Letter to Editor

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Utilizing Digital Twins for the Transformation of Medical Education

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Dear Editor

Innovative educational strategies are being utilized in medical education to transform students into qualified professionals, and New digital approaches offer diversity and enrichment. To ensure the success of medical education, it is crucial to integrate novel teaching, learning, and evaluation techniques (1).

Simulation is one such innovative strategy that has gained recognition in medical education. It involves replacing or supplementing real-life experiences with guided simulations. Numerous systematic reviews have reported that simulation as an educational intervention has a greater impact than traditional methods in terms of learning and achieving competency in care and treatment skills, while also ensuring patient safety (2). However, there are challenges associated with fidelity in simulations. One limitation is that simulations may not perfectly replicate real-life situations, highlighting the need for careful scenario design. Unrealistic scenario durations compared to actual events are another drawback. Despite the high costs involved, preventable patient harm and fatalities continue to occur at alarming rates. This suggests that predetermined scenarios alone are insufficient in meeting educational goals and improving safety and quality of care as intended (3). In regards to these challenges, a new generation of simulation tools known as digital twins (DTs) has emerged as a potential solution.

A DT is a digital copy of a physical entity that bridges physical and virtual worlds. It accurately reflects the characteristics of its physical counterpart and serves as a digital transcript of physical entities (4). In addition to the features offered by traditional simulations such as non-invasiveness, controllability, and repeatability, DTs possess unique capabilities. For instance, DTs can facilitate the review of multiple simulations and enable two-way information flow using real-time data. In medicine, a DT can be constantly updated based on online data to predict future changes in organs, tissues, cells, etc., thereby creating a virtual environment for testing treatment ideas freely.

DT can be used for various purposes in medical education, such as simulation, diagnosis, treatment, and management. Additionally, they can be utilized in healthcare and hospital management. DT models can incorporate treatment methods and drug information for validation purposes (5). For instance, cardiovascular DT models combine CT scans with patient heart anatomy to provide real-time 3D views, enabling a clear understanding of the procedure and allowing for surgery simulation to evaluate treatment suitability based on individual patient factors (6). A study that proposed a framework for developing DTs of patients with chronic diseases, such as diabetes and hypertension (7). The study used data from electronic health records, wearable devices, and mobile applications to create personalized DTs that can monitor the patients' health status, predict the risk of complications, and provide feedback and recommendations. A project that developed a DT of the human heart based on computational fluid dynamics and machine learning (8). The project aimed to improve the understanding of cardiac physiology and pathology, as well as support clinical decision making and education. Laubenbacher et al. have presented a roadmap for building a Digital Twin (DT) to depict the key features of the immune system. This initiative aims to transform the landscape of biomedical research, expediting both clinical training and basic research (9).

In summary, DTs enable accurate predictions, diagnoses, and treatments. They also facilitate a shift towards preventive medicine through the analysis of lifestyle data and personalized recommendations, ultimately improving overall health outcomes. Furthermore, DTs optimize hospital resource management and medical planning based on demand, making them valuable for staff training.

However, it is important to note that DT medicine is still in its early stages and lacks comprehensive quality evaluation studies. The integration of real and simulated data remains a challenge, with limited implementation in real-world environments and only a few patient cases available at present. Stable internet connectivity is crucial to avoid delays, security risks, and reduced accuracy in DT applications. Moreover, the high costs associated with implementing DTs could potentially exacerbate existing inequalities in healthcare access. Privacy protection is also an ethical concern that necessitates ongoing monitoring and adherence to standards. Additionally, the requirement for specialists at each hospital poses a challenge to widespread adoption of DT technology.

Looking ahead to the future, it is envisioned that each individual may have a lifelong DT created from birth that continually enriches with data to monitor health in real-time. This would enable timely prevention strategies and tailored treatments without the need for in-person consultations. However, research on DTs in medical education is limited and merits further exploration given the potential to improve precision medicine, treatment, and patient safety. In the coming years, the convergence of simulation and virtual reality platforms is poised to significantly impact the teaching of fundamental technical skills across diverse surgical specialties, enhancing training for assistants and enabling real-time performance assessment. Concurrently, DTs, when integrated with IoT technologies, big data, and artificial intelligence, are anticipated to fuel a surge in research studies investigating the applications of DTs in medical education.

Authors' Contribution

All authors contributed to the discussion, read and approved the manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated resolved.

Conflict of Interest

The authors declare no conflicts of interest.

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