Artificial intelligence in infectious diseases: is it real?

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With the unprecedented tsunami of novel digital technologies and devices, artificial intelligence (AI) has changed the modern world, and medicine is no exception. AI is being extensively used in various clinical settings to improve patient care and hospital operations, and in 2016, the largest investments in AI research were made in its application in healthcare[1]. Learning algorithms can collect increasing amounts of diverse data to generate a more accurate diagnosis. AI is a novel technical profession that imitates human intelligence by utilising computer technology and providing new concepts and solutions for complex problems[2].

There are two subtypes of AI in medicine: physical and virtual[2]. The physical part consists of the application of AI in robots capable of performing surgeries and various medical procedures[1]. Whereas the virtual aspect is represented by machine learning[2], which is used in medical applications such as electronic health records (EHR) [1]. In machine learning (ML) algorithms programmed by engineers use medical data to learn and clarify unexplained events[3].

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The application of AI in the medical field is certainly growing[1], and AI is being employed nowadays for the improvement of diagnosis, thus helping healthcare workers by decreasing the workload and shortening the time required for diagnosis[4] **(Figure)**. AI is applied in various medical domains including radiology, ophthalmology, pathology, dermatology and gastroenterology [4,5,6]. For example, in the radiology field, computer assisted diagnosis helped in early detection of COVID-19 infection[7] and in the classification of lung nodules as malignant or benign[8]. And in ophthalmology, machines with AI algorithms are used for the diagnosis and screening of retinal diseases [9].

When it comes to infectious diseases (ID), multiple applications of AI were studied, including infection control, disease diagnosis and microbiology[10]. Regarding infection control, a few established health-care associated infection (HAI) surveillance programmes are used to analyse information from multiple data sources and observe patterns to identify clusters and predict the upcoming trends[10]. The transmission of an infection can be simulated by analysing the chain of contacts using AI algorithms[11]. For example, an AI algorithm was used to predict outbreaks of methicillin-resistant *Staphylococcus aureus* (MRSA) and influenza in different hospital departments and helped in early initiation of the needed interventions[11]. Also, ML applications were used to estimate the risk of hospital acquired *Clostridium difficile* infection[10]. Regarding infectious diseases diagnosis, AI was applied in the identification of *Mycobacterium tuberculosis* (MTB) infections on chest images by image analysis computer aided diagnosis. The latter was notably beneficial in areas with high MTB prevalence and shortage in radiology specialists[12]. Also, ML image analysis helps in the diagnosis of malaria through reading of thick and thin blood smears[13] and in the diagnosis of bacterial vaginosis after training the machine on smears that are classified by Nugent rules[14]. In addition, at Johns Hopkins hospital AI algorithms were used to make a classification tree based on specific provided variables to identify the patients at risk of extended spectrum beta lactamase (ESBL) producing organisms causing bacteremia[15]. The positive predictive value of this tree was 90.8% and it was proved that it can be used in clinical settings and help start the appropriate empirical antibiotic therapy[15]. Furthermore, there are multiple applications of AI in microbiology through image analysis and convolutional neural network (CNN)[13,14]. Millions of images are used to train the machine to identify bacterial Gram stain in positive blood cultures[14], and to identify parasites in fecal samples[13]. The same mechanism of ML is used to analyse the growth of microbes on agar plates, thus decreasing the number of negative plates that need to be reviewed by the microbiology technician[14]. AI is used in the antimicrobial resistance (AMR) field as well[16]. Multiple developed algorithms are applied to predict the presence of AMR genes in bacteria such as in *Staphylococcus aureus*, *MTB,* and *Pseudomonas aeruginosa*[16]. In addition, AI has also been used to aid in the development of new antimicrobial drugs. An example would be the COVID-19 pandemic where researchers

studied how the SARS-COV-2 virus infected hosts and used AI algorithms to search for approved medications that can counter the viral infection mechanism and cytokine storm, and this has led to the identification of Baricitinib as a treatment option for COVID-19 infection[17].

The future of ID relies on novel diagnostic tools[18]. This evolution is possible through the combination of AI and ML with various information (such as patients' vital signs, laboratory results, inflammatory markers and medical notes) to produce excellent clinically useful results and impact outcomes[18]. More research is being done to identify potential uses of AI in ID such as helping in bacterial identification[14], and in the discovery of new antimicrobials[17]. Health care personnel must be trained on the uses and applications of AI in medicine, as it will be an essential component of healthcare in the future[1].

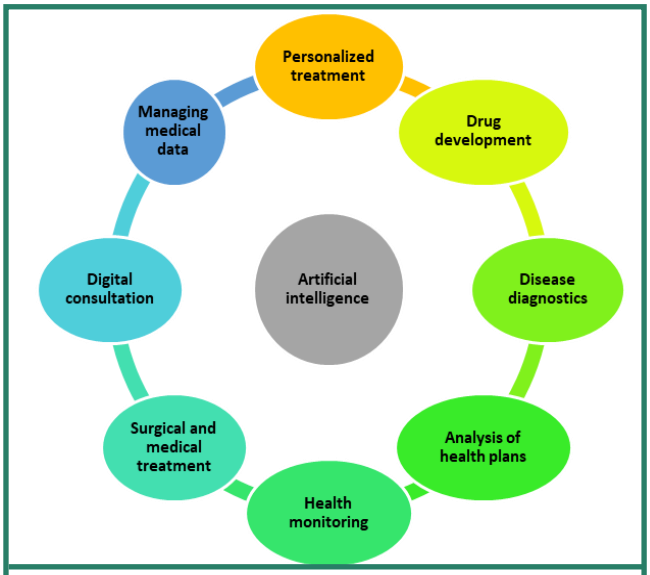

Figure: Applications of AI in health care[1]

References:

1. Amisha F *et al.* Overview of artificial intelligence in medicine. *J Family Med Prim Care*. 2019;8:2328-31
2. Hamet P *et al*. Artificial intelligence in medicine. *Metabolism.* 2017;69s:S36-s40
3. Hinton G. Deep Learning-A Technology With the Potential to Transform Health Care. *Jama.* 2018;320:1101-2
4. Liu P-R *et al*. Application of Artificial Intelligence in Medicine: An Overview. *Current Medical Science*. 2021;41:1105-1115
5. Esteva A *et al*. Dermatologist-level classification of skin cancer with deep neural networks. *Nature*. 2017;542:115-8
6. Namikawa K *et al.* Utilizing artificial intelligence in endoscopy: a clinician's guide. *Expert Rev Gastroenterol Hepatol*. 2020;14:689-706
7. Zhang HT *et al*. Automated detection and quantification of COVID-19 pneumonia: CT imaging analysis by a deep learning-based software. *Eur J Nucl Med Mol Imaging*. 2020;47:2525-32
8. Gong J *et al.* Computer-aided diagnosis of lung cancer: the effect of training data sets on classification accuracy of lung nodules. *Phys Med Biol*. 2018;63:035036
9. Sorrentino FS *et al*. Application of Artificial Intelligence in Targeting Retinal Diseases. *Curr Drug Targets*. 2020;21:1208-15
10. Fitzpatrick F *et al.* Using Artificial Intelligence in Infection Prevention. *Curr Treat Options Infect Dis*. 2020;12:135-44
11. Cusumano-Towner M *et al.* A social network of hospital acquired infection built from electronic medical record data. *Journal of the American Medical Informatics Association*. 2013;20:427-34
12. Lakhani P *et al*. Deep Learning at Chest Radiography: Automated Classification of Pulmonary Tuberculosis by Using Convolutional Neural Networks. *Radiology.* 2017;284:574-82
13. Goodswen SJ *et al*. Machine learning and applications in microbiology. *FEMS Microbiol Rev*. 2021;45
14. Smith K *et al*. Image analysis and artificial intelligence in infectious disease diagnostics. *Clin Microbiol Infect*. 2020;26:1318-23
15. Goodman KE *et al*. A Clinical Decision Tree to Predict Whether a Bacteremic Patient Is Infected With an Extended-Spectrum β-Lactamase-Producing Organism. *Clin Infect Dis*. 2016;63:896-903.
16. Lau HJ *et al*. The role of artificial intelligence in the battle against antimicrobial-resistant bacteria. *Curr Genet*. 2021;67:421-9
17. Richardson PJ *et al.* The AI-Assisted Identification and Clinical Efficacy of Baricitinib in the Treatment of COVID-19. *Vaccines (Basel).* 2022;10:951
18. Tran NK *et al.* Evolving Applications of Artificial Intelligence and Machine Learning in Infectious Diseases Testing. *Clin Chem*. 2021;68:125-33