Digital Health in Radiation Oncology: Imagining the Future of Patient Management

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Abstract

Digital health, which has grown quickly in the last decade, includes mobile health (mHealth), health information technology (IT), wearable devices, telehealth and telemedicine, and personalized medicine. Digital health holds significant promise for the way we operate our clinics, communicate with patients, and diagnose and treat diseases. This review article will focus on oncology digital health, including the current state and the future of digital health technology in radiation oncology practice. A number of patient-facing digital health studies have been published in recent years, covering mHealth, wearables, and patient-reported outcomes (PRO). Clinical trials and drug development are also experiencing a transformation from artificial intelligence (AI) and digital health. Lastly, personalized medicine has become more of a reality as analysis of big data provides more tailored treatment recommendations. Digital health has the potential to reduce health inequities if it is deployed in a proactive and targeted manner to populations that lack access to care. This article also covers barriers to widespread adoption of digital health, and an imagined future state of radiation oncology clinics that integrate health IT into all aspects of practice.

Keywords: Digital health, mHealth, health IT, wearables, artificial intelligence, equity

Digital health, which has exploded in the past decade, holds significant promise for the way we operate our clinics, communicate with patients, and diagnose and treat diseases. Digital health includes mobile health (mHealth), health information technology (IT), wearable devices, telehealth and telemedicine, and personalized medicine.[1] mHealth is the use of mobile devices in health care; it commonly refers to patient-facing applications for treatment support and chronic disease management.

Digital health has been rapidly adopted as a way to improve patient access to care, reduce unnecessary visits and costs, and personalize medicine. Patients can also use digital health to better manage their own health. Furthermore, when digital health is used well, it can mitigate the effects of the current national health care labor shortage by reducing the need for in-person or synchronous management. Digital health tools can allow patients to manage their care remotely with the clinical staff, and/or reduce the need for synchronous clinical staff intervention as in the case of mobile apps or chatbots that provide patient engagement and education directly to the patient.

This review article will focus on oncology digital health, including the current state and the future of digital health technology in radiation oncology practice. Categories explored in this manuscript include patient-facing mHealth, wearables, clinical trials and drug development, and personalized medicine. This article will not discuss telemedicine, which has been thoroughly reviewed in several other settings, nor will it discuss electronic health records.

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Patient-facing mHealth

A number of pilot studies of mHealth in oncology have been published in the last decade, beginning with simple studies of symptom tracker applications (apps), to measurement of patient reported outcomes (PRO) on mobile devices, and advancing now to mHealth leveraging artificial intelligence (AI) for communication between patients and the medical practice.

The electronic PRO movement gained momentum in the last decade as several studies clearly demonstrated benefits of patient symptom reporting. Researchers at the University of Wisconsin created a platform called CHESS (Comprehensive Health Enhancement Support System) for patient education, engagement, and networking delivered via the internet; an update of the program collects PRO and alerts clinicians to concerning scores.[2] An updated version of CHESS, developed for patients with advanced lung cancer, collects PRO data and alerts clinicians to above threshold scores. This intervention was associated with higher 2-year survival.[3] A randomized controlled trial of lung cancer patients receiving electronic PRO-based symptom management vs usual care showed that the PRO group had fewer complication rates and lower symptom burden for up to 4 weeks post discharge.[4] In a non-prespecified overall survival analysis of a randomized controlled trial, Basch et al showed that routine integration of PRO measurement into oncology clinical care was associated with an increase in overall survival compared with usual care.[5] Since then, a major category of mHealth research has been the use of mobile patient-facing apps for health tracking or health communication. A group from Northwell Health published favorable feasibility and usability results for an app called LogPal for tracking PROs among 38 head-and-neck cancer survivors over 8 weeks.[6] A multi-institutional group published a single-arm pilot study of the Strength Through Insight app for ePRO tracking once per week for 12 weeks. They found that patients preferred ePRO monitoring to traditional methods.[7] Researchers from the University of Pennsylvania/Villanova University published usability and acceptability results of a 2-week pilot study of a patient mobile health tracking app called Health Storylines among 32 radiation oncology patients.[8] A group from Thomas Jefferson University published results of a pilot feasibility study of 12-week digital health coaching for 88 prostate cancer patients, where they found that this approach was feasible.[9] Another small pilot study of 10 patients with gynecologic cancers used wearable devices along with PRO measurement; patients and clinicians reported improved physical activity, communication, and symptom management.[10]

Other approaches to mHealth include the use of automated virtual assistants or “chatbots,” which mimic the physician or clinician’s medical advice without requiring the provider to be aware of patient queries in real time or to actually provide the advice. Ma et al published results of 84 patients undergoing head-and-neck cancer radiation who received weekly “Chats” – chatbot communications via text or email before, during, and after treatment.[11] Chats measured PRO and identified a notable discordance between PRO and clinician-reported outcomes.

Remote monitoring is another subset of mHealth that allows the clinical team to remotely assess patient functioning and physiology between doctors’ visits. Researchers from The University of Texas MD Anderson Cancer Center published their experience collecting sensor and mobile data for colorectal cancer and head and neck cancers survivors; they reported high completion rates, ease of use, and self-efficacy.[12] Several commercial entities, including startups, now offer all of the above mHealth offerings. These entities work with hospitals and clinics to set up remote monitoring and other forms of check-ins to facilitate communication between clinic and patient.

Wearables

One promising data acquisition approach is the use of wearable devices that can proactively identify abnormalities of physiology and alert the patient and providers.[13] Wearables collect “real-world” data regarding patient activity or vital signs. These wearables, such as smartwatches and other smart devices, are primarily used recreationally by higher-income patients who pay out of pocket. Disruptive technologies – those that change how consumers or industries operate – are initially expensive, and then become cheaper as technological progress drives the production costs lower. It is likely that wearables and smart sensors will be “disruptive” to the traditional ways of practicing medicine where all data collection and all care takes place in a clinic or hospital setting. The digital health community is working to demonstrate the medical value of wearables in improving outcomes, lowering costs, and reducing adverse events in broader populations. We have learned that wearables data is not inherently clinically relevant; a recent study showed that data from a wearable used by head and neck cancer patients was not associated with hospital admissions or pain medication usage.[14]

Over time, wearables and smart sensors are likely to follow the trajectory of other new technologies that rapidly drop in price and reach a wider audience. As more people use wearables, millions of datapoints will be available for analysis. AI provides a way to discern meaning from large-scale real-world data. AI has the potential to predict that certain datapoints from wearables or smart sensors are associated with patient outcomes, such as hospitalization and worsening quality of life.

Clinical Trials and Drug Development

Clinical trial participants require close monitoring as well as the ability to report and quickly manage the effects of trial interventions. Furthermore, clinical trials face challenges related to the enormity of data to collect, patient recruitment, and patient compliance. Trialists are turning to digital health solutions to address these challenges.[15] mHealth and wearables play a large part in remote patient monitoring and PRO assessment for decentralized clinical trials. Pharmaceutical companies contract with digital health companies to provide these services to clinical trial participants. As trials become more decentralized and more monitoring takes place in doctors' offices or patient homes, digital health will be the foundation for successful execution of monitoring outside of traditional health care settings.

Personalized Medicine

Personalized, or precision, medicine relies on high-quality data inputs, data analytics, and presentation of data in an actionable way. Clinical data collected before, during, and after treatment – from the electronic medical record (EMR), apps, or wearables – can be used to predict toxicities. Furthermore, molecular testing creates vast amounts of tumor genomics data. AI has the ability to use clinical and molecular inputs to provide reliable, actionable insights to physicians at the point of care. One study used AI algorithms, first trained on clinical data from EMRs, to accurately predict emergency room and hospital admissions in patients receiving radiation or chemoradiation.[16] AI can transform many patient-facing aspects of radiation oncology practice, including patient evaluation and dose prescription, toxicity prediction and management, and follow-up care.[17]

Health Equity Implications

Digital health has the potential to improve health equity by reaching people who traditionally have low access to care. Digital health and mHealth can be used to overcome barriers to health care access by allowing communication between patients and providers to be asynchronous, or without continuous real-time interaction; tailoring education to patient preferences; allowing symptom reporting to better inform clinical staff of treatment course; and facilitate patient self-management.[18] Telemedicine can be leveraged to improve medical access for patients in underserved areas, although its use in these settings may be limited by inadequate broadband internet and devices.[19] For example, authors from the University of Arkansas for Medical Sciences published their approach to creating an enterprise-wide digital health innovation platform intended to support patients in rural communities.[20]

Barriers to Digital Health Adoption

Roadblocks to digital health adoption and implementation fall into 3 major categories: resources, privacy, and technological access. Resources includes financial costs, time, and efforts required to implement useful digital health solutions. In my own experience implementing a patient-facing mHealth program into a radiation oncology clinic, there are considerable investments of physician and staff time required to create the content, operationalize the program, ensure its success, and follow up on PRO.

Most digital health programs require upfront capital investment to purchase the software/hardware and/or to build it in house. To prove they are worth the cost, digital health solutions must demonstrate value. Return on investment is not easy to calculate for most of these programs, as many digital health tools improve communication and patient management, but those outcomes are typically not financially quantifiable. Instead, surrogate endpoints are often reported to show value: fewer ED visits, re-admissions, or adverse events. These endpoints can then be converted to financial savings, especially under value-based care payment arrangements (vs fee-for-service models).

Data security and privacy are at risk whenever a technology type is developing faster than regulation can keep up. To mitigate data security risks of digital health, the FDA has released draft guidance for industry, investigators, and other stakeholders regarding health information gathered by digital health technologies.[21]

Finally, technological access is an ongoing challenge for any field where technology is advancing rapidly. Nearly 1 in 4 US households do not have home internet, and only 64% of Americans aged 65 or older have a home broadband connection.[22,23,] While 85% of Americans have smartphones, not all have reliable internet on their smartphones. Furthermore, 15% of US adults are "smartphone only" internet users; that number rises to 27% of people with an annual household income less than $30,000. Therefore, digital health will not reach entire swaths of the population unless a concerted effort is made to compensate for the lack of home internet access. One such effort that clinicians can make is to provide tablets and computers in the clinical setting so patients can still benefit from digital health, even if not at home.

Future State

As we learn about the rapid progress of digital health, it is only natural to imagine how it will enable the future of radiation oncology. If we allow our imaginations to wander, we may envision the following future as a possibility; this description is not intended to be an absolute depiction.

The radiation oncology clinic of the near future will be technology-immersive. Patients will complete PRO assessments by smartphone or in the clinic using a tablet. They will be able to see if their treatment machine is operating on time or delayed. They will know if their doctor is on time or delayed. They will enter an examination room where they and their doctor can interact with their medical chart on a large screen. The patient encounter will be automatically recorded and transcribed to the patient chart, reducing the clinician's documentation time for each patient to a few minutes at most. An AI assistant will suggest evidence-based treatments, and the clinician will determine if they agree with those recommendations. Tests and simple imaging will be done in the office with immediate results driven by AI-powered interpretation of radiology, images, and labs. The patient will receive a summary of the visit and next steps on their mobile device and can interact with it anytime. Patients will also be able to interact with a virtual AI-driven assistant throughout their treatment.

As health care moves more toward value-based care, well-executed digital health solutions can play a large role in helping providers and patients reach their potential. Value-based care payments rely on meeting a number of quality metrics. Thoughtful design of technology can ensure that those quality measures are met seamlessly within existing clinical workflows.

Conclusion

Technological progress has been one of the great feats of mankind that has raised living standards for billions of people. Health care is the next great frontier where the intersection of user-friendly technology and medical knowledge can create meaningful improvements in quality and equity of care. Digital health is in its infancy; with thoughtful implementation and close clinical oversight, digital health has the potential to transform the way we care for patients.

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