Editorial

Avicenna Journal of Medical Biotechnology
Volume 18, Issue 4, 266-267
https://doi.org/10.18502/ajmb.v18i4.22924

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Bridging the High-Tech Divide: Why Cognitive Care Must Remain Human-Centered

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Aging of the global population leads to the emergence of the increase in neurodegenerative disorders and cognitive dysfunction with dementia expected to increase from 57.4 million cases in 2019 to 152.8 million by 2050 with the disproportionate impact on developing nations [1,2]. Mild Cognitive Impairment (MCI) affects 13-17% of adults older than 50, along with cognitive deficits due to stroke, Traumatic Brain Injury (TBI), and Attention-Deficit/Hyperactivity Disorder (ADHD). Cognitive impairments reduce patient functioning and pose significant physical, psychological, and economic burden on informal caregivers [1-4]. For example, the socioeconomic cost of dementia was estimated as $250 billion in 2020 in China, where family members are under significant psychological pressure because of a lack of nationwide assistance [1].

Neuro-rehabilitation is increasingly relying on advanced technological innovations, including Artificial Intelligence (AI) for health tracking, digital biomarkers for disease detection, and VR for cognitive training [5,6]. New and advanced technologies such as neuro-imaging and "Cognitive-Physiological Digital Twins" (CPDTs) that represent digital replica of the physiological states of a patient became popular in clinical setting [7]. However, rapid development of technologies such as digital health might pose additional barriers including the difficulty to navigate through information and risks of overloading the patient and reducing his/her participation [2,5]. Thus, technology should enhance clinicians' and caregivers' skills, not replace human empathy and complex clinical reasoning necessary for successful treatment [2].

Use of AI in the early detection of cognitive dysfunction shows great promise. Machine learning can detect physiological changes not perceptible to humans [8]. For example, automated speech and language analysis achieves about 80% accuracy in differentiation between MCI and healthy control with use of the biomarkers such as low semantic coherence and high number of pauses [8,9]. Wearable sensors used in testing such as "Timed Up and Go" can achieve 97.75% accuracy [8,10]. Despite usefulness, these AI systems often work as "black box" unable to understand the context of emotions, nonverbal communication, and social situation experienced by a patient [11,12]. They may ignore important factor – subjective well-being of a patient necessary to achieve good outcomes without any human control [11,13].

Immersive VR revolutionized neuro-rehabilitation for stroke and TBI survivors through allowing patients to learn how to perform everyday activities such as preparing toast or going to a grocery store in a safe environment in 3D games such as VIRTUE [14,15]. This technology increases engagement of patients and fosters self-efficacy [16]. However, cybersickness, fatigue, limited transfer to real world, and lack of interactive communication still remains major issues [14,17]. Virtual assistants cannot substitute the important component of therapy known as therapeutic alliance – the relationship between therapist and patient [15,17].

Neuromodulation techniques, such as Deep Brain Stimulation (DBS) targeting specific neural networks can help improve memory and executive functions in some patients with long-lasting effects [12]. Such techniques bring a lot of neuroethical issues, including the question of protection of personal identity and story of a patient [12]. Human identity in combination with AI and issue of informed consent in patient with limited consciousness require close ethical scrutiny [12]. Thus, mental privacy of a patient and restoration of her/his agency, not improvement of performance of machines, is the important task [12].

The development of cognitive healthcare in the future will rely on the "human-in-the-loop" approach whereby the role of AI and CPDTs will be to assist but not replace the clinician [7]. Multimodal data integration into CPDTs may enable simulating the course of patients' diseases, facilitating clinical decision-making [7]. Combined with DTx, these tools must ensure the expansion of the scope of medical activities into patients' houses and real-time coaching to reduce the burden of care [2,6,7]. It calls for the transition towards "human-centered" AI, which acknowledges patients as stakeholders and subjects who have their data-related rights and interests [7].

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To achieve it, coordinated actions should be taken: the developers and engineers of AI technologies need to implement participatory co-design with the help of clinicians and patients, including privacy safeguards at an early stage of development [2,7]; the healthcare providers need to address the "digital health gap" by implementing the necessary digital literacy and care provider training [2,6]; and the policy-makers and regulators need to set up harmonized global standards and guidelines to avoid the risks of algorithmic bias before the deployment of neurotechnology [6,18,19]. In the end, the neurotechnology should facilitate the connection between the patient and the physician, not automate it [2].

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References

1. Jiang B, Liu Q, Li JP, Lin SN, Wan HJ, Yu ZW, et al. Prevalence and risk factors for dementia and mild cognitive impairment among older people in Southeast China: a community-based study. BMC Geriatr 2024;24(1):466.
2. Albertyn CP, Surodina S, Świeboda P, Tan B, Woods T, Corner L, et al. Proposing a person-centred health data ecosystem framework to optimise digital innovation and artificial intelligence for dementia prevention and cognitive longevity. Longevity 2025;6(1):2570721.
3. Shankar R, Chew E, Bundele A, Mukhopadhyay A. Protocol for detection and monitoring of post-stroke cognitive impairment through AI-powered speech analysis: a mixed methods pilot study. Front Aging Neurosci 2025 May 1;17:1581891.
4. Tam I, Wang K. Prevalence of Cognitive Impairment/Dementia and Associated Risks Factors Among Community-Dwelling Elderly People Aged 65 or Above in the Community Centers in Hong Kong: A Cross-Sectional Study. Brain Behav 2025;15 (3):e70388.
5. Khomenko V. Accessibility barriers in mobile medical applications for users with cognitive impairments: analysis ia, and design recommendations. PASN [Internet]. 30, May 2026 [cited on 14, August 2026];(30).
6. Wang C, Lee C, Shin H. Digital therapeutics from bench to bedside. NPJ Digit Med 2023;6(1):38.
7. Nath SS. Cognitive-Physiological Digital Twins: An AI Framework for Integrating Mental Health and Clinical Medicine. TechRxiv 2025;2025(0903).
8. Moreno-Pineda M, Ortiz-Mallasén V, Cervera-Gasch Á. Artificial Intelligence for the Early Detection of Patients with Cognitive Impairment: A Scoping Review. Healthcare (Basel) 2026;14(6):768.
9. Jafari Z, Andrew MK, Rockwood KJ. Diagnostic utility of speech-based biomarkers in mild cognitive impairment: a systematic review and meta-analysis. Age Ageing 2025;54(10):afaf316.
10. Huang J, Wu L, Wang H, Chen L, Hu B, Zhang F, et al. Gait Analysis for Identifying Normal Cognition, Subjective Cognitive Decline, and Mild Cognitive Impairment in Parkinson Disease: Diagnostic Study. JMIR Mhealth Uhealth 2026;14:e69273.
11. Alsuhaibani M, Pourramezan Fard A, Sun J, Poor F, Pressman P, Mahoor M. A Review of Machine Learning Approaches for Non-Invasive Cognitive Impairment Detection. IEEE Access 2025;13:56355-84.
12. Shaw J, Pyreddy S, Rosendahl C, Lai C, Ton E, Carter R. Current Neuroethical Perspectives on Deep Brain Stimulation and Neuromodulation for Neuropsychiatric Disorders: A Scoping Review of the Past 10 Years. Diseases 2025;13(8):262.
13. Noda Y. The New Ethics of Neuromodulation with Transcranial Magnetic Stimulation: A Critical Appraisal. J Integr Neurosci 2024 Jun 5;23(6):112.
14. Chatterjee K, Buchanan A, Cottrell K, Hughes S, Day TW, John NW. Immersive Virtual Reality for the Cognitive Rehabilitation of Stroke Survivors. IEEE Trans Neural Syst Rehabil Eng 2022;30:719–28.
15. Quan W, Liu S, Cao M, Zhao J. A Comprehensive Review of Virtual Reality Technology for Cognitive Rehabilitation in Patients with Neurological Conditions. Applied Sciences. 2024;14(14):6285.
16. Park M, Ha Y. Effects of Virtual Reality-Based Cognitive Rehabilitation in Stroke Patients: A Randomized Controlled Trial. Healthcare (Basel) 2023;11(21):2846.
17. Crowe SE, Yousefi M, Shahri B, Piumsomboon T, Hoermann S. Interactions with virtual therapists during motor rehabilitation in immersive virtual environments: a systematic review. Frontiers in Virtual Reality 2024 Feb 5;5:1284696.
18. Yao H, Liao Z, Zhang X, Zhang X, Li M, You L, et al. A comprehensive survey of the clinical trial Landscape on digital therapeutics. Heliyon 2024;10(16):e36115.
19. Lutz J, Offidani E, Taraboanta L, Lakhan SE, Campellone TR. Appropriate controls for digital therapeutic clinical trials: A narrative review of control conditions in clinical trials of digital therapeutics (DTx) deploying psychosocial, cognitive, or behavioral content. Front Digit Health 2022;4:823977.