

Education

IN LIFESTYLE MEDICINE

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Utilizing Digital Health Technologies for Patient Education in Lifestyle Medicine

Abstract: *Technology has redefined the way patients and providers communicate and obtain health information. The realm of digital health encompasses a diverse set of technologies, including mobile health, health information technology, wearable devices, telehealth and telemedicine, and personalized medicine. These technologies have begun to improve care delivery without the traditional constraints of distance, location, and time. A growing body of evidence supports the use of digital health technology for improving patient education and implementation of skills and behaviors integral to lifestyle medicine. Patient education can now be delivered in standard formats (eg, articles, written messages) as well a wide array of multimedia (video, audio, interactive games, etc), which may be more appropriate for certain topics and learning styles. In addition, patient engagement in their care plays an important role in improving health outcomes. Despite digital health technology development often outpacing its research, there is sufficient evidence to support the use of many current technologies in clinical practice. Digital health tools will continue to grow in*

their ability to cost-effectively monitor and encourage healthy behaviors at scale, and better methods of evaluation will likely increase clinician confidence in their use.

Keywords: Digital health technology, patient education, lifestyle medicine



[Digital] technologies have begun to improve care delivery without the traditional constraints of distance, location, and time.



Technology has redefined the way patients and providers communicate and obtain health information. Globally, an estimated 6.75 million internet queries on health-related topics are conducted every day.¹ In 2013, the Pew Research Center found that 72% of Internet users in the United States searched for health information the previous year, with 35% using the Internet to determine their own or someone else's medical condition.²

Digital health encompasses a diverse set of technologies, including mobile health, health information technology,

wearable devices, telehealth and telemedicine, and personalized medicine.³ These technologies have begun to improve care delivery without the traditional constraints of distance, location, and time.⁴ They also offer new opportunities to educate patients and facilitate the process of behavior change

integral to lifestyle medicine. Patient education can now be delivered in standard formats (eg, articles, written messages) as well a wide array of multimedia (video, audio, interactive games, etc), which may be more appropriate for certain topics and learning styles. Furthermore, education is not only the consumption of information but also the implementation and mastery of skills, sometimes referred to as experiential learning. Patient engagement in their care plays an important role in health outcomes. Engaged patients cost health care systems 8% less than

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nonengaged patients in their base year, and 21% less in future years.⁵

Text Messaging

Text messaging is the most widely used data application in the world—used by over 78% of all mobile phone subscribers as of 2012^{6,7} and over 97% of all mobile phone subscribers in the United States as of 2015.⁸ It is effective for reaching its audience, with estimates that 99% of received mobile text messages are opened and 90% within three minutes of receipt.^{9,10} Messages can be timed precisely, ranging from infrequent reminders to bursts throughout the day to specific moments of decision making. Multiple reviews have shown benefit in diabetes, cardiovascular disease, weight loss, physical activity, smoking cessation, and medication adherence.¹¹⁻¹⁵

Extensive literature exists on user-centered design for provision of educational material. Considerations include the length of the message,¹⁶ sender of the message, style of writing, cultural and linguistic appropriateness,^{6,17} literacy level of the population (generally eighth-grade level is maximum used for adults), and the need for translations.¹⁸ Some studies provide more messages during key behavior change periods, some only send messages when requested by a user, and others vary frequency based on the text habits of their users or based on users' adherence (e.g. higher frequency when adherence is low).¹⁸ An example includes The Tobacco, Exercise and Diet Messages (TEXT ME) trial, a randomized clinical trial of 710 patients with coronary heart disease. The intervention group received 4 text messages per week for 6 months in addition to usual care. Text messages provided advice, motivational reminders, and support to change lifestyle behaviors. Compared with usual care, this intervention resulted in a modest improvement in LDL-C (low-density lipoprotein cholesterol) level and greater improvement in other cardiovascular disease risk factors.¹⁹

Mobile (Smartphone and Tablet) Applications

A mobile application (“app”) is a computer program designed to run on a mobile device such as a smartphone or tablet. An estimated 81% of US adults owned a smartphone as of 2018,²⁰ and approximately 325 000 health-related applications existed in 2017 for Apple iOS or Android smartphones,²¹ with the most popular apps focused on healthy eating and physical activity.^{22,23} Apps educate patients by providing insight into their behaviors and opportunities to practice new skills. A systematic review demonstrated that women with diabetes receiving preconception care education delivered either digitally or via health care professionals had significantly improved levels of glycosylated hemoglobin with fewer preterm deliveries and adverse fetal outcomes. The digital interventions further showed significant improvements in knowledge and attitudes toward preconception care, along with reduced barriers.²⁴ Other examples of apps that provide education include myIBDcoach, my AF and mySinusitisCoach.²⁵⁻²⁷

Wearables Devices

Wearable devices and sensors most commonly provide heart rate tracking and physical activity monitoring. Additionally, they can monitor sleep, track mood or stress levels, or deliver workouts. One in 6 consumers in the United States now uses wearable technology,²⁸ with over half being smartwatches. As of 2017, 17% of US adults used a wearable device such as a smartwatch or a wrist-worn fitness band.²⁹ Nonwearable sensors are contributing to the rise of the Internet of Things—a network of sensor-equipped devices able to exchange data. For example, digital scales can now detect not only weight and body fat measurements but also streamline daily weigh-ins by automatically sending measurements to a smartphone application or an online database.³⁰ Smart refrigerators can help track

available groceries, create shopping lists, and even help order food.³¹ Mattress covers connected to the internet can monitor temperature, breathing, and heart rate to track sleep quality.³² Eventually, these smart devices may operate in concert to monitor patient lifestyle and provide personalized education and feedback to encourage healthier behaviors.

Social Media

Social media is defined as an online means of communication used to share information and develop social contacts.³³ It includes online social networks, forums, and messaging boards. Though it does not replace the need for in-person networks and connections, social media creates a new space for education, emotional support, campaigning, fundraising, and network formation.³⁴ Online social support is particularly valuable for individuals with limited mobility as it decreases barriers for physical transportation. There have been positive studies with weight loss and smoking cessation.³⁵⁻⁴⁰ Patient-shared data can also be collected online to create research databases. For example, a social network focused on ALS (amyotrophic lateral sclerosis) treatment compiled patient outcomes showing that lithium had no clinical effect within the first 12 months,⁴¹ highlighting the potential of patient shared data to accelerate clinical findings. Evidence about social media's impact on health knowledge, behavior, and outcomes shows these tools can be effective in meeting individual and population health needs.⁴²

Telehealth

Telemedicine is broadly defined as the use of technologies to remotely diagnose, monitor, and treat patients.⁴³ Telemedicine fits under the larger umbrella of telehealth services, which entails the application of technologies to help patients manage their own illnesses through improved self-care and access to education and support systems.⁴⁴ Examples of telehealth interventions that

have shown benefit in mortality and cost-savings include home telemonitoring programs for congestive heart failure, remote intensive care unit monitoring, and home health monitoring for veterans. Additionally, telehealth programs have been shown to improve medication adherence and access to specialty providers.⁴⁴ A telehealth educational platform and interactive care plan for people with diabetes uses a voice-enabled scale and diabetic foot scanner.⁵

Digital Therapeutics

Digital therapeutics are evidence-based digital health tools, often Food and Drug Administration approved, which integrate the above technologies in order to treat or reverse disease conditions. They are comprehensive treatment programs that may be prescribed by a clinician to replace or augment traditional treatments. Some digital therapeutic programs for diabetes and weight loss are now covered by insurance plans.⁴⁵ Digital therapeutics can collect a high volume of user data from a variety of sources, ranging from traditional clinical biomarkers to physiologic sensors⁴⁶⁻⁴⁸ and social patterns.⁴⁹ These data sets allow for big data analytics during active treatment periods, easy access to longitudinal data patterns, insight into the effectiveness of specific lifestyle medicine program variations, and opportunities to provide education. Most digital therapeutics provide some form of patient education. For example, a randomized control trial demonstrated a 12-week remote digital care program improved low back pain by providing sensor-guided exercise therapy, education, cognitive behavioral therapy, behavioral coaching and tracking.⁵⁰ Other programs providing patient education have shown benefit in improving sleep,⁵¹ diabetes and other chronic disease management.^{52,53}

Emerging Technologies

Virtual and Augmented Reality

Virtual reality (VR) is an artificial, computer-generated simulation of a

real-life environment, usually requiring users to wear a headset for an immersive experience. Augmented reality (AR) is a technology that layers computer-generated enhancements atop an existing reality. AR is built into applications on mobile devices to add digital components into the real world.⁵⁴ This technology allows patients to implement new behaviors and skills through experiential learning. A lifestyle medicine application is the augmented reality game called *Pokemon Go* (developed by Niantic, Inc) that was developed for iOS and Android devices. The application was adopted by 40 million users worldwide and had 500 million downloads.⁵⁵ A study showed a 34.8% relative increase in step counts, while the number of participants achieving a goal of 10,000 steps per day increased from 15.3% to 27.5%.⁵⁶ A recent randomized review presented another augmented reality example in which a tablet application helped participants more accurately measure standard serving sizes compared with those who received information only.⁵⁷ Finally, a 2017 systematic review and meta-analysis of 28 studies showed that virtual reality games had positive effects on balance and fear of falling in community-dwelling older adults.⁵⁸

Big Data and Machine Learning

The technologies described in the preceding sections will generate massive amounts of data, requiring advanced analytics to make the data meaningful and actionable. Artificial intelligence—the ability for machines to mimic facets of human cognition—is already being applied to other fields of medicine, such as making diagnoses in radiology and pathology.⁵⁹ The branch of artificial intelligence that likely holds the most short-term relevance for lifestyle medicine is that of machine learning (ML). ML is an analytical method that allows a computer to be trained on massive quantities of data to make decisions about other data.⁶⁰ ML can identify certain patterns of physiological or behavioral data, sometimes referred to

as digital biomarkers, which can be used to predict the likelihood of future clinical outcomes. Such “predictive analytics” have potential to augment digital lifestyle medicine, as they could be embedded in behavioral feedback loops and population medicine strategies.⁶¹ For example, a digital therapeutic could capture patient text messaging patterns to assess the need for mental health intervention⁶² or monitor arm movements to determine abnormal eating patterns.⁶³

Physician's Role

The 2003 Health Information National Trends Survey found that nearly half of 6,369 surveyed adults searched online first for information on cancer compared to only 11% who sought a physician's counsel first. Information available on the internet has helped inform and empower patients, shifting the patient-physician dynamic in the process.⁶⁴ Despite the ease of access to information, there remains a lack of standards and a broad spectrum of quality and rigor.⁶⁵ Physicians can play a major role in directing patients toward appropriate and substantiated educational materials and facilitating the uptake of digital health technologies in their patient populations.⁶⁶ For example, physicians can communicate electronically with patients through the electronic medical record, which has been shown to increase patient satisfaction, promote adherence to preventative and treatment recommendations, improve clinical outcomes, and lower medical costs.⁶⁷ However, physicians themselves need better ability to assess the validity and utility of digital health products, and recent proposals such as a digital health scorecard utilizing an evaluation framework with technical, clinical, usability, and cost domains may increase clinician confidence.⁶⁸

Conclusion

A growing body of evidence supports the use of digital health technology for improving patient education and

implementation of skills and behaviors integral to lifestyle medicine. Despite digital health technology development outpacing its research, there is sufficient evidence to support the use of many current technologies in clinical practice. Digital health tools will continue to grow in their ability to cost-effectively monitor and encourage healthy behaviors at scale, and better methods of evaluation will likely increase clinician confidence in their use.

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Trial Registration

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References

1. Fox S. Health topics. <https://www.pewresearch.org/internet/2011/02/01/health-topics-2/>. Published February 1, 2011. Accessed November 9, 2019.
2. Fox S, Duggan M. Health online 2013. <https://www.pewresearch.org/internet/2013/01/15/health-online-2013/>. Published January 15, 2013. Accessed November 9, 2019.
3. US Food and Drug Administration. Digital health. <https://www.fda.gov/medicaldevices/digitalhealth/>. Updated November 5, 2019. Accessed November 9, 2019.
4. Kataria S, Ravindran V. Digital health: a new dimension in rheumatology patient care. *Rheumatol Int*. 2018;38:1949-1957. doi:10.1007/s00296-018-4037-x
5. Wellpepper. White papers. www.wellpepper.com/whitepapers. Published 2019. Accessed November 9, 2019.
6. Willoughby JF, Furberg R. Underdeveloped or underreported? Coverage of pretesting practices and recommendations for design of text message-based health behavior change interventions. *J Health Commun*. 2015;20:472-478. doi:10.1080/10810730.2014.977468
7. Pew Research Center. Global digital communication: texting, social networking popular worldwide. <https://www.pewresearch.org/global/2011/12/20/global-digital-communication-texting-social-networking-popular-worldwide/>. Published December 20, 2011. Updated February 29, 2012. Accessed November 9, 2019.
8. Smith A. US smartphone use in 2015. www.pewresearch.org/internet/2015/04/01/us-smartphone-use-in-2015/. Published April 1, 2015. Accessed November 9, 2019.
9. Mobile Squared. Conversational advertising. <https://mobilesquared.co.uk/wp-content/uploads/2017/12/Conversational-Advertising.pdf>. Published June 2010. Accessed November 9, 2019.
10. Tatango. SMS open rates exceed 99%. <https://www.tatango.com/blog/sms-open-rates-exceed-99/>. Published April 10, 2013. Accessed November 9, 2019.
11. Hall AK, Cole-Lewis H, Bernhardt JM. Mobile text messaging for health: a systematic review of reviews. *Annu Rev Public Health*. 2015;18:393-415. doi:10.1146/annurev-publhealth-031914-122855
12. Adler AJ, Martin N, Mariana J, et al. Mobile phone text messaging to improve adherence to cardiovascular disease secondary prevention of. *Cochrane Database Syst Rev*. 2017;(4):CD011851. doi:10.1002/14651858.CD011851
13. Arambepola C, Ricci-Cabello I, Manikavasagam P, Roberts N, French DP, Farmer A. The impact of automated brief messages promoting lifestyle changes delivered via mobile devices to people with type 2 diabetes: a systematic literature review and meta-analysis of controlled trials. *J Med Internet Res*. 2016;18:e86. doi:10.2196/jmir.5425
14. Finitis DJ, Pellowski JA, Johnson BT. Text message intervention designs to promote adherence to antiretroviral therapy (ART): a meta-analysis of randomized controlled trials. *PLoS One*. 2014;9:e88166. doi:10.1371/journal.pone.0088166
15. Whittaker R, McRobbie H, Bullen C, Rodgers A, Gu Y. Mobile phone-based interventions for smoking cessation. *Cochrane Database Syst Rev*. 2016;(4):CD006611. doi:10.1002/14651858.CD006611.pub4
16. Horvath T, Azman H, Kennedy GE, Rutherford GW. Mobile phone text messaging for promoting adherence to antiretroviral therapy in patients with HIV infection. *Cochrane Database Syst Rev*. 2012;14:CD009756. doi:10.1002/14651858.CD009756
17. US Department of Health and Human Services. Using health text messages to improve consumer health knowledge, behaviors, and outcomes: an environmental scan. <https://www.hrsa.gov/sites/default/files/archive/healthit/txt4tots/environmentalscan.pdf>. Published May 2014. Accessed November 9, 2019.
18. Abrams LC, Whittaker R, Free C, Van Alstyne JM, Schindler-Ruwisch JM. Developing and pretesting a text messaging program for health behavior change: recommended steps. *JMIR Mhealth Uhealth*. 2015;3:e107. doi:10.2196/mhealth.4917
19. Chow CK, Redfern J, Hillis GS, et al. Effect of lifestyle-focused text messaging on risk factor modification in patients with coronary heart disease. *JAMA*. 2015;314:1255-1263. doi:10.1001/jama.2015.10945
20. Pew Research Center. Mobile fact sheet. <https://www.pewresearch.org/internet/fact-sheet/mobile/>. Published June 12, 2019. Accessed November 9, 2019.
21. Santo K, Redfern J. The potential of mHealth applications in improving resistant hypertension self-assessment, treatment and control. *Curr Hypertens Rep*. 2019;21:81. doi:10.1007/s11906-019-0986-z
22. Statista. Top preferences for health apps in the United States in 2012. <https://www.statista.com/statistics/348731/preferences-for-health-apps-by-type-in-the-us/>. Published February 20, 2018. Accessed November 9, 2019.
23. Krebs P, Duncan DT. Health app use among US mobile phone owners: a national survey. *JMIR Mhealth Uhealth*. 2015;3:e101. doi:10.2196/mhealth.4924
24. Nwoli CH, Carey N, Shawe J. Preconception care education for women with diabetes: a systematic review of conventional and digital health interventions. *J Med Internet Res*. 2016;18:e291. doi:10.2196/jmir.5615
25. Yin AL, Hachuel D, Pollak JP, Scherl EJ, Estrin D. Digital health apps in the clinical care of inflammatory bowel disease:

- scoping review. *J Med Internet Res*. 2019;21:e14630. doi:10.2196/14630
26. Kotecha D, Chua WWL, Febritz L, et al. European Society of Cardiology smartphone and tablet applications for patients with atrial fibrillation and their health care providers. *Europace*. 2018;20:225-233. doi:10.1093/europace/eux299
 27. Seys SF, Bousquet J, Bachert C, et al. mySinusitisCoach: patient empowerment in chronic rhinosinusitis using mobile technology. *Rhinology*. 2018;56:209-215. doi:10.4193/Rhin17.253
 28. Patel MS, Asch DA, Volpp KG. Wearable devices as facilitators, not drivers, of health behavior change. *JAMA*. 2015;313:459-460. doi:10.1001/jama.2014.14781
 29. Sim I. Mobile devices and health. *N Engl J Med*. 2019;381:956-968. doi:10.1056/nejmra1806949
 30. Fitbit. Fitbit Aria 2. <https://www.fitbit.com/aria2>. Published 2019. Accessed November 9, 2019.
 31. Samsung Electronics America. Family Hub refrigerator overview. <https://www.samsung.com/us/explore/family-hub-refrigerator/overview/>. Published 2019. Accessed November 9, 2019.
 32. Luna Mattress. Luna mattress protectors. <https://www.lunamattress.com/>. Published 2019. Accessed November 9, 2019.
 33. Dictionary.com. Social media. <https://www.dictionary.com/browse/social-media>. Published 2019. Accessed November 9, 2019.
 34. Griffiths F, Dobermann T, Cave JAK, et al. The impact of online social networks on health and health systems: a scoping review and case studies. *Policy Internet*. 2015;7:473-496. doi:10.1002/poi3.97
 35. Christakis NA, Fowler JH. The spread of obesity in a large social network over 32 years. *N Engl J Med*. 2007;357:370-379. doi:10.1056/NEJMsa066082
 36. Poncela-Casasnovas J, Spring B, McClary D, et al. Social embeddedness in an online weight management programme is linked to greater weight loss. *J R Soc Interface*. 2015;12:20140686. doi:10.1098/rsif.2014.0686
 37. Hwang KO, Ottenbacher AJ, Green AP, et al. Social support in an Internet weight loss community. *Int J Med Inform*. 2010;79:5-13. doi:10.1016/j.ijmedinf.2009.10.003
 38. Myneni S, Cobb N, Cohen T. In pursuit of theoretical ground in behavior change support systems: analysis of peer-to-peer communication in a health-related online community. *J Med Internet Res*. 2016;18:e28. doi:10.2196/jmir.4671
 39. Latkin CA, Knowlton AR. Social network assessments and interventions for health behavior change: a critical review. *Behav Med*. 2015;41:90-97. doi:10.1080/08964289.2015.1034645
 40. Sweet CMC, Chiguluri V, Gumpina R, et al. Outcomes of a digital health program with human coaching for diabetes risk reduction in a Medicare population. *J Aging Health*. 2018;30:692-710. doi:10.1177/0898264316688791
 41. Wicks O, Vaughan TE, Massagli MP, Heywood J. Accelerated clinical discovery using self-reported patient data collected online and a patient-matching algorithm. *Nat Biotechnol*. 2011;29:411-414. doi:10.1038/nbt.1837
 42. Korda H, Itani Z. Harnessing social media for health promotion and behavior change. *Health Promot Pract*. 2013;14:15-23. doi:10.1177/1524839911405850
 43. Sood S, Mbarika V, Jugoo S, et al. What is telemedicine? A collection of 104 peer-reviewed perspectives and theoretical underpinnings. *Telemed J E Health*. 2007;13:573-590. doi:10.1089/tmj.2006.0073
 44. Kvedar J, Coye MJ, Everett W. Connected health: a review of technologies and strategies to improve patient care with telemedicine and telehealth. *Health Aff (Millwood)*. 2014;33:194-199. doi:10.1377/hlthaff.2013.0992
 45. Centers for Medicare & Medicaid Services (CMS), HHS. Medicare program; revisions to payment policies under the physician fee schedule and other revisions to part B for CY 2018; Medicare shared savings program requirements; and Medicare Diabetes Prevention Program. Final Rule. *Fed Regist*. 2017;82:52976-53371.
 46. Webb RC, Bonifas AP, Behnaz A, et al. Ultrathin conformal devices for precise and continuous thermal characterization of human skin. *Nat Mater*. 2013;12:938-944. doi:10.1038/nmat3755
 47. Xi W, Yeo JC, Yu L, Zhang S, Lim CT. Ultrathin and wearable microtubular epidermal sensor for real-time physiological pulse monitoring. *Adv Mater Technol*. 2016;2:1700016. doi:10.1002/admt.201700016
 48. Thomas A, Heinemann L, Ramirez A, Zehe A. Options for the development of noninvasive glucose monitoring. *J Diabetes Sci Technol*. 2016;10:782-789. doi:10.1177/1932296815616133
 49. Hird N, Ghosh S, Kitano H. Digital health revolution: perfect storm or perfect opportunity for pharmaceutical R&D? *Drug Discov Today*. 2016;21:900-911. doi:10.1016/j.drudis.2016.01.010
 50. Shebib R, Bailey JF, Smittenaar P, Perez DA, Mecklenburg G, Hunter S. Randomized controlled trial of a 12-week digital care program in improving low back pain. *NPJ Digit Med*. 2019;2:1. doi:10.1038/s41746-018-0076-7
 51. Big Health. Outcomes. <https://www.bighealth.com/outcomes>. Published 2019. Accessed November 9, 2019.
 52. Livongo. Proven results. https://www.livongo.com/impact.html#Clinical_Outcomes. Published 2019. Accessed November 9, 2019.
 53. Omada Health. Clinical outcomes. <https://www.omadahealth.com/outcomes>. Published 2019. Accessed November 9, 2019.
 54. Augment. Virtual reality vs augmented reality. <http://www.augment.com/blog/virtual-reality-vs-augmented-reality/>. Published October 6, 2015. Accessed November 9, 2019.
 55. Althoff T, White RW, Horvitz E. Influence of Pokémon GO on physical activity: study and implications. *J Med Internet Res*. 2016;18:e315. doi:10.2196/jmir.6759
 56. Xian Y, Xu H, Xu H, et al. An initial evaluation of the impact of Pokémon GO on physical activity. *J Am Heart Assoc*. 2017;6:e005341. doi:10.1161/JAHA.116.005341
 57. Rollo ME, Bucher T, Smith SP, Collins CE. ServAR: an augmented reality tool to guide the serving of food. *Int J Behav Nutr Phys Act*. 2017;14:65. doi:10.1186/s12966-017-0516-9
 58. Neri SG, Cardoso JR, Cruz L, et al. Do virtual reality games improve mobility skills and balance measurements in community-dwelling older adults? Systematic review and meta-analysis. *Clin Rehabil*. 2017;31:1292-1304. doi:10.1177/0269215517694677
 59. Jha S, Topol EJ. Adapting to artificial intelligence: radiologists and pathologists as information specialists. *JAMA*. 2016;316:2353-2354. doi:10.1001/jama.2016.17438
 60. Jeffcock P. What's the difference between AI, machine learning, and deep learning? <https://blogs.oracle.com/bigdata/difference-ai-machine-learning-deep-learning>. Published July 11, 2018. Accessed November 9, 2019.
 61. Berman MA, Appelbaum KJ, Edwards KL, Eisenberg DM, Katz DL. FareWell and the how of lifestyle medicine. *Am J Lifestyle Med*. 2017;11:314-317. doi:10.1177/1559827617701411

62. Cook BL, Progovac AM, Chen P, Mullin B, Hou S, Baca-Garcia E. Novel use of natural language processing (NLP) to predict suicidal ideation and psychiatric symptoms in a text-based mental health intervention in Madrid. *Comput Math Methods Med*. 2016;2016:8708434. doi:10.1155/2016/8708131
63. Thomaz E, Bedri A, Prioleau T, Essa I, Abowd GD. Exploring symmetric and asymmetric bimanual eating detection with inertial sensors on the wrist. *DigitalBiomarkers 17 (2017)*. 2017;2017:21-26.
64. Sun GH. The digital divide in Internet-based patient education materials. *Otolaryngol Head Neck Surg*. 2012;147:855-857. doi:10.1177/0194599812456153
65. Davis DW, Logsdon MC, Vogt K, et al. Parent education is changing: a review of smartphone apps. *MCN Am J Matern Child Nurs*. 2017;42:248-256. doi:10.1097/nmc.0000000000000353
66. Gordon NP, Crouch E. Digital information technology use and patient preferences for Internet-based health education modalities: cross-sectional survey study of middle-aged and older adults with chronic health conditions. *JMIR Aging*. 2019;2:e12243. doi:10.2196/12243
67. Griffin A, Skinner A, Thornhill J, Weinberger M. Patient portals: who uses them? What features do they use? And do they reduce hospital readmissions? *Appl Clin Inform*. 2016;7:489-501. doi:10.4338/ACI-2016-01-RA-0003
68. Mathews SC, McShea MJ, Hanley CL, Ravitz A, Labrique AB, Cohen AB. Digital health: a path to validation. *NPJ Digit Med*. 2019;2:38. doi:10.1038/s41746-019-0111-3