

Emerging trends in digital therapeutics and their integration with conventional drug therapies

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ABSTRACT

Digital therapeutics (DTx) are transforming health care using software-based interventions to treat and manage medical conditions. This article explores key trends and advancements in DTx and their integration with conventional drug therapies. Unlike traditional digital health tools, DTx offer personalized, evidence-based treatments, utilizing mobile platforms, artificial intelligence, and real-time data analytics to deliver interventions for conditions such as diabetes, mental health disorders, and chronic diseases. The synergy between DTx and pharmacological treatments is highlighted, as combining these approaches enhances patient outcomes by improving medication adherence, offering real-time feedback, and enabling precise monitoring. Technological innovations such as telemedicine, wearable devices, and machine learning are driving the adoption of DTx, making health care more accessible and patient-centered. Despite challenges such as regulatory hurdles and data privacy concerns, DTx are proving to be cost-effective, reducing hospitalizations and enhancing chronic disease management. As health-care systems evolve, integrating DTx into standard care protocols holds the potential to revolutionize treatment by offering more personalized, efficient, and scalable health-care solutions. The future of medicine lies in the seamless partnership between DTx and conventional drug therapies.

Keywords: AI in health care, conventional drug therapies, digital therapeutics, personalized medicine, telemedicine

Introduction

In recent years, digital therapeutics (DTx) have emerged as a revolutionary approach in health care, leveraging technology to deliver evidence-based therapeutic interventions directly to patients.^[1] Unlike traditional digital health tools, which often focus on monitoring or improving lifestyle factors, DTx encompass a broader scope – utilizing software applications, mobile platforms, and algorithm-driven technologies to prevent, manage, or treat medical conditions. These interventions are designed to be clinically validated, targeting diseases through personalized, data-driven methods that complement existing medical treatments.^[2]

The integration of DTx with conventional drug therapies is gaining momentum as health-care systems seek more holistic, patient-centered

solutions. Combining DTx with pharmacological treatments offers a synergistic approach that can enhance the efficacy of medications by improving patient adherence, providing real-time feedback, and enabling more precise monitoring of therapeutic outcomes.^[3] By seamlessly merging these technologies with traditional treatment regimens, DTx have the potential to revolutionize chronic disease management, mental health care, and a variety of other therapeutic areas. The potential improvements in patient outcomes, through increased personalization and engagement, underscore the importance of integrating these innovative tools into the broader health-care framework.^[4]

How Did DTx Evolve into a Health-care Game Changer?

The journey of DTx from conceptual frameworks to clinical reality has been marked by significant advancements in technology and health-care delivery. The early roots of DTx can be traced back to the rise of digital health tools in the late 1990s and early 2000s, which primarily focused on fitness tracking and general wellness.^[5] As technology matured, so did

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the ambition to move beyond health monitoring and into the realm of active disease management. The integration of behavioral interventions through software platforms began to take hold, laying the foundation for the formal development of DTx as a therapeutic category.^[2]

Key milestones in the evolution of DTx include the Food and Drug Administration's first approval of a digital therapeutic in 2017 – reSET®, a mobile app for substance use disorder – marking a turning point in the regulatory recognition of these tools as legitimate treatments. Since then, the field has grown exponentially, with numerous applications targeting conditions such as diabetes, mental health disorders, and respiratory diseases.^[6]

This rapid evolution has been largely fueled by technological advances. Artificial intelligence (AI) and machine learning have enabled DTx to become more personalized and adaptive, analyzing patient data in real-time to optimize interventions. Data analytics further enhance the capabilities of DTx, allowing for continuous monitoring and feedback that can lead to improved clinical outcomes. The role of mobile health and telemedicine has also been pivotal, providing the infrastructure to deliver DTx seamlessly to patients' smartphones and wearable devices, making treatment accessible anytime, anywhere. These innovations are enhancing traditional therapies and redefining how we think about disease prevention and management in the digital age.^[7]

How Do DTx Work to Transform Health?

DTx leverage cutting-edge technology to offer more than just passive health-care support. They actively intervene in disease management through scientifically-backed mechanisms that promote behavioral and cognitive changes. By providing targeted, real-time interventions, DTx work to improve patient outcomes in ways that traditional treatments alone often cannot achieve. However, how exactly do they work? Let's explore their core mechanisms.^[8]

Behavioral and cognitive interventions: Reprogramming health habits

One of the most impactful ways DTx contributes to disease management is by addressing behavioral and cognitive aspects of chronic conditions such as diabetes, hypertension, and mental health disorders. Many DTx use cognitive behavioral therapy (CBT), motivational techniques, and habit-forming algorithms to influence a patient's daily decisions, helping them stick to healthy behaviors. For example, a DTx for diabetes might offer educational content on dietary choices while simultaneously tracking blood sugar levels, encouraging the patient to adjust habits in real-time.

Lifestyle modifications are critical for managing chronic diseases, and DTx provides a structure to enforce these changes consistently. Whether it's reducing stress for anxiety sufferers or promoting physical activity in patients with cardiovascular disease, the behavioral interventions delivered by DTx are designed to be accessible, engaging, and adaptable to the user's needs.^[9]

Personalization and real-time feedback: Precision in every interaction

What sets DTx apart from traditional approaches is their ability to provide personalized, patient-specific interventions. Using data analytics and AI, these tools can adapt to individual patient profiles, delivering interventions that match a user's unique disease patterns and lifestyle. This is particularly useful in chronic disease management, where individualized treatment plans are essential for long-term success.

Real-time monitoring also plays a crucial role in ensuring patients adhere to their treatment plans. By continuously collecting and analyzing health data – such as glucose levels for diabetics or sleep patterns for those with insomnia – DTx offer immediate feedback, prompting users to take necessary actions to stay on track. This not only improves adherence but also gives health-care providers actionable insights into the effectiveness of treatment in real-time, enabling proactive adjustments for optimal outcomes.^[10]

By integrating these behavioral, cognitive, and personalized mechanisms, DTx are transforming the way we manage chronic conditions, offering a more dynamic and responsive approach to health care.

Where are DTx Making the Biggest Impact in Medicine?

DTx are rapidly gaining traction across multiple areas of medicine, delivering innovative solutions for managing chronic diseases, improving mental health, and addressing a range of other conditions. Their ability to provide personalized, on-demand interventions makes them a game-changer in various therapeutic domains. However, where are they making the biggest impact today?

Chronic disease management: A new approach to lifelong conditions

Chronic diseases such as diabetes, hypertension, and cardiovascular disease are some of the most common and costly conditions in health care. DTx offer a powerful tool for managing these conditions by delivering real-time data and actionable insights directly to patients and their health-care providers. For example, apps that monitor blood glucose levels for diabetics can automatically adjust recommendations for insulin doses or dietary changes. Patients with hypertension can receive personalized guidance on lifestyle changes, such as exercise routines and dietary restrictions, all based on continuous monitoring of their blood pressure.^[11]

By integrating into the daily lives of patients, DTx not only helps improve adherence to treatment regimens but also allows for more precise disease management, reducing the likelihood of complications and hospitalizations.

Mental health interventions: Breaking new ground in psychiatry

Mental health is another area where DTx have shown tremendous promise. DTx targeting conditions such as depression, anxiety, and post-traumatic stress disorder often use CBT and other psychological strategies to deliver clinically validated treatments. These platforms provide patients with tools to manage their symptoms independently, offering exercises, real-time emotional support, and mindfulness techniques to improve mental well-being.

For patients with psychiatric conditions, DTx provides an easily accessible and often less stigmatizing way to receive care, especially in regions with limited access to mental health professionals. They also allow for continuous monitoring of symptoms, enabling more timely interventions when a patient's mental health deteriorates.

Expanding horizons: Pain management, respiratory conditions, and rehabilitation

Beyond chronic diseases and mental health, DTx are also being applied to a variety of other medical conditions. For instance, patients suffering from chronic pain can benefit from DTx which uses behavioral techniques and real-time tracking of pain triggers, helping reduce reliance on opioid medications. In respiratory diseases such as asthma and chronic obstructive pulmonary disease, DTx monitors inhaler use and provides personalized action plans to prevent exacerbations.

DTx are also playing a growing role in rehabilitation, offering personalized recovery plans for patients after surgery or injury, including physical therapy exercises delivered through interactive platforms. These tools help ensure patients adhere to their rehabilitation regimens, improving recovery outcomes and reducing the need for in-person follow-ups.

In these diverse areas of medicine, DTx is not only improving the standard of care but is reshaping how patients engage with their health, fostering a more proactive, informed, and personalized approach to treatment.

Can DTx enhance the power of conventional drug therapies?

The integration of DTx with conventional drug therapies holds great promise for enhancing treatment outcomes, particularly in chronic disease management and mental health. By complementing pharmacological interventions with personalized, data-driven digital tools, DTx can improve medication adherence, optimize dosing, and provide real-time monitoring, ultimately leading to better overall patient outcomes. However, how exactly does this integration work, and what challenges come with it?

Complementary Role of DTx with Medications: A Powerful Partnership

DTx can significantly enhance the effectiveness of conventional drugs by providing ongoing patient support that extends beyond the pill. For

instance, in conditions such as diabetes, where medication alone may not suffice, DTx can offer personalized lifestyle recommendations, track blood sugar fluctuations, and remind patients to take their insulin. This combination allows for more precise disease management and better control of blood glucose levels compared to medication alone.

In mental health, DTx can complement medications for depression or anxiety by delivering CBT modules, helping patients manage their symptoms in between doses. By supporting behavior modification and promoting medication adherence, DTx ensures that pharmacological treatments are as effective as possible.

Synergistic outcomes: When 1+1 equals more than 2

The combined use of DTx and conventional drug therapies has led to remarkable improvements in patient outcomes, as seen in several case studies. For example, in diabetes management, studies have shown that patients using both insulin therapy and a DTx platform for continuous glucose monitoring experienced better glycemic control than those relying on medication alone. Similar synergistic outcomes have been observed in conditions such as hypertension, where DTx helped patients achieve greater blood pressure reduction by providing real-time feedback on medication adherence and lifestyle modifications.

Another notable example is the integration of DTx in oncology, where digital tools assist cancer patients in managing the side effects of chemotherapy, such as nausea and fatigue. By monitoring symptoms and providing early interventions, DTx help patients stay on track with their treatment plans, improving their quality of life and treatment efficacy.

Challenges in integration: Bridging the gap

While the potential benefits of integrating DTx with conventional therapies are significant, there are several challenges to overcome. Regulatory frameworks for approving DTx alongside pharmaceuticals remain fragmented across different countries, creating hurdles in ensuring that both are evaluated with the same rigor. Ethical concerns also arise, particularly regarding patient data privacy and the security of health information shared through digital platforms.

From a practical standpoint, health-care providers may face difficulties in seamlessly integrating DTx into existing care protocols, especially in systems that are not equipped with the necessary infrastructure to support real-time data monitoring. In addition, patient and provider acceptance of these digital tools varies, with some individuals hesitant to embrace technology-driven interventions alongside traditional treatments.^[12]

Despite these challenges, the integration of DTx with conventional drug therapies is rapidly progressing, with continued advancements in technology and regulatory reforms. The future of medicine may well be shaped by this powerful partnership, offering a more comprehensive and personalized approach to treatment.

Clinical and Economic Impacts of DTx

Improved patient outcomes: Proven efficacy in clinical settings

DTx have been rigorously tested through numerous clinical trials, demonstrating their efficacy across a wide range of medical conditions. Studies have shown that DTx can lead to significant improvements in managing chronic diseases, such as diabetes and cardiovascular disease, by enhancing medication adherence, promoting behavioral changes, and providing real-time feedback to both patients and health-care providers. For example, clinical trials in diabetes management have found that patients using a combination of DTx and conventional insulin therapies achieved better glycemic control compared to those relying solely on medication.

Mental health interventions using DTx have also shown promising results. Trials evaluating the efficacy of DTx for depression and anxiety treatment have demonstrated outcomes comparable to traditional therapy, with the added benefit of scalability and accessibility. These clinical outcomes highlight the growing role of DTx as a valuable complement to conventional drug therapies.

Cost-effectiveness: A boon for health-care economics

The economic impact of DTx is becoming increasingly evident, as they have the potential to reduce overall health-care costs while improving patient outcomes. By preventing hospitalizations, reducing emergency visits, and improving chronic disease management, DTx contributes to significant cost savings. For example, studies in diabetes care have shown that DTx can reduce the frequency of complications, thereby lowering health-care costs associated with hospital admissions and long-term care.

In addition, by facilitating remote monitoring and reducing the need for frequent in-person consultations, DTx help alleviate the burden on health-care systems and allows providers to focus on more complex cases. This not only makes health care more efficient but also reduces the financial strain on both patients and the system as a whole.^[13]

Impact on health-care access and delivery: Bridging the gap

One of the most transformative impacts of DTx is their ability to improve health-care access, particularly for underserved populations. DTx can be delivered through mobile apps and online platforms, making them accessible to individuals who may not have regular access to traditional health-care services due to geographical, financial, or logistical barriers. In rural areas, where access to specialized care is often limited, DTx provides an effective alternative, offering personalized care that can be managed remotely.

By extending health-care services beyond clinical settings and into patients' daily lives, DTx are reshaping health-care delivery, making it more inclusive and adaptable to a wide range of needs. This expansion

in accessibility is especially crucial for managing chronic diseases and mental health conditions, where continuous support is necessary.^[14]

Future Directions and Potential for Expansion

Integration into standard care protocols: A seamless future

As DTx becomes more widely accepted, their integration into standard clinical practice is critical. To ensure a smooth transition, health-care providers, regulatory bodies, and technology developers must collaborate to create seamless workflows that incorporate DTx into existing care pathways. This may involve integrating DTx into electronic health records systems, training health-care professionals to effectively use these tools, and establishing clear guidelines for their use in combination with conventional therapies.

Standardizing the use of DTx in clinical practice will pave the way for more widespread adoption and ensure that both providers and patients can benefit from these innovations in a structured and effective manner.

Innovations in personalized medicine: The future of precision care

DTx are at the forefront of personalized medicine, offering tailored interventions that cater to individual patient profiles. As AI and machine learning technologies continue to evolve, DTx will become even more precise, analyzing vast amounts of data to deliver highly customized treatments. From predicting patient responses to medications to monitoring real-time health data, DTx will drive the future of precision medicine, ensuring that treatments are not only effective but also tailored to each patient's unique needs.^[15]

Challenges and barriers to widespread adoption: Overcoming hurdles

Despite their potential, the widespread adoption of DTx faces several challenges. Regulatory hurdles, such as inconsistent approval processes across different regions, create barriers to market entry. In addition, technical challenges, such as ensuring data security and privacy, need to be addressed to build patient and provider trust in these platforms.

Acceptance among health-care providers and patients is another critical barrier. Many providers may be hesitant to adopt new technologies, while patients may have concerns about the reliability of digital interventions. Overcoming these challenges will require continued education, clearer regulatory frameworks, and a focus on creating user-friendly, secure platforms.^[16]

Conclusion

DTx offer a transformative complement to conventional drug therapies, enhancing patient outcomes through personalized, cost-effective, and accessible care. As their integration into standard practice advances, DTx will drive innovation in precision medicine,

though regulatory and acceptance challenges must be addressed to fully realize their potential in reshaping modern health care.

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