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Research Article

A Narrative Review on the Conceptual and Methodological Advancements in Digital Disruption: A Way to Improved Quality of Services in Health Care

Devika Kanade [1,2], Shailendrakumar Kale [1], Mamatha GS Reddy [3], Ankita Mathur [4*]

[1]Global Business School and Research Centre, Dr D. Y. Patil Vidyapeeth (Deemed to be University) Pune, Maharashtra, India.
[2]Dr. D. Y. Patil Dental College and Hospital, Dr. D. Y. Patil Vidyapeeth, Pimpri, Pune 411018, India.
[3]Department of Oral Pathology and Microbiology, Dr. D. Y. Patil Dental College and Hospital, Dr. D. Y. Patil Vidyapeeth, Pimpri, Pune 411018, India.
[4]Department of Dental Research Cell, Dr. D. Y. Patil Dental College and Hospital, Dr. D. Y. Patil Vidyapeeth, Pimpri, Pune 411018, India.

*Corresponding Author: Ankita Mathur, Department of Dental Research Cell, Dr. D. Y. Patil Dental College and Hospital, Dr. D. Y. Patil Vidyapeeth, Pimpri, Pune 411018, India. Email: amathur@statsense.in

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Abstract

Background: The adoption and successful implementation of digital health solutions heavily depend on digital health literacy, which is particularly critical in the current COVID-19 era. Low levels of digital health literacy are associated with poor preventative practices, the spread of inaccurate information, vaccine hesitancy, and reduced subjective well-being. Thus, the aim of this review was to highlight areas of current scholarly interest and identify any gaps in the literature regarding conceptual and methodological advancements in digital disruption.

Methods: The authors conducted a literature search using the databases Scopus, Embase, Web of Science, PubMed, and Google Scholar, focusing on papers released between 2003 and October 2023. The following keywords were used to conduct a thorough literature search: ((digital health OR digital disruption OR digital dental health)) AND (medical health OR telemedicine)), ((online doctor OR online consultation OR online health app)) AND (COVID-19 OR pandemic)). A total of 1,244 studies were screened, including duplicates and non-English research. After applying inclusion and exclusion criteria, 72 articles were selected for the review.

Results: A total of 72 articles were included in this review. The studies discussed the potential reasons for disrupted access to healthcare, which is linked to avoidable hospital admissions. Delayed care due to disruptions can lead to disease progression, the exacerbation of existing conditions, and chronic ambulatory care-sensitive conditions. Digital health innovations were presented as solutions to enhance care, reduce clinical workload, and promote independent living.

Conclusions: In conclusion, this narrative review provides a comprehensive overview of the conceptual and methodological advancements in digital technology related to healthcare. It demonstrates the potential of digital technology to revolutionize both medical and dental education.

Keywords: Digital Disruption; Telemedicine; COVID-19; Digital Health

1. Introduction

In recent years, the healthcare industry has undergone significant changes due to the rapid evolution of technology and large-scale research and development. One critical aspect of providing quality healthcare is the ability to analyze large volumes of medical data quickly and accurately. As healthcare practices become more technical and sophisticated, healthcare providers must stay informed about these changes and learn how to implement them correctly. The World Health Organization (WHO) has encouraged countries to maximize the opportunities for digital health interventions (DHIs) to accelerate sustainable health development and achieve universal health coverage (1). Digital health interventions include applications of various technologies such as smartphones, health information technology, wearable devices, telemedicine, and personalized medicine, all of which facilitate healthcare and help achieve desired health outcomes (2). Healthcare institutions are seeking digital health innovations to improve care quality by integrating these technologies. However, there are barriers, especially in resource-limited countries, that hinder the implementation of digital health, highlighting the need for well-developed strategies to maximize the benefits of digital health-enabled patient-centered systems (3).

The COVID-19 pandemic served as a testing ground for emerging digital health concepts and practices. The DHIs provided immense support during the pandemic, particularly during the period of social distancing, which disrupted healthcare service delivery (4). Telemedicine, for example, facilitated the continuity of services and showed great potential in protecting both patients and healthcare providers. The closure of hospitals during the pandemic forced the public to seek and adopt alternative digital health solutions, such as using smartphones to connect with clinicians and follow up on routine care. Digital health solutions for COVID-19 screening reduced the number of visits to emergency departments while also improving the organization of healthcare systems (5). mHealth, telemedicine, eHealth, and various mobile applications rose to prominence during lockdowns and were widely used for diagnosis, clinical care, and patient follow-up, demonstrating their potential beyond serving marginalized and underprivileged communities (6). Virtual communication platforms enabled remote interactions between healthcare professionals and patients and supported the creation of operational management dashboards to optimize workflows, resources, and patient-centered care (7, 8). Several healthcare institutions adopted cloud technologies to implement COVID-19-related functionalities such as testing, diagnostics, monitoring, triage, and patient consultations. The pandemic thus highlighted the need for healthcare institutions to embrace digital health innovations and leverage their full potential. A large number of research papers accessible through the COVID-19 Open Research Database can be quickly analyzed using machine learning to extract relevant knowledge about drugs that may be beneficial for the treatment of COVID-19. By generating data summaries from multiple sources, artificial intelligence (AI) platforms enabled real-time monitoring of patients in high-risk settings for COVID-19. Insurance companies have implemented health-tracking reward programs that encourage the use of wearable health technologies, and their adoption has been relatively straightforward (9-11).

However, the lack of standardization in data-sharing agreements and transactional norms between institutions impedes the establishment of a basic infrastructure necessary for the growth of public health. The COVID-19 pandemic has highlighted the necessity of data sharing and the importance of addressing ethical issues in digital health. One of the challenges facing biomedical research is maintaining control over the continuous generation of data while promoting its active use for scientific discovery. Acquiring informed consent has proven somewhat difficult, as not all medical institutions are equipped to offer digital consent processes. This issue is compounded by factors such as participants' access to technology and the absence of features that make consent agreements easily understandable (12).

Thus, the aim of this review was to highlight areas of current scholarly interest and identify gaps in the literature on conceptual and methodological advancements in digital disruption.

2. Methods

The impact of digital technology or e-health on healthcare has been an emerging field of research in recent years. It has opened up new avenues in education, various surgical procedures, and patient-doctor interactions. Using the databases Scopus, Embase, Web of Science, PubMed, and Google Scholar, the authors conducted a literature search focusing on papers released between 2003 and October 2023. The following keywords were used to perform a thorough literature search: ((digital health OR digital disruption OR digital dental health)) AND (medical health OR telemedicine)), ((online doctor OR online consultation OR online health app)) AND (COVID-19 OR pandemic)). A total of 1,244 studies were screened, excluding duplicates and non-English research. Articles were disqualified if they included e-health or digital technology but did not address its effect on dental education or if they focused on other dental professionals.

Additional publications and cited papers were looked up in the references of the articles. The data was independently categorized by the authors into emerging themes, which were discussed and narrowed down to key topics. The use of digital technology has led to improved patient care, enhanced efficiency and effectiveness of treatment procedures, and greater access to all healthcare services. Furthermore, digital technology has transformed educational systems by providing new learning opportunities and advanced training. However, the review also highlights the need for further research in the area of dental digital technology, particularly regarding its impact on patient outcomes and the ethical considerations surrounding its use.

3. Results

The study examined how the COVID-19 epidemic affected people's searches for digital health information. All nations saw an immediate increase in search volumes, while keywords related to digital health eventually decreased. This suggests that although public interest in digital health surged during the pandemic, it later declined. However, during the pandemic, the number of searches for health apps either remained steady or increased, likely due to the widespread use of these apps for surveillance purposes. A total of 72 articles were selected for this review (Figure 1).

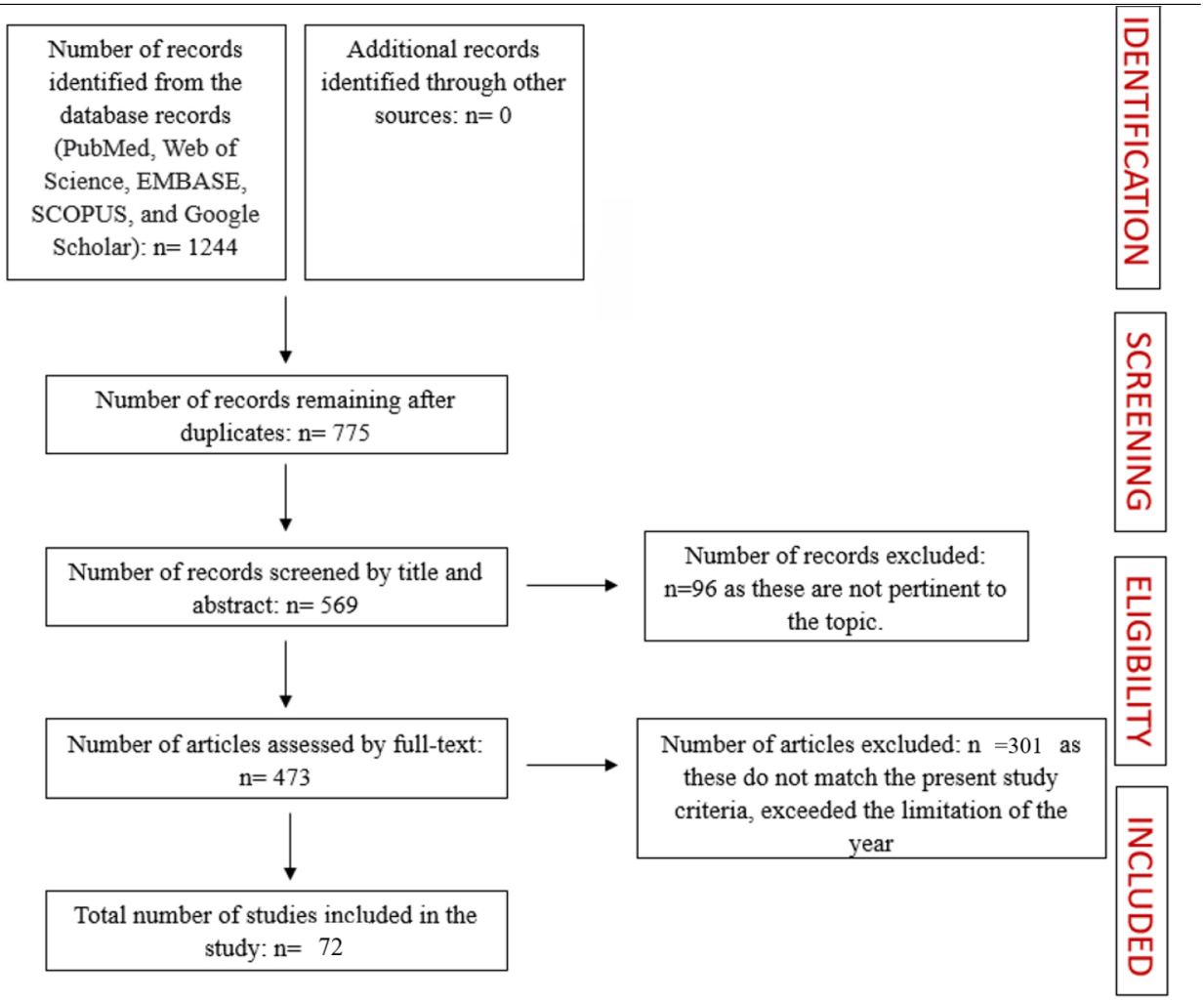

Figure 1. PRISMA flowchart of included studies

The studies discussed the potential reasons why disrupted access to healthcare is associated with avoidable hospital admissions. Delayed care due to these disruptions can lead to disease progression, the worsening of existing conditions, and chronic ambulatory care-sensitive conditions. Digital health innovations have been proposed as solutions to enhance care, reduce clinical workload, and promote independent living. However, despite research showing improvements in hospital admissions, services, and patient outcomes, these innovations often face a high rate of failure when implemented in healthcare settings. The complexities of integrating new technologies into existing infrastructures are frequently overlooked, resulting in the failure to achieve the intended scale and impact of these innovations.

The internet of things (IoT) has gained increasing attention in recent years, with applications in healthcare that include wearables, sensors, and connected medical devices for remote monitoring, management, or diagnosis of chronic conditions. Health and care IoT innovations are often promoted as solutions to address capacity and staff shortages, provide inexpensive, efficient, and reliable diagnoses, reduce the need for repeat hospital monitoring, improve patient safety in the community, bring clinical monitoring and care closer to home, and reduce caregiver burden. The IoT applications in healthcare include wearables, sensors, and other connected medical devices for the remote monitoring, management, or diagnosis of chronic conditions such as heart failure, asthma, chronic obstructive pulmonary disease, dementia, and diabetes (13-16). These innovations aim to address capacity and staff shortages, improve efficiency, and bring healthcare services closer to patients, while also reducing the burden on caregivers (17-19).

4. Discussion

The advent of digital disruption has brought about significant transformation in the medical field. A new treatment is considered disruptive if it is quicker, more efficient, and less costly than previous methods. The medical field has seen the emergence of several disruptive tech-

nologies that have revolutionized healthcare (20). One such technology is AI-driven algorithms, which can diagnose patients faster than doctors. This technology has been a game-changer, leading to faster diagnoses, better treatment, and improved patient outcomes. In addition, medical robots have been developed to assist healthcare providers by continuously moving patients and equipment. The use of medical robots has made healthcare delivery more efficient, safer, and less costly (21).

Virtual reality technology has also been adopted by healthcare providers to help hospital patients feel less anxious and uncomfortable. This technology has been shown to significantly impact patient recovery by reducing stress and anxiety levels (22).

Another disruptive technology in the medical field is digital tattoos with thin sensors. These tattoos can alert patients to changes in their vital signs and health indicators, which is especially useful for patients who require continuous monitoring, such as those with chronic diseases (23). Wearable technology has also been developed to make it easier to monitor vital signs and health measures when patients are not in a doctor's office. This technology allows patients to closely monitor their health and be more proactive in their health management (24).

While disruptive technologies offer great potential, they also pose risks and raise ethical concerns. The use of these technologies in the medical field brings up issues related to data privacy, security, and consent. Proper regulation and ethical guidelines are necessary to ensure that these technologies are used in the best interest of patients. Disruptive technologies have transformed the medical field by improving patient outcomes, reducing costs, and increasing efficiency (25, 26). However, there is a need for appropriate regulation and ethical standards to ensure that these technologies are applied safely and responsibly.

4.1. Digital Disruptive Use in Healthcare and Medicine

With the rise of digital technologies, healthcare and medicine are undergoing a significant transformation. The use of robots, blockchain, 3D printing, and AI is revolutionizing healthcare, making it more accessible, efficient, and cost-effective (27). In particular, digital disruptive technologies like 3D printing have the potential to provide inexpensive prosthetics where they are needed, while robotic technology has been applied to various tasks such as biopsies, assisting the elderly and disabled, and distributing food and medication. Additionally, the COVID-19 pandemic demonstrated the effectiveness of robots in healthcare, taking over tasks that would otherwise put human lives at risk. Robotic monitoring systems that detect infections and notify medical staff of a patient's condition are being developed, offering significant financial benefits and advancing digitalization in healthcare (28, 29).

In digital healthcare, which utilizes more easily accessible health data to identify high-risk patients, track the spread of infections, estimate mortality risks, manage healthcare data, and combat COVID-19 and other pandemics, the authors explore the potential uses and applications of blockchain and AI (30). Blockchain provides an immutable and secure method for storing and sharing electronic health records, while AI aids doctors in diagnosing patients more accurately, improving treatment outcomes, and reducing medical errors—all of which free up more time for patient care (31, 32).

However, the application of AI in healthcare raises several ethical and legal concerns. While AI has the potential to significantly enhance medical practice in the future, a multifaceted approach is required—one that involves lawmakers, developers, medical professionals, and patients—to address these issues. Moreover, AI is limited in its ability to provide certain types of care, such as empathy. Therefore, it is crucial to ensure that AI is used as a complementary tool to human expertise, rather than as a replacement (33).

Artificial intelligence in medicine and the healthcare system emerged as a result of the development of three radical disruptive innovations: Algorithms for Natural Language Processing (NLP) on medical records, the digitalization of medical imaging techniques for parametric use, and deep learning algorithms for processing uncategorized data (34, 35). These disruptive technologies have proven to be more accurate than radiologists in certain areas, enabling the automatic detection of lesions and paving the way for the diagnosis of various types of cancer.

4.2. Benefits and Drawbacks

Digital disruptions, including the rise of AI, have the potential to significantly advance patient outcomes, diagnosis, and tailored treatments in the healthcare industry (36, 37). Artificial intelligence can reduce the possibility of false positives by analyzing vast volumes of medical data, leading to more accurate diagnoses and treatment plans (35). The technology can also assist in creating customized treatment plans that consider a patient's genetic information and medical history, offering personalized care that can improve patient outcomes. Additionally, AI can monitor patients, predict potential future health problems, and notify medical experts about preventive measures (38). By analyzing massive amounts of data, AI can also accelerate the process of drug discovery and help identify effective treatments for diseases.

However, there are potential drawbacks to the use of AI in healthcare. One of the primary concerns involves moral dilemmas, as the technology raises ethical questions regarding the use of patient data, privacy, and the potential for bias (27). Additionally, some AI applications lack clinical validity, making it difficult to determine their effectiveness and reliability (39). Furthermore, both pa-

tients and healthcare providers may hesitate to adopt AI due to concerns about its accuracy and reliability, which could slow the adoption of this technology in the healthcare industry (40).

Despite these challenges, the benefits of AI in healthcare are evident. The technology holds the potential to significantly improve patient outcomes, personalize treatment plans, and expedite the development of new drugs (41). However, it is essential that investments in AI technology within the healthcare industry are made ethically and responsibly, with careful consideration of issues related to privacy, bias, and clinical effectiveness. Overall, the advancement of AI in healthcare has the potential to revolutionize the industry and enhance the lives of patients worldwide (42).

4.3. Digital Disruptive use in Diagnosis

The development of biosensors has revolutionized the field of personalized medicine. Optoelectronic biosensors, which use a one-step coaxial electrospinning process to encapsulate nanosensors into microfiber textiles, have been integrated into wound bandages to monitor oxidative stress during wound healing. This technology enables real-time monitoring of individual physiological states (43). Pressure biosensors, which continuously and quantitatively measure mechanical disturbances, are also gaining prominence (44, 45). However, the trade-off between sensitivity and linear range remains a significant challenge.

Electrochemical biosensing technology, on the other hand, offers distinct advantages, including ease of miniaturization, high sensitivity, and low power consumption, making it well-suited for wearable perspiration analysis. Recently, wearable electrochemical sensors have been developed for monitoring human body fluids such as sweat, saliva, and tears. A multi-channel sweat biosensor platform based on a fully integrated patch-type array for the quantitative analysis of sweat is essential for widespread use (46-49). Other types of biosensors include electromagnetic, thermo-sensitive, and ultrasonic sensing mechanisms.

A fully flexible electromechanical system sensor has been developed to perform wearable monitoring of mechanical displacements with good adaptability to complex surface morphologies (50). Thermal sensing, a new non-invasive skin health monitoring method, can measure the thermal characteristics of the skin at different depths, up to a few millimeters. Additionally, a fully flexible, ultrathin, skin-integrated breathing sensor utilizing the thermal convection effect is under development (51, 52). A flexible, reusable, portable, and non-invasive skin hydration sensor is also being developed for monitoring volumetric water content.

The continuous detection of central blood pressure waveforms generated from deep-tissue blood vessels has the potential to predict cardiovascular events. Thank you for bringing it to our notice. It is not Xu et al.,. it is Zhang et al.

Reference 53: Zhang L, Du W, Kim JH, Yu CC, Dagdeviren C. An emerging era: conformable ultrasound electronics. Advanced Materials. 2024 Feb;36(8):2307664.. have developed a stretchable and conformal ultrasound device for non-invasive, continuous monitoring of vital signs from deep tissues, adding a new dimension to the sensing capabilities of conventional stretchable electronics (53). The diverse range of biosensors currently being developed has the potential to revolutionize healthcare by enabling real-time monitoring of physiological conditions.

4.4. Digital Disruption in 3D Printing

3D printing has become an integral part of healthcare and medical applications, enabling the customization of medical products and the fabrication of complex designs for implants, prostheses, surgical aids, and models (54). The technology has advanced from early printers, which created rough sculptures using plastic, ceramic, and plaster, to more advanced printers capable of printing polymers, ceramics, and metals in various feedstock forms, including powder, filament, and bioinks (55). 3D printing technologies have the potential to overcome the limitations of conventional manufacturing methods, allowing for the creation of patient-specific devices (56).

4.5. Digital Disruption and Dentistry

Neville and van der Zande discusses the impact of digital technology on dentistry, emphasizing the need for sustained engagement with e-health concepts and further academic exploration of its effects on clinical practice (5, 57). Digital technology has transformed teaching, learning, and assessment in dental education, making it more self-directed and efficient. However, the ethical implications of these advancements have often been overlooked, resulting in a trade-off between therapeutic efficacy and the best interests of patients. Critical studies could offer an integrative alternative to digital dualism, empowering patients to become self-sufficient and contribute to preventive care (5, 58, 59).

4.6. The Impact of Digital Disruption on Dental Services and Oral Health Promotion

Digitalization has significantly transformed dental services and oral health promotion, making them more flexible and mobile (60). Mobile technologies, such as phones and PDAs, support m-health, enabling teledentistry and mobile oral examinations (61, 62). This shift has led to a more behavior-driven, outcome-based, and individualized oral healthcare system. However, challenges such as managing exaggerated patient expectations and addressing unethical treatment demands remain (63, 64).

4.7. Limitation

The present study investigates the impact of the CO-

VID-19 pandemic on search behavior related to digital health. The findings reveal that while there was an initial surge in search traffic for digital health across all countries, this interest decreased over time. This indicates a decline in public interest in digital health during the pandemic, following the initial growth. However, the use of health apps for surveillance may have contributed to the stability or growth in search volumes for health applications during the epidemic.

The study also identified significant seasonal variations in search behavior from 2017 to 2019, primarily showing a negative skew, which suggests no spurious association. Therefore, increasing resource capacity is essential for the efficient application and evaluation of digital health technologies, while aligning with national objectives and requirements.

The adoption and expansion of digital health technology in resource-constrained environments face several challenges, including disparities in infrastructure, internet access, and electricity. The level of digital health literacy among the general population often influences the effectiveness and adaptability of digital health solutions in a given country. Factors such as subjective wellness, vaccine hesitancy, COVID-19 preventive measures, and the accuracy of information are all linked to low levels of digital health literacy.

Additionally, a shortage of trained and skilled personnel in the field presents a significant barrier to the use of digital health apps, especially in resource-limited environments. The absence of policies, strategies, governance structures, standard operating procedures, and financial resources further complicates the successful deployment and implementation of digital health initiatives in many countries with limited resources. Furthermore, much of the technology has not been culturally adapted to local contexts, making it difficult for both patients and clinicians to understand. The transition from traditional in-person treatment to digital health-enabled remote care and monitoring has been challenging, with the benefits and drawbacks varying depending on the country, program, and type of technology used.

Overall, these findings emphasize the importance of developing tailored and culturally appropriate digital health solutions that can be effectively implemented in resource-constrained environments.

4.8. Conclusions

In conclusion, this narrative review provides a comprehensive overview of the conceptual and methodological advancements in digital technology as they relate to healthcare. The findings demonstrate the potential of digital technology to revolutionize both medical and dental education. However, further research is needed to fully understand the broader impact of digital technology in healthcare and to address any ethical concerns that may emerge during its implementation.

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