to establish whether machine learning algorithms can produce reliable prognostic stratification for mortality that could improve physicians' decision-making in the management of patients hospitalized for COVID-19. Analyzing the strengths of this research, it is worth noting the advantages offered by the use of data-driven models to fit comprehensive real-time (or near-real-time) analyses that have the ability to process a huge number (more than 200) of clinical and laboratory factors. These factors have been meticulously chosen for the proposed methodology, although only a relatively small sample size ($n = 151$) of patients was considered to have data of adequate quality for the analyses [2]. Lack of high-quality input data was not uncommon under the circumstances of collapsing hospital services overwhelmed by huge numbers of patients with severe complications from COVID-19 [11, 12].

As acknowledged by the authors, reproducibility and generalizability of the method are questionable due to the space–time distribution of the analysis, which was limited

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to the first COVID-19 wave of 2020 and to a single hospital [2]. Since then, several aspects of COVID-19 have changed. First, the virus has evolved, producing new variants with different disease profiles from the wild-type infection, while the development of effective vaccines against COVID-19 has been important in stopping the progression into severity [13, 14]. Second, we improved our ability to manage with patients, in terms of both clinical and therapeutic approaches, with direct impact on disease severity and COVID-19 attributable mortality [11]. Therefore, the value of machine learning in the prediction of patients' risks could be undermined by a constantly evolving response, with some algorithms failing to guarantee optimality of the risk stratification or a global classification performance. Indeed, evidence to date already claimed possible weakness of the existing machine learning models, with low levels of accuracy or conflicting results across them [1, 15]. In this sense, it is important to emphasize that validation of the model via external and large datasets must be compulsory prior to more widespread adoption of clinical predictions that are based on machine learning models.

In light of the surge of virulent SARS-CoV-2 variants that continue to pose a challenge to public health and healthcare, the work by Casillas and colleagues may stimulate further discussion and debate on the implementation of novel machine learning tools to be implemented in healthcare systems for clinical practice and medical research, which have proved their usefulness for a precise identification of predictive performance models for diseases' severity and mortality [2, 16]. In our view, the interesting aspects proposed call for further prospective research on the implementation and validation of machine learning algorithms to support medical practice. It is well recognized that their application has the potentiality of providing an advance for understanding clinical characteristics of patients affected by COVID-19 (and other clinical conditions), and their evolution could inform the constant updating of clinical practice guidelines and pathways that facilitate decision-making for physicians, as well as the development of targeted treatments and therapies.

In a nutshell, machine learning has potential to improve healthcare systems and may assist professionals in taking the right steps to prevent and treat illness. Despite the challenges and limits, this innovative technology offers tremendous benefits that are already transforming the global healthcare sector. Alan Turing, a pioneering mathematician and father of theoretical computer sciences, stated in the closing sentence of his 1950 *Mind* paper—a seminal paper on the topic of artificial intelligence: «*We can only see a short distance ahead, but we can see plenty there that needs to be done*» [17]. Seven decades later, the prediction of Turing, the challenge of developing 'machines that can think' is becoming a reality also in healthcare environment.

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Declarations

Conflict of interest PF and SB declare no conflict of interest. RP is full tenured professor of Internal Medicine at the University of Catania (Italy) and Medical Director of the Institute for Internal Medicine and Clinical Immunology at the same University. In relation to his recent work in the area of respiratory diseases, clinical immunology, and tobacco control, RP has received lecture fees and research funding from Pfizer, GlaxoSmithKline, CV Therapeutics, NeuroSearch A/S, Sandoz, MSD, Boehringer Ingelheim, Novartis, Duska Therapeutics, and Forest Laboratories. Lecture fees from a number of European EC industry and trade associations (including FIVAPE in France and FIESEL in Italy) were directly donated to vaper advocacy no-profit organizations. RP has also received grants from European Commission initiatives (U-BIOPRED and AIRPROM) and from the Integral Rheumatology & Immunology Specialists Network (IRIS) initiative. He has also served as a consultant for Pfizer, Global Health Alliance for treatment of tobacco dependence, CV Therapeutics, Boehringer Ingelheim, Novartis, Duska Therapeutics, ECITA (Electronic Cigarette Industry Trade Association, in the UK), Arbi Group Srl., Health Diplomats, and Sermo Inc. RP has served on the Medical and Scientific Advisory Board of Cordex Pharma, Inc., CV Therapeutics, Duska Therapeutics Inc, Pfizer, and PharmaCielo. RP is also the founder of the Center for Tobacco prevention and treatment (CPCT) at the University of Catania and of the Center of Excellence for the acceleration of HArm Reduction (CoEHAR) at the same University, which has received support from Foundation for a Smoke Free World to conduct eight independent investigator-initiated research projects on harm reduction. RP currently involved in a patent application concerning an app tracker for smoking behavior developed for ECLAT Srl. RP is also currently involved in the following pro bono activities: scientific advisor for LIAF, Lega Italiana Anti Fumo (Italian acronym for Italian Anti-Smoking League), the Consumer Advocates for Smoke-free Alternatives (CASAA) and the International Network of Nicotine Consumers Organizations (INNCO); Chair of the European Technical Committee for standardization on "Requirements and test methods for emissions of electronic cigarettes" (CEN/TC 437; WG4).

Informed consent For this type of article, informed consent is not required.

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