Advances and opportunities in the new digital era of telemedicine, e-health, artificial intelligence, and beyond

Harry HX Wang[1,2,3] #, PhD, **Yu-ting Li**[4] #, MPH, **Junjie Huang**[5], PhD, **Wenyong Huang**[4], MD, **Martin CS Wong**[5,6,7,8,9] *, MD, MPH

[1] *School of Public Health, Sun Yat-Sen University, Guangzhou, China*
[2] *Department of General Practice, The Second Hospital of Hebei Medical University, Shijiazhuang, China*
[3] *Usher Institute, Deanery of Molecular, Genetic and Population Health Sciences, The University of Edinburgh, Scotland, United Kingdom*
[4] *State Key Laboratory of Ophthalmology, Zhongshan Ophthalmic Center, Sun Yat-Sen University, Guangzhou, China*
[5] *Centre for Health Education and Health Promotion, The Jockey Club School of Public Health and Primary Care, Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong SAR, China*
[6] *Editor-in-Chief, Hong Kong Medical Journal*
[7] *School of Public Health, Fudan University, Shanghai, China*
[8] *The Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing, China*
[9] *School of Public Health, Peking University, Beijing, China*

# Equal contribution
* Corresponding author: wong_martin@cuhk.edu.hk

Over the past decade, there has been an explosion in the development and use of digital technologies in health and health-related areas. In 2018, the 71st World Health Assembly Resolution on Digital Health demonstrated collective recognition of the contributions of digital technologies to improving health, reducing health inequalities, and enhancing healthcare services in the context of achieving the Sustainable Development Goals laid down by the United Nations.[1] The increasing popularity of digital tools, wearable devices, information systems, and electronic resources in clinical practices and health services has resulted in unique opportunities to reshape healthcare in response to diverse existing and emerging health system challenges. Furthermore, technological innovations have been evolving at an unprecedented scale, transforming the ways in which medicine is practised. This transformation has created a range of opportunities for telemedicine and mobile health to transform service delivery, and for advanced 'big data' and artificial intelligence approaches to enhance evidence-based decision support. At the global level, the World Health Organization established an e-health vision in its Global Strategy on Digital Health 2020-2025, with strategic objectives and an action framework to support countries in various development contexts when expanding the implementation of digital health technologies.[2]

In this issue of the *Hong Kong Medical Journal*, two original articles report survey findings regarding the perception and acceptance of telemedicine, a service which is rapidly expanding to overcome distance barriers in healthcare delivery.[3,4] Hung et al[3]

analysed the experiences of individuals who used telemedicine during the coronavirus disease 2019 (COVID-19) pandemic in Hong Kong. They found a high level of satisfaction with telemedicine consultations; users felt that such consultations were useful in disease diagnosis and management. Choi et al[4] explored the values, concerns, and expectations associated with telemedicine among Hong Kong adults aged ≥60 years in two hypothetical scenarios: during a severe outbreak while under government-imposed lockdown, and after the COVID-19 pandemic. The results of both studies supported the use of high-quality telemedicine as a novel approach to enhance clinical consultations and patient education, while emphasising the need for government- and provider-level support to promote and expand services.

There has been global recognition of the power that digital health technologies (eg, telemedicine) have to exchange information for disease diagnosis, treatment, and prevention. For example, the use of telemedicine technologies to educate patients and train community care providers is included in an innovative stepwise approach recommended by the World Kidney Day Steering Committee to improve service affordability and access for patients with kidney disease and their care partners in low-resource settings.[5] The increasing access to digital resources and growing popularity of electronic health records have substantially supported patient self-education and public advocacy regarding kidney disease awareness and learning, thereby bridging gaps in kidney health education and literacy.[6] Mobile messaging applications and social media platforms,

characterised by multi-channel information dissemination and knowledge sharing, also play key roles in meeting the need for community empowerment and public engagement through digital health communications.[7]

In addition to the collaborative efforts of healthcare professionals and scientists to navigate challenges arising during the COVID-19 pandemic, digital health technologies have significantly contributed to the widespread adoption of the quick-response code–based contact tracing system in many countries. In particular, the LeaveHomeSafe mobile application in Hong Kong has enabled the public to more accurately record the date and time of entering and exiting various locations.[8] There has been a remarkable increase in the use of artificial intelligence—a cutting-edge computing science innovation—to inform diagnosis, prognosis, treatment, and triage decisions across clinical settings. As summarised in a recent scoping review, 66 artificial intelligence products and tools have been used in the healthcare response to COVID-19, including pulmonary evaluations, assessments of infection risk, personalised care recommendations, triage decisions, patient deterioration monitoring, and predictions of disease severity.[9] Another scoping review specifically examined the cost savings, performance in improving health outcomes, workflow efficiency in treatment and diagnosis, local feasibility, user friendliness, and reliability and trust associated with the implementation of artificial intelligence in low- and middle-income countries.[10] Innovations such as clinical decision support systems, treatment planning and triage assistants, and health chatbots have demonstrated the potential to strengthen healthcare systems.[10]

Regarding the management of arterial hypertension, which is the most important contributor to the global burden of disease, the 2023 European Society of Hypertension Guidelines recommend the use of internet-based, interactive digital interventions in home blood pressure monitoring to enhance the digital storage and transfer of home blood pressure data, and to facilitate evaluation of those data by healthcare professionals.[11] Remote clinical management programmes based on standardised home blood pressure monitoring supported by automatic transmission via mobile applications, along with collaborations involving multiple healthcare providers in the context of team-based care, could help reduce nonadherence to antihypertensive treatment. Meta-analyses have shown that virtual care for hypertension, mediated by telemonitoring and smartphone applications, provides benefits such as better patient education, greater blood pressure reduction, and improved cardiovascular outcomes.[11] A scientific statement from the American Heart Association has affirmed the utility of telehealth in risk factor modification, medication adherence, and symptom monitoring during the management of various cardiovascular diseases.[12]

Ophthalmology is another branch of medicine that has closely embraced new models of care to improve patient-physician interactions through digital health innovations, such as multi-purpose mobile applications, community-based teleconsultation units, and medical chatbots for improved case triage.[13] Additionally, the screening and management of diabetic retinopathy—a major complication of diabetes mellitus and leading cause of preventable blindness worldwide—has been augmented by advances in healthcare digitisation and increasing emphasis on telehealth initiatives. In primary care and community settings, deep learning–based artificial intelligence for automated image-recognition, combined with telemedicine programmes based on low-cost devices and remote interpretation, would enable greater population coverage and facilitate timely referral to ophthalmic specialists for the management of vision-threatening conditions.[14]

Digital infrastructure can also play a central role in efforts to support and expand research capacity. As accurate and reliable sources of research data, electronic patient record systems have been extensively used in epidemiological investigations of clinical manifestations, radiological characteristics, laboratory results, and biomarkers.[15-18] The use of electronic clinical management systems for patient screening and data collection to identify socio-economic factors, as well as health-protective and health-damaging behaviours associated with quality of life and health outcomes, was demonstrated in a study of childhood cancer survivors in Hong Kong.[19]

Despite potential risks and challenges related to oversight, regulations, data protection, and privacy—the focus of stepwise capacity-building efforts and mitigation strategies—digital health innovations have been implemented worldwide. Considering the rapid growth and development of digital health technologies, the use of telemedicine, e-health, and artificial intelligence as integral components of routine health service delivery is revolutionising medicine and health; the greatest impacts involve management of the increasingly complex conditions and circumstances encountered in primary care.[20] These innovations and advancements will benefit medical education, clinical practice, and healthcare delivery, thereby ensuring service quality, accessibility, and affordability. In terms of effectiveness, acceptability, and feasibility, studies with rigorously designed methodologies in various contexts are needed to formulate evidence-based recommendations regarding the use of digital health technologies.

Author contributions

All authors contributed to the editorial, approved the final version for publication, and take responsibility for its accuracy and integrity.

Conflicts of interest

The authors have declared no conflicts of interest.

References

1. World Health Organization. WHO guideline: recommendations on digital interventions for health system strengthening. Geneva: World Health Organization; 2019.
2. World Health Organization. Global strategy on digital health 2020-2025. Geneva: World Health Organization; 2021.
3. Hung KK, Chan EY, Lo ES, Huang Z, Wu JC, Graham CA. User perceptions of COVID-19 telemedicine testing services, disease risk, and pandemic preparedness: findings from a private clinic in Hong Kong. Hong Kong Med J 2023;29:404-11.
4. Choi MC, Chu SH, Siu LL, et al. Telemedicine acceptance by older adults in Hong Kong during a hypothetical severe outbreak and after the COVID-19 pandemic: a cross-sectional cohort survey. Hong Kong Med J 2023;29:412-20.
5. Kalantar-Zadeh K, Li PK, Tantisattamo E, et al. Living well with kidney disease by patient and care partner empowerment: kidney health for everyone everywhere. Hong Kong Med J 2021;27:97-8.
6. Langham RG, Kalantar-Zadeh K, Bonner A, et al. Kidney health for all: bridging the gap in kidney health education and literacy. Hong Kong Med J 2022;28:106.e1-8.
7. Wang HH, Li YT, Wong MC. Leveraging the power of health communication: messaging matters not only in clinical practice but also in public health. Hong Kong Med J 2022;28:103-5.
8. Li VW, Wan TT. COVID-19 control and preventive measures: a medico-legal analysis. Hong Kong Med J 2021;27:224-5.
9. Mann S, Berdahl CT, Baker L, Girosi F. Artificial intelligence applications used in the clinical response to COVID-19: a scoping review. PLOS Digit Health 2022;1:e0000132.
10. Ciecierski-Holmes T, Singh R, Axt M, Brenner S, Barteit S. Artificial intelligence for strengthening healthcare systems in low- and middle-income countries: a systematic scoping review. NPJ Digit Med 2022;5:162.
11. Mancia G, Kreutz R, Brunström M, et al. 2023 ESH Guidelines for the management of arterial hypertension The Task Force for the management of arterial hypertension of the European Society of Hypertension Endorsed by the International Society of Hypertension (ISH) and the European Renal Association (ERA). J Hypertens 2023 Jun 21. Epub ahead of print.
12. Takahashi EA, Schwamm LH, Adeoye OM, et al. An overview of telehealth in the management of cardiovascular disease: a scientific statement from the American Heart Association. Circulation 2022;146:e558-68.
13. Tham YC, Husain R, Teo KY, et al. New digital models of care in ophthalmology, during and beyond the COVID-19 pandemic. Br J Ophthalmol 2022;106:452-7.
14. Vujosevic S, Limoli C, Luzi L, Nucci P. Digital innovations for retinal care in diabetic retinopathy. Acta Diabetol 2022;59:1521-30.
15. Wang Y, Luo S, Zhou CS, et al. Clinical and radiological characteristics of COVID-19: a multicentre, retrospective, observational study. Hong Kong Med J 2021;27:7-17.
16. Baig NB, Chan JJ, Ho JC, et al. Paediatric glaucoma in Hong Kong: a multicentre retrospective analysis of epidemiology, presentation, clinical interventions, and outcomes. Hong Kong Med J 2021;27:18-26.
17. Tam EM, Kwan YK, Ng YY, Yam PW. Clinical course and mortality in older patients with COVID-19: a cluster-based study in Hong Kong. Hong Kong Med J 2022;28:215-22.
18. Kwok CC, Wong WH, Chan LL, et al. Effects of primary granulocyte-colony stimulating factor prophylaxis on neutropenic toxicity and chemotherapy dose delivery in Chinese patients with breast cancer who received adjuvant docetaxel plus cyclophosphamide chemotherapy: a retrospective cohort study. Hong Kong Med J 2022;28:438-46.
19. Cheung YT, Yang LS, Ma JC, et al. Health behaviour practices and expectations for a local cancer survivorship programme: a cross-sectional study of survivors of childhood cancer in Hong Kong. Hong Kong Med J 2022;28:33-44.
20. Wang HH, Li YT, Wong MC. Strengthening attributes of primary care to improve patients' experiences and population health: from rural village clinics to urban health centres. Hong Kong Med J 2022;28:282-4.