Viewpoint

Advancing Digital Health Innovation in Oncology: Priorities for High-Value Digital Transformation in Cancer Care

Smit Patel[1], PharmD; Jennifer C Goldsack[1], MChem, MA, MBA; Grace Cordovano[2], BCPA, PhD; Andrea Downing[3], BBA; Karen K Fields[4], MD; Cindy Geoghegan[5], BA; Upinder Grewal[6], MSc; Jorge Nieva[7], MD; Nikunj Patel[8], PharmD; Dana E Rollison[4], PhD; Archana Sah[9], MS; Maya Said[10], ScD; Isabel Van De Keere[11], MSc, PhD; Amanda Way[12], MSc; Dana L Wolff-Hughes[13], PhD; William A Wood[14], MD; Edmondo J Robinson[4], MBA, MS, MD

[1]Digital Medicine Society, Boston, MA, United States

[2]Enlightening Results LLC, West Caldwell, NJ, United States

[3]The Light Collective, Shoreline, WA, United States

[4]Center for Digital Health, Moffitt Cancer Center, Tampa, FL, United States

[5]Patient and Partners LLC, Madison, CT, United States

[6]Bayer AG, Reading, United Kingdom

[7]Norris Comprehensive Cancer Center, University of Southern California, Los Angeles, CA, United States

[8]AstraZeneca PLC, Gaithersburg, MD, United States

[9]AS Pharma Advisors, Inc, San Francisco, CA, United States

[10]Outcomes4Me Inc, Boston, MA, United States

[11]Immersive Rehab, London, United Kingdom

[12]Jazz Venture Partners, San Francisco, CA, United States

[13]Division of Cancer Control and Populations Sciences, National Cancer Institute, Bethesda, MD, United States

[14]Lineberger Comprehensive Cancer Center, University of North Carolina Chapel Hill, Chapel Hill, NC, United States

Corresponding Author:
Jennifer C Goldsack, MChem, MA, MBA
Digital Medicine Society
90 Canal St, 4th Floor
Boston, MA, 02114
United States
Phone: 1 765 234 3463
Email: jennifer@dimesociety.org

Abstract

Although health care delivery is becoming increasingly digitized, driven by the pursuit of improved access, equity, efficiency, and effectiveness, progress does not appear to be equally distributed across therapeutic areas. Oncology is renowned for leading innovation in research and in care; digital pathology, digital radiology, real-world data, next-generation sequencing, patient-reported outcomes, and precision approaches driven by complex data and biomarkers are hallmarks of the field. However, remote patient monitoring, decentralized approaches to care and research, "hospital at home," and machine learning techniques have yet to be broadly deployed to improve cancer care. In response, the Digital Medicine Society and Moffitt Cancer Center convened a multistakeholder roundtable discussion to bring together leading experts in cancer care and digital innovation. This viewpoint highlights the findings from these discussions, in which experts agreed that digital innovation is lagging in oncology relative to other therapeutic areas. It reports that this lag is most likely attributed to poor articulation of the challenges in cancer care and research best suited to digital solutions, lack of incentives and support, and missing standardized infrastructure to implement digital innovations. It concludes with suggestions for actions needed to bring the promise of digitization to cancer care to improve lives.

KEYWORDS

Introduction

In an ideal world, the incidence and disease burden of cancer would be reduced and inequities ameliorated by improvements in education, prevention, screening, and early detection. Every person living with cancer could easily access timely screening and the right treatment at the right time. Personalized treatment would be the standard of care, and patients' health status would be continually monitored to ensure their safety and optimize their quality of life. In addition, patients and their care partners [1] would have ready access to high-quality research and fit-for-purpose educational resources to help them understand their diagnosis and care journey. Care partners would be welcomed into the lifetime journey that a cancer diagnosis or prognosis can bring, and patients whose lives are cut short by cancer would be supported with access to high-quality end-of-life care rooted in dignity and compassion. Additionally, clinicians could follow their vocation to save and improve lives, with documentation, reimbursement, and payment cycle workflows fully optimized to reduce their administrative burden.

In the digital era of health care, it is possible for data and information to flow freely and for patient-physician encounters to transcend place and time. Currently, however, cancer care is incredibly frustrating and physically, mentally, emotionally, and financially taxing for patients, care partners, and clinicians alike, and this burden is not distributed equally [2]. The likelihood of survival from cancer varies by the patient's zip code [3], race [4-8], socioeconomic status [9,10], sex [11,12], and site of care [13]. Patients who *do* survive cancer can face the long-term effects of physical and financial toxicity [14-16]. Cancer care is disconnected from cancer research, preventing refinement of care from each test performed, diagnosis made, and treatment administered. Disparate data sources and systems hamper coordination of care and raise the possibility of gaps in management or even working at cross purposes.

The integrated digitization of the various streams of health care data can inform better decision-making [17-26] and improve coordination of care while respecting patient preference and privacy. Screening, diagnosis, and treatment can be informed by personalized risk models that apply equally well to every member of the population, in real time and on a continuous basis. For clinicians, integrated digitization offers the possibilities of streamlined administrative tasks and comprehensive views of their patients' journeys, improving delivery of care. For payers, digitization can improve the efficiency of reimbursements and reduce the possibility of duplicative or redundant services and claims.

In December 2021, the Digital Medicine Society and Moffitt Cancer Center convened over 40 multistakeholder experts, including patients, clinicians, researchers, regulators, payers, health care executives, policy makers, technology innovators, investors, and advocates for presentations and a roundtable discussion. Conversations addressed the current state of digital innovation in cancer care, identified root causes of challenges to digital health innovation in oncology, and described action-oriented approaches to collaborative solutions to be advanced by the workshop hosts and partners. This viewpoint summarizes these discussions and suggests avenues for future exploration.

The Digitization of Cancer Care: Opportunities and Obstacles

Cancer care is complex, often characterized by multiple interventions provided by a variety of providers over extended periods of time. This results in a high patient burden in the absence of support through care coordination. Additionally, oncology clinical pathways, intended to manage this complexity and support evidence-based care, improve outcomes, and contain costs, are not comprehensive enough and universally applied, leading to less-than-optimal clinical interventions despite clinicians' best intentions and efforts.

Effective cancer treatment, management, and research require the facile exchange of large amounts of data and information. But standardization of oncology data is impeded by how we measure disease progression, with the most important information often buried in images, narratives, and other unstructured data. The interoperability challenges that characterize our current health system have an outsized negative impact on patients with cancer due to the volume and complexity of oncology data. Patients often face delays in accessing essential cancer care due to challenges in accessing and aggregating all of their necessary medical records and health information. This forces patients with cancer and their care partners to do substantial work to get the care they need; it also can affect their treatment outcomes [27,28].

Patients with cancer and their care partners also need better, more accessible, and culturally competent information to better navigate their disease. Currently, most patients lack access to point-of-care educational materials designed to help them navigate the decisions they must make and access the emotional support they need as their disease evolves, resolves, or progresses. This includes end-of-life care. This unmet need for information is often compounded, particularly in the United States, by financial toxicity [29]—the problems a patient with cancer has related to the costs of their treatment—leaving significant gaps between our potential to care for people with cancer, their outcomes, and the reality of their lifetime cancer journeys.

Target Digital Innovation to Do the Greatest Good for Individuals With Cancer

Fit-for-purpose digital innovation offers the potential to bridge the gap between the reality of cancer care today and our vision

for caring for people with cancer in the future. Attendees of the roundtable agreed that digital innovation in oncology lags behind other therapeutic areas despite high unmet need. This lag was attributed to poor articulation of the challenges in cancer care and research best suited to digital solutions (Table 1), lack of incentives and support, and missing standardized infrastructure to implement digital innovations. We address these issues in the remainder of this piece.

Table 1. Persistent challenges in oncology that are highly suited for effective digital solutions.

Theme areas and topic	Challenges	Opportunities for digital innovation
Research and development		
End point measurement	Current *performance status measures* in oncology are subjective, episodic, and provide limited high-value information about a patient	Define and optimize a set of *core digital measures* that address unmet clinical need by accelerating the development of high-quality, relevant, trustworthy digital measures of performance status
QoL[a] measurement	Lack of *data on the impact of treatments on QoL* impedes optimal treatment decision-making	Develop digital *approaches to measuring the impact* of treatments on QoL
Scientific methods	*Lack of scientific methods* for evaluating digital solutions within the highly complex field of oncology	Develop and drive the broad adoption of standardized methodological approaches for digital oncology solutions
Clinical care		
Operational inefficiency	*Operational burden* associated with poorly coordinated clinical pathways in oncology has created ineffectiveness in care delivery	Leverage digital tools to *automate, augment, and streamline clinical operations* and decision support, making oncology care efficient so that dollars can be redeployed into direct care
Implementation barriers	Lack of clinician and health system confidence in digital innovation due to the *poorly implemented digital strategies* to date	Propose *implementation parameters* for deploying digital tools to support successful implementation in clinical care
Constrained capacity	Specialized *oncology workforce shortages and administrative burdens* delay necessary critical care [30,31]	*Modernize cancer care delivery* through *digitized capabilities* that reduce clinician administrative burden and free up capacity to provide timely necessary care to individuals with cancer
Care personalization and coordination		
Data integration	Myriad data sources generating *heterogeneous data* relevant to each patient's cancer journey impede optimized decision-making	Develop approaches to *data integration* that streamline and aggregate various data sets and touchpoints for precision insights and clinical decision-making
Data governance	Data liquidity is limited due to the *lack of governance models* to support trustworthy data exchange and authorized access	Develop frameworks [32,33] and *approaches for increasing data liquidity* through rapid, seamless, and transparent sharing and exchange of data for personalized cancer care
Inclusion	*Persistent inequities* in cancer risk, disease incidence and burden, and clinical outcomes	Deploy *inclusive approaches* to all digital solutions: leverage new digital solutions to access hard-to-reach and underserved populations and capture data on populations who have been previously invisible
Payer policy and reimbursement		
Financial toxicity	Widespread treatment-related *financial harm* [29]	Prioritize reducing barriers to financial *assistance and digitize* traditionally paper-based *applications* to minimize processing and review times
Payer innovation	Inadequate systemwide *payment structures* [34-36] inhibit development and adoption of digital solutions	Build evidence for payment innovation with the development of *novel incentive structures* to implement digital health technologies favoring value-based care
Engagement and education		
Engagement	Challenges dedicating resources to consistent, active, and *equitable engagement* of populations relative to their cancer risks or disease burden [37]	Build clear broadly accepted *strategies* for ongoing equitable *engagement and re-engagement* of patients at various stages of their cancer journey with the use of digital tools
Education	*Lack of resources* for patients and care partners to navigate treatment decision-making negatively impacts the care of individuals with cancer [38]	Use digital approaches to make culturally appropriate *education materials* accessible to all individuals who could benefit

[a]QoL: quality of life.

Effective digital solutions must focus on the full spectrum of each person's cancer journey, from reducing the risk of diagnosis to whole-person support of every individual with a cancer diagnosis, not just episodic care clinically focused on treating cancer once diagnosed. Digital solutions must be evaluated in a longitudinal manner, recognizing that their value may change with disease progression and a lifetime of different needs. Digital solutions must be created that are valuable and acceptable to every person, recognizing that every patient with cancer deserves culturally competent care. We also must recognize the needs of care partners throughout patients' cancer care journeys. There is no exception for these needs during advanced stages of disease and end-of-life care.

To place individuals living with cancer at the center of their care, digital solutions that support both privacy and information sharing should be prioritized. The health care delivery model should be reimagined, decentralizing it and moving the focus from the provider-centric facility-based health care model to a whole-person approach that meets patients wherever they may be.

Digitized decision-support systems offer the potential to deliver on the promise of oncology clinical pathways to improve outcomes and reduce costs. Further, they offer the possibility of removing disparities in outcomes between centers of excellence and community-based care settings by democratizing optimized decision-making. Tools that streamline data management in electronic health records and offer computerized clinical workflows could improve outcomes, efficiency, and provider satisfaction while minimizing the risk of harm. Addressing the needs and preferences of health care practices and clinicians must be considered integral to the success of any digital innovation and may be a target for many digital solutions.

To use research and development as an example, consider the use of biometric monitoring technologies. Before these technologies can be deployed in clinical research or practice, we must first consider the potential context of use. From the relevant health concept of interest identified, investigators can then develop potential metrics needed to measure this concept at baseline and over time. For geriatric oncology, contexts of use might include baseline frailty or electronic rapid fitness assessments and monitoring for adverse events or functional deterioration between clinic visits. The use of home-based electronic patient-reported outcomes monitoring is currently being evaluated for the latter purpose [39].

Whatever the outcomes used, they must be meaningful to patients. Cancer cachexia, for example, affects quality of life, treatment options, and mortality. Physical activity has been proposed as an outcome measure in cancer cachexia trials [40], but the gold standard for measurement of physical activity (eg, stable isotope studies) can be complex, expensive, and burdensome for patients. Digital health technologies are likely to offer advantages in situations such as this. In fact, a feasibility study showed near-universal acceptability to patients with cancer in wearing a small lightweight step monitor for a week [41]. The investigators noted strong correlations between step counts and both stepping and nonstepping energy expenditure [41]. Physical activity has also been shown to be correlated with

quality-of-life scores in patients with advanced cancer [42]. In addition, nutraceutical intervention has been shown to improve physical activity in patients with cachexia due to pancreatic cancer [43].

The use of digital technologies also offers an opportunity to increase the enrollment of patients with cancer into clinical trials. In a survey of more than 1100 patients who had been diagnosed with or treated for cancer in the past 7 years, up to 85% stated they would be more likely to enroll in clinical trials if the burdens on their time and travel were reduced, including through the use of remote technology and other tools to decentralize data gathering [44]. Their willingness varied depending on the type of decentralization: 67% said they would be more likely to enroll if offered intravenous trial medications administered by trial staff, whereas 82% said they would be more likely to sign up if they were offered wearable technology to gather trial data.

Delivering on the Promise of Digital Innovation to Advance a Better Approach to Cancer Care

For digital innovation to deliver on its potential to improve the lives of all people with cancer, we must prioritize the opportunities for greatest impact and consider equity and inclusion as givens when developing and deploying digital solutions, acknowledge and address the methodological gaps and absence of data infrastructure required for successful digital health innovation, and recognize that digital innovation in cancer care and research is not a silver bullet; we have rich flows of data and a powerful new suite of tools in the toolbox, but absent a human-centered approach with a focus on access, equity, efficiency, and effectiveness, digital tools are unlikely to be solutions for this disease that claims the lives of one in six people worldwide.

The National Cancer Act was passed in 1971 and has driven waves of improvements in the lives of people diagnosed with cancer. Earlier this year, the US government reignited the cancer "moonshot" [45], noting that the death rate from cancer has decreased by 25% over the past 25 years. Among new initiatives the administration touted were the National Institutes of Health (NIH) expansion of the Cancer Research Data Ecosystem, which supports better data sharing for treatment discovery [46]. The president also announced a new proposed entity within the NIH, the Advanced Research Projects Agency for Health. This agency, modeled after the Department of Defense's Advanced Research Project Agency, will have a singular purpose: to drive breakthroughs to prevent, detect, and treat diseases, including cancer [45]. The US Department of Agriculture is also working with the NIH to combine persistent poverty and cancer surveillance data to identify targets for intervention [46]. But without the intentional embrace of digital solutions that work for all individuals, we are likely to fall short of the promise of patient-, clinician-, and system-level transformation that well-implemented fit-for-purpose digital innovations offer.

There is no clinical or technical reason for the successful digitization of oncology to lag behind other therapeutic areas.

Digital innovation promises to support the development of more effective and equitable approaches to risk reduction, reduction of disease burden, accelerated research, and care that can scale. It is up to us, as a multistakeholder community, to identify the right problems in oncology to solve, to develop the science and infrastructure necessary to build trust, to support clinicians and practices through digital transformation with the appropriate resources, and to reimagine the systems of research and care necessary for digital approaches to truly transform the life of every person living with cancer.

Authors' Contributions

SP and JCG drafted the outline of the manuscript; all other authors reviewed and provided substantive comments. SP drafted the initial version of the manuscript with input from JCG and EJR. All other authors provided input and edits into the complete draft. The final draft for submission was prepared by SP and JCG and approved by all authors.

Conflicts of Interest

DLW-H works for the National Cancer Institute. WAW consults for Teladoc and Quantum Health and owns equity in Koneksa Research; he receives funding (paid to the institution) from Genentech and Pfizer and receives an honorarium from the ASH Research Collaborative. NP is an employee and shareholder in AstraZeneca pharmaceutical. The other authors have no conflicts to declare.

References

1. Bennett PN, Wang W, Moore M, Nagle C. Care partner: a concept analysis. Nurs Outlook 2017;65(2):184-194. [doi: 10.1016/j.outlook.2016.11.005] [Medline: 27993361]
2. Parikh RB, Basen-Enquist KM, Bradley C, Estrin D, Levy M, Lichtenfeld JL, et al. Digital health applications in oncology: an opportunity to seize. J Natl Cancer Inst 2022 Oct 06;114(10):1338-1339 [FREE Full text] [doi: 10.1093/jnci/djac108] [Medline: 35640986]
3. Charlton M, Schlichting J, Chioreso C, Ward M, Vikas P. Challenges of rural cancer care in the United States. Oncology (Williston Park) 2015 Sep;29(9):633-640 [FREE Full text] [Medline: 26384798]
4. Palmer NR, Kent EE, Forsythe LP, Arora NK, Rowland JH, Aziz NM, et al. Racial and ethnic disparities in patient-provider communication, quality-of-care ratings, and patient activation among long-term cancer survivors. J Clin Oncol 2014 Dec 20;32(36):4087-4094 [FREE Full text] [doi: 10.1200/JCO.2014.55.5060] [Medline: 25403220]
5. Loggetto P, Ritter J, Marx K, Metzger ML, Lam CG. Equity in national cancer control plans in the region of the Americas. Lancet Oncol 2022 May;23(5):e209-e217. [doi: 10.1016/S1470-2045(22)00057-2] [Medline: 35489352]
6. Turner T. Op-ed: Breast cancer is disproportionately killing Black women in Chicago: here's what needs to change. Chicago Tribune. 2022 Jan 04. URL: https://www.chicagotribune.com/opinion/commentary/ct-opinion-breast-cancer-black-women-disparity-20220104-t53seac33vgc3btjqd5xbnd7ya-story.html [accessed 2022-09-27]

XSL•FO
RenderX

7.   Tehranifar P, Neugut A, Phelan J, Link BG, Liao Y, Desai M, et al. Medical advances and racial/ethnic disparities in cancer survival. Cancer Epidemiol Biomarkers Prev 2009 Oct;18(10):2701-2708 [FREE Full text] [doi: 10.1158/1055-9965.EPI-09-0305] [Medline: 19789367]

8.   Penner LA, Dovidio JF, Gonzalez R, Albrecht TL, Chapman R, Foster T, et al. The effects of oncologist implicit racial bias in racially discordant oncology interactions. J Clin Oncol 2016 Aug 20;34(24):2874-2880 [FREE Full text] [doi: 10.1200/JCO.2015.66.3658] [Medline: 27325865]

9.   Freeman HP. Poverty, culture, and social injustice: determinants of cancer disparities. CA Cancer J Clin 2004;54(2):72-77 [FREE Full text] [doi: 10.3322/canjclin.54.2.72] [Medline: 15061597]

10. de Souza JA, Hunt B, Asirwa FC, Adebamowo C, Lopes G. Global health equity: cancer care outcome disparities in high-, middle-, and low-income countries. J Clin Oncol 2016 Jan 01;34(1):6-13 [FREE Full text] [doi: 10.1200/JCO.2015.62.2860] [Medline: 26578608]

11. Wakelee HA, Wang W, Schiller JH, Langer CJ, Sandler AB, Belani CP, Eastern Cooperative Oncology Group. Survival differences by sex for patients with advanced non-small cell lung cancer on Eastern Cooperative Oncology Group trial 1594. J Thorac Oncol 2006 Jun;1(5):441-446 [FREE Full text] [Medline: 17409897]

12. Zeng C, Wen W, Morgans AK, Pao W, Shu X, Zheng W. Disparities by race, age, and sex in the improvement of survival for major cancers: results from the National Cancer Institute Surveillance, Epidemiology, and End Results (SEER) program in the United States, 1990 to 2010. JAMA Oncol 2015 Apr;1(1):88-96 [FREE Full text] [doi: 10.1001/jamaoncol.2014.161] [Medline: 26182310]

13. Wolfson JA, Sun C, Wyatt LP, Hurria A, Bhatia S. Impact of care at comprehensive cancer centers on outcome: results from a population-based study. Cancer 2015 Nov 01;121(21):3885-3893 [FREE Full text] [doi: 10.1002/cncr.29576] [Medline: 26218755]

14. Shankaran V, Unger J, Darke A, Suga JM, Wade JL, Kourlas PJ, et al. S1417CD: a prospective multicenter cooperative group-led study of financial hardship in metastatic colorectal cancer patients. J Natl Cancer Inst 2022 Mar 08;114(3):372-380. [doi: 10.1093/jnci/djab210] [Medline: 34981117]

15. Carrera PM, Kantarjian HM, Blinder VS. The financial burden and distress of patients with cancer: understanding and stepping-up action on the financial toxicity of cancer treatment. CA Cancer J Clin 2018 Mar;68(2):153-165 [FREE Full text] [doi: 10.3322/caac.21443] [Medline: 29338071]

16. Knight TG, Deal AM, Dusetzina SB, Muss HB, Choi SK, Bensen JT, et al. Financial toxicity in adults with cancer: adverse outcomes and noncompliance. J Oncol Pract 2018 Oct 24:JOP1800120. [doi: 10.1200/JOP.18.00120] [Medline: 30355027]

17. Zini EM, Lanzola G, Quaglini S, Bossi P, Licitra L, Resteghini C. A pilot study of a smartphone-based monitoring intervention on head and neck cancer patients undergoing concurrent chemo-radiotherapy. Int J Med Inform 2019 Sep;129:404-412. [doi: 10.1016/j.ijmedinf.2019.06.004] [Medline: 31445284]

18. Tran C, Dicker A, Leiby B, Gressen E, Williams N, Jim H. Utilizing digital health to collect electronic patient-reported outcomes in prostate cancer: single-arm pilot trial. J Med Internet Res 2020 Mar 25;22(3):e12689 [FREE Full text] [doi: 10.2196/12689] [Medline: 32209536]

19. Ciani O, Cucciniello M, Petracca F, Apolone G, Merlini G, Novello S, et al. Lung Cancer App (LuCApp) study protocol: a randomised controlled trial to evaluate a mobile supportive care app for patients with metastatic lung cancer. BMJ Open 2019 Feb 15;9(2):e025483. [doi: 10.1136/bmjopen-2018-025483] [Medline: 30772862]

20. Min YH, Lee JW, Shin Y, Jo M, Sohn G, Lee J, et al. Daily collection of self-reporting sleep disturbance data via a smartphone app in breast cancer patients receiving chemotherapy: a feasibility study. J Med Internet Res 2014 May 23;16(5):e135 [FREE Full text] [doi: 10.2196/jmir.3421] [Medline: 24860070]

21. Eliasen A, Abildtoft MK, Krogh NS, Rechnitzer C, Brok JS, Mathiasen R, et al. Smartphone app to self-monitor nausea during pediatric chemotherapy treatment: user-centered design process. JMIR Mhealth Uhealth 2020 Jul 20;8(7):e18564 [FREE Full text] [doi: 10.2196/18564] [Medline: 32706744]

22. Benze G, Nauck F, Alt-Epping B, Gianni G, Bauknecht T, Ettl J, et al. PROutine: a feasibility study assessing surveillance of electronic patient reported outcomes and adherence via smartphone app in advanced cancer. Ann Palliat Med 2019 Apr;8(2):104-111. [doi: 10.21037/apm.2017.07.05] [Medline: 29156896]

23. Kim J, Lim S, Min YH, Shin Y, Lee B, Sohn G, et al. Depression screening using daily mental-health ratings from a smartphone application for breast cancer patients. J Med Internet Res 2016 Aug 04;18(8):e216 [FREE Full text] [doi: 10.2196/jmir.5598] [Medline: 27492880]

24. Lalloo C, Jibb LA, Rivera J, Agarwal A, Stinson JN. "There's a Pain App for That": review of patient-targeted smartphone applications for pain management. Clin J Pain 2015 Jun;31(6):557-563. [doi: 10.1097/AJP.0000000000000171] [Medline: 25370138]

25. Lee JH, Jeong JH, Ji W, Lee HJ, Lee Y, Jo M, et al. Comparative effectiveness of smartphone healthcare applications for improving quality of life in lung cancer patients: study protocol. BMC Pulm Med 2022 May 02;22(1):175 [FREE Full text] [doi: 10.1186/s12890-022-01970-8] [Medline: 35501757]

26. McCaughan E, Parahoo K, Hueter I, Northouse L, Bradbury I. Online support groups for women with breast cancer. Cochrane Database Syst Rev 2017 Mar 10;3(3):CD011652 [FREE Full text] [doi: 10.1002/14651858.CD011652.pub2] [Medline: 28278559]

27. Jung SY, Sereika SM, Linkov F, Brufsky A, Weissfeld JL, Rosenzweig M. The effect of delays in treatment for breast cancer metastasis on survival. Breast Cancer Res Treat 2011 Dec;130(3):953-964. [doi: 10.1007/s10549-011-1662-4] [Medline: 21739101]

28. Coca-Pelaz A, Takes RP, Hutcheson K, Saba NF, Haigentz M, Bradford CR, et al. Head and neck cancer: a review of the impact of treatment delay on outcome. Adv Ther 2018 Feb;35(2):153-160. [doi: 10.1007/s12325-018-0663-7] [Medline: 29396681]

29. Zafar SY. Financial toxicity of cancer care: it's time to intervene. J Natl Cancer Inst 2016 May;108(5):djv370. [doi: 10.1093/jnci/djv370] [Medline: 26657334]

30. Health and Social Care Committee. Cancer services: twelfth report of session 2021–22. United Kingdom Parliament. 2022 Apr 05. URL: https://publications.parliament.uk/pa/cm5802/cmselect/cmhealth/551/report.html [accessed 2022-09-27]

31. Campbell D. NHS England waiting times for cancer referral and treatment at record high. The Guardian. 2022 Feb 06. URL: https://www.theguardian.com/society/2022/feb/06/nhs-england-waiting-times-for-cancer-referral-and-treatment-at-record-high [accessed 2022-09-27]

32. Kean MA, Abernethy AP, Clark AM, Dalton WS, Pollock BH, Shulman LN, et al. Achieving data liquidity in the cancer community: proposal for coalition of all stakeholders. National Academy of Medicine. 2012 May 11. URL: https://nam.edu/perspectives-2012-achieving-data-liquidity-in-the-cancer-community-proposal-for-coalition-of-all-stakeholders/ [accessed 2022-10-03]

33. Boja E, Chandramouliswaran I. Breaking down barriers to sharing cancer data—The NIH Generalist Repository Ecosystem Initiative. National Cancer Institute: Center for Biomedical Informatics and Information Technology. 2022 Sep 08. URL: https://datascience.cancer.gov/news-events/blog/breaking-down-barriers-sharing-cancer-data-nih-generalist-repository-ecosystem [accessed 2022-10-03]

34. Areia M, Mori Y, Correale L, Repici A, Bretthauer M, Sharma P, et al. Cost-effectiveness of artificial intelligence for screening colonoscopy: a modelling study. Lancet Digit Health 2022 Jun;4(6):e436-e444 [FREE Full text] [doi: 10.1016/S2589-7500(22)00042-5] [Medline: 35430151]

35. Cardoso F, MacNeill F, Penault-Llorca F, Eniu A, Sardanelli F, Nordström EB, et al. Why is appropriate healthcare inaccessible for many European breast cancer patients? - The EBCC 12 manifesto. Breast 2021 Feb;55:128-135 [FREE Full text] [doi: 10.1016/j.breast.2020.12.010] [Medline: 33461060]

36. Mehlis K, Witte J, Surmann B, Kudlich M, Apostolidis L, Walther J, et al. The patient-level effect of the cost of cancer care - financial burden in German cancer patients. BMC Cancer 2020 Jun 05;20(1):529 [FREE Full text] [doi: 10.1186/s12885-020-07028-4] [Medline: 32503459]

37. Baird A. Re-engaging EU citizens with national screening programmes and cancer diagnosis post-pandemic. Lancet Oncol 2022 May;23(5):566-567 [FREE Full text] [doi: 10.1016/S1470-2045(22)00090-0] [Medline: 35489337]

38. Casolino R, Braconi C, BABEL working group of the COST Action 18122 (EURO-CHOLANGIO-NET), part of the European Network for the Study of Cholangiocarcinoma. Bridging the equity gap in patient education: the biliary tract cancer BABEL project. Lancet Oncol 2022 May;23(5):568-570. [doi: 10.1016/S1470-2045(22)00143-7] [Medline: 35489338]

39. Shahrokni A, Loh KP, Wood WA. Toward modernization of geriatric oncology by digital health technologies. Am Soc Clin Oncol Educ Book 2020 Mar;40:1-7 [FREE Full text] [doi: 10.1200/EDBK_279505] [Medline: 32243198]

40. Mantovani G, Madeddu C, Serpe R. Improvement of physical activity as an alternative objective variable to measure treatment effects of anticachexia therapy in cancer patients. Curr Opin Support Palliat Care 2010 Dec;4(4):259-265. [doi: 10.1097/SPC.0b013e32833b35c0] [Medline: 20531198]

41. Maddocks M, Byrne A, Johnson CD, Wilson RH, Fearon KCH, Wilcock A. Physical activity level as an outcome measure for use in cancer cachexia trials: a feasibility study. Support Care Cancer 2010 Dec;18(12):1539-1544. [doi: 10.1007/s00520-009-0776-2] [Medline: 19956982]

42. Dahele M, Skipworth RJ, Wall L, Voss A, Preston T, Fearon KC. Objective physical activity and self-reported quality of life in patients receiving palliative chemotherapy. J Pain Symptom Manage 2007 Jun;33(6):676-685 [FREE Full text] [doi: 10.1016/j.jpainsymman.2006.09.024] [Medline: 17360150]

43. Moses AWG, Slater C, Preston T, Barber MD, Fearon KCH. Reduced total energy expenditure and physical activity in cachectic patients with pancreatic cancer can be modulated by an energy and protein dense oral supplement enriched with n-3 fatty acids. Br J Cancer 2004 Mar 08;90(5):996-1002 [FREE Full text] [doi: 10.1038/sj.bjc.6601620] [Medline: 14997196]

44. Adams DV, Long S, Fleury ME. Association of remote technology use and other decentralization tools with patient likelihood to enroll in cancer clinical trials. JAMA Netw Open 2022 Jul 01;5(7):e2220053 [FREE Full text] [doi: 10.1001/jamanetworkopen.2022.20053] [Medline: 35788672]

45. Remarks by President Biden at an event to reignite the cancer moonshot. The White House. 2022 Feb 02. URL: https://tinyurl.com/ymjb9rb8 [accessed 2022-09-27]

46. Biden's $2B biotech, biomanufacturing plan – here's what in it. WRAL TechWire. 2022 Sep 21. URL: https://wraltechwire.com/2022/09/21/bidens-2b-biotech-biomanufacturing-plan-heres-what-in-it/ [accessed 2022-10-04]

XSL•FO

RenderX

Abbreviations

NIH: National Institutes of Health

XSL•FO
RenderX