COVID-19, BIG DATA: HOW IT WILL CHANGE THE WAY WE PRACTICE MEDICINE

Prof. ARES PASIPOULARIDES, MD, PHD, FACC

Formerly, Director of Cardiac Function, Duke/NSF Center for Emerging Cardiovascular Technologies

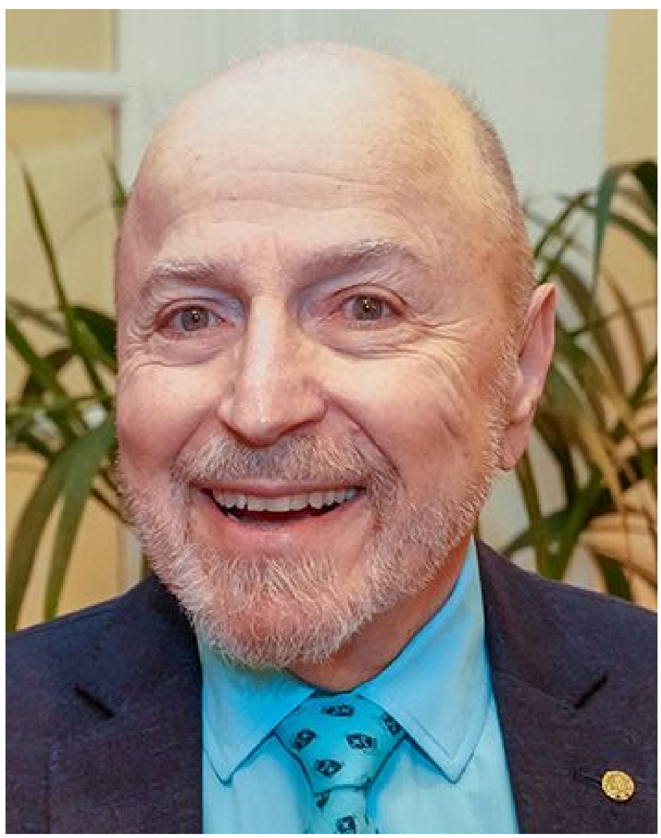
Emeritus Faculty of Surgery and of Biomedical Engineering

Duke University School of Medicine and Graduate School

Durham, North Carolina, USA

apasipou@duke.edu

Tel: 828-254-0279



COVID-19 disease encompasses heterogeneous and sporadically severe effects. It is caused by SARS-CoV-2, a single-stranded positive-sense RNA virus (+ssRNA), and produces mild infirmity for most affected; however, it can induce lingering problems, grave illness and death. Older, obese individuals, and those with pre-existing medical conditions (such as diabetes, chronic respiratory, renal, or cardiovascular disease) are at risk for critical syndromes. Personalized management of any disease exhibiting patient-heterogeneity, with variety of outcomes and potential remedies, can be enhanced by Big Data (BD) strategies; BD lies at the heart of efforts to comprehend and forecast the impact that Coronavirus will have on all of us. Upholding the transdisciplinary approach of Aristotle and Leonardo,[1-3] data scientists are today helping healthcare workers, biomed-experts, epidemiologists and policymakers to aggregate, synthesize and exploit monitored data in planning disease-prevention and treatment efforts (Figure 1). Complementing today's huge genomics advances, NIH's "*All-of-Us*" initiative has opened ambitious COVID-19 investigations [http://www.allofus.nih.gov/], allowing studies of host-COVID-19 interactions via genomic constituents, including miRNAs.[4]

Conventional monitoring assessing disease symptoms and signs entails checking over well-defined time-frameworks; consequently, there is granularity in available data, which may miss significant variability-details. Conversely, the continuous collection of data by up-to-date personal biosensors-and-smartphones allows uninterrupted sign-assessments,[5] yielding reliable information regarding variability and modifications by interventions or treatments. Smartphone-apps, analytics and artificial intelligence (AI),[6] all make finding and treating people with infectious ailments far more efficient than ever before. Today's connectivity provides ammunition to fight the pandemic in ways never heretofore achievable. Continuous acquisition delivers consistently precise-and-comprehensive assemblies of heterogeneous, voluminous data; but, to yield actionable insights, the massive data require specific BD analytics-methods.[7] Early definitions of BD focus on 3 *Vs*: *velocity*, denoting the speed at which data are generated; *volume*, indicating data amount and storage needed; and *variety*, alluding to diverse data acquired through multimodal technologies. More recent characterizations add *veracity*, concerning data-reliability, and *value*, signifying that integrating these traits generates *value* for patients-and-caregivers.

Morbidity and mortality motivate research into BD incorporating patient-genomics,[8-11] for risk prediction, individualized treatments, and prognosis. Machine learning (ML) techniques can provide predictive models at the individual level. The field of BD and ML in COVID-19 is still in its infancy; nonetheless, BD analytics-technology contributes unique opportunities to practice evidence-based Medicine in managing the inherent complexity of real patients. In traditional healthcare systems, huge amounts of readily available but untapped patient-specific information, could expedite AI-diagnoses.[12] Nonetheless, the full scope of individual-patient information, including evidence from event sequence-and-timeframes, remains underexploited; lack of suitable statistical techniques is the limiting-constraint. The emerging field of BD and ML can consider wide-ranging complex datasets in real-time,[13] to advance understanding and the management of COVID-19.

In day-to-day practice, most of the search for useful *patterns* in massive, diverse data is possible through ML, a powerful pattern recognition tool responsible for most recent advances in AI.[7] ML and AI enable computers to simulate human intelligence and ingest vast data-volumes to quickly discern patterns and provide clarity on how COVID-19 spreads, along with insights speeding-up research and treatments. They hold key roles in understanding and addressing COVID-19, enabling telemedicine for contactless-screening of COVID-19 symptoms, and answering public's questions, including finding government-authorized COVID-19-reports, using ML-enabled *chatbots. Chat*-(ro)-*bots* use software simulating human-like conversations with users via text-messages to answer questions, e.g., evaluation of someone's COVID-19 risk. Chatbots respond rapidly and can chat with multiple users simultaneously, helping patients become active participants in their treatment plans.

Brick-and-mortar Medicine is rife with the possibility of virus exposure; people with the hallmark symptoms of COVID-19 – fever, cough and shortness of breath – physically visit a healthcare-provider. They could instead call a chatbot or a telemedicine center and describe their symptoms to resolve whether they need COVID-19-testing, without exposing others. If they don't need intensive care, patients could then check with their telehealth doctor every evening and report *if* their fever persists, they have shortness-of-breath, or they are feeling worse. If they are getting sicker, an ambulance can take them to the hospital. Such *virtual-monitoring* can reassure people about staying at-home. Beyond individual-level care, data gathered by telehealth services can be mined to predict the epidemic's ebb-and-flow trajectory. BD-perfected surveillance-case-definitions [http://www.who.int/publications/i/item/WHO-2019-nCoV-Surveillance_Case_Definition-2020.1] and digital technologies can better expose key epidemiological transmission aspects, helping us understand spread, disease-spectrum, and impact on public-health strategies.[7, 14]

They can also inform operational models for implementation of countermeasures such as case-isolation, contact tracing and ensuing quarantine, to reduce the potential spread and impact of infection. In this context, it is important to ascertain a threshold that distinguishes between infection and *infectiousness*: one not only showing if a person is infected, but also if he/she is contagious. It is becoming evident that infected people are contagious for about one-week after first symptoms: from epidemiological observations and because in the laboratory, one-week after the onset of symptoms, the virus can be cultured in only one-fifth of all samples. *Likely-infectious, gray-area,* or *probably-not infectious at specimen-collection time*, could become part of future lab-reports.

AI is used to study the BD-universe covering thousands of variables across millions of individuals, to identify and contact those at highest risk of COVID-19. And controlling the spread of COVID-19 is changing radically the doctor-patient experience across the Western care-continuum, which had been little-changed since the times of Hippocrates and Galen.[15] The current COVID-19 pandemic may turn out to be the trial-by-ordeal that telemedicine needs to prove its worth;[16] notwithstanding the existence for a few-decades of virtual healthcare apps-and-technologies, it has taken 20-years for BD digital health to become an overnight-success. And only recently has Medicare begun reimbursing for telemedicine at rates comparable to in-person visits. COVID-19 teaches that what was effective years ago and now may differ vastly. Hopefully, even before this pandemic has been eradicated, the use of technology and data analytics in Medicine will be light-years ahead of today. Regardless, the pandemic is like a clarion call on how indispensable Telemedicine is. It will transform the way we practice, and our healthcare-system. The future starts now!

Bibliography

1. Pasipoularides A. Heart's Vortex : Intracardiac Blood Flow Phenomena. Shelton, CT: PMPH USA, Ltd.; 2010.
2. Pasipoularides A. Emulating Leonardo da Vinci (1452–1519): the convergence of science and art in biomedical research and practice. Cardiovasc Res. 2019;115:e181–e3.
3. Pasipoularides A. Historical continuity in the methodology of modern medical science: Leonardo leads the way. Int J Cardiol. 2014;171(2):103-15.
4. Bartoszewski R, Dabrowski, M, Jakiela, B, Matalon, S, Harrod, KS, Sanak, M, et al. SARS-CoV-2 may regulate cellular responses through depletion of specific host miRNAs. Am J Physiol Lung Cell Mol Physiol. 2020;319:L444–L55.
5. Rodrigues D, Barbosa, AI, Rebelo, R, Kwon, IK, Reis, RL, Correlo, VM. Skin-integrated wearable systems and implantable biosensors: a comprehensive review. Biosensors (Basel). 2020;10(7).
6. Jin X, Liu, C, Xu, T, Su, L, Zhang, X. Artificial intelligence biosensors: Challenges and prospects. Biosens Bioelectron. 2020;165:112412.
7. Lytras M, Papadopoulou, P, Editors. Applying Big Data Analytics in Bioinformatics and Medicine. Hershey, PA, USA: IGI Global; 2018.
8. Pasipoularides A. Linking genes to cardiovascular diseases: gene action and gene-environment interactions. J Cardiovasc Transl Res. 2015;8(9):506-27.
9. Pasipoularides A. The new era of whole-exome sequencing in congenital heart disease: brand-new insights into rare pathogenic variants. J Thorac Dis. 2018;10(Suppl 17):S1923-s9.
10. Pasipoularides A. Implementing genome-driven personalized cardiology in clinical practice. J Mol Cell Cardiol. 2018;115:142-57.
11. Pasipoularides A. Genomic translational research: paving the way to individualized cardiac functional analyses and personalized cardiology. Int J Cardiol. 2017;230:384-401.
12. Mei X, Lee, HC, Diao, KY, Huang, M, Lin, B, Liu, C, et al. Artificial intelligence–enabled rapid diagnosis of patients with COVID-19. Nat Med. 2020;26:1224–8.
13. Efnusheva D, Cholakoska, A, Tentov, A. A survey of different approaches for overcoming the processor-memory bottleneck. (IJCSIT) International Journal of Computer Science and Information Technologies. 2017;9(2):151-64.
14. Ting D, Carin, L, Dzau, V, Wong TY. Digital technology and COVID-19. Nat Med. 2020;26:459-61.
15. Pasipoularides A. Galen, father of systematic medicine. An essay on the evolution of modern medicine and cardiology. Int J Cardiol. 2014;172(1):47-58.
16. Patel P, Cobb, J, Wright, D, Turer, RW, Jordan, T, Humphrey, A, et al. Rapid development of telehealth capabilities within pediatric patient portal infrastructure for COVID-19 care: barriers, solutions, results. J Am Med Inform Assoc. 2020;27(7):1116-20.

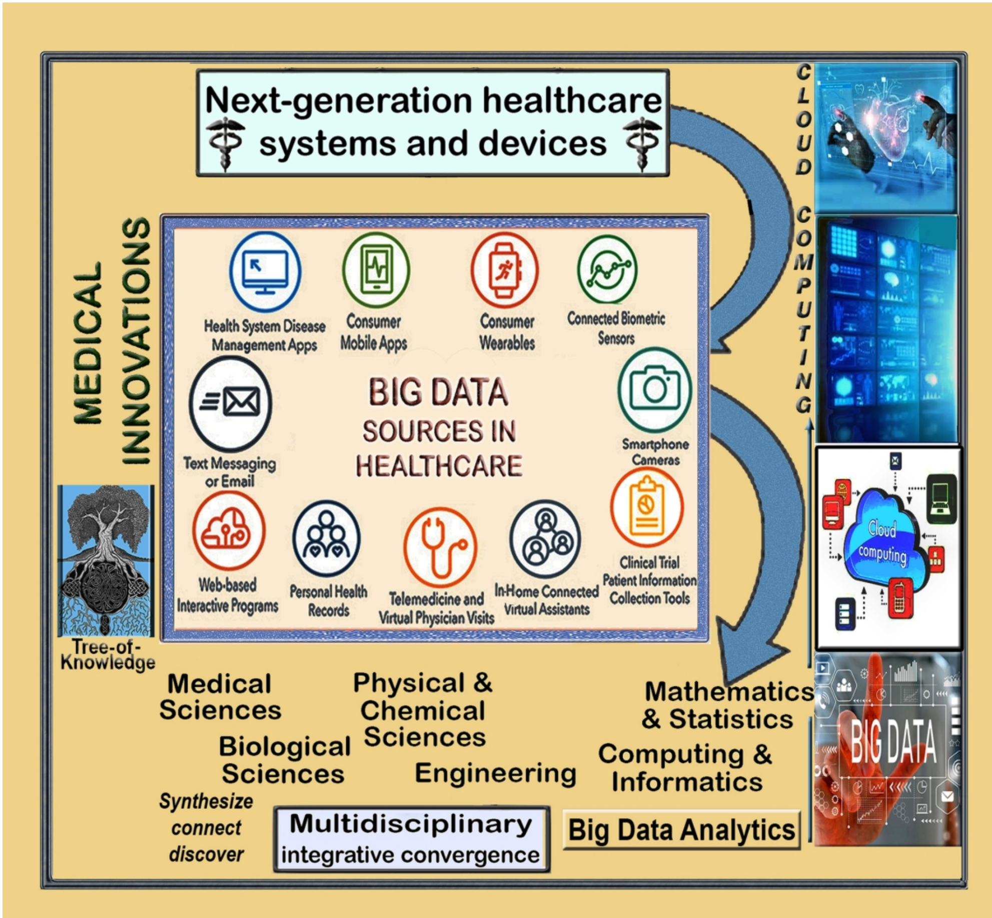


Figure 1 Legend
The Multidisciplinary integrative convergence of Big Data in Medicine combines analytical and diagnostic technologies. Next-generation healthcare-solutions (systems & devices) to complex challenges focus on deeper and comprehensive understanding of bodily systems' function through a holistic view of pathology and medicine; this entails combining multiple academic disciplines, or professional specializations. Through Analytics using statistics, operations research and Cloud computing, offering data storage (cloud-storage) and computing power, comprehensive Big Data allows superior understanding of diseases, including COVID-19, enabling innovative therapies and their coordination and delivery. [Graphic created by the author.]

175x162mm (300 x 300 DPI)