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Using information technology in the assessment and monitoring of geriatric oncology patients

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Abstract

Purpose of review—Older adults with cancer have complex medical needs and often experience higher rates of treatment-related toxicities compared to their younger counterparts. The advent of health information technologies can address multiple gaps in the care of this population. We review the role of existing and emerging technologies in facilitating the use of comprehensive geriatric assessment (CGA) in routine clinics, promoting symptom reporting, and monitoring medication adherence.

Recent findings—Increasingly studies demonstrate the feasibility of implementing electronic CGA in routine oncology practices. Evidence also suggests that electronic symptom reporting can improve outcomes in patients with cancer. In addition, technology devices can be used to promote adherence to cancer therapy.

Summary—There are many opportunities for information technology to be integrated into the management and treatment of older adults with cancer. However, further evaluation of these technologies is needed to ensure that they meet the needs of the targeted end-users.

Keywords

Information technology; symptom monitoring; medication adherence; geriatric assessment

Introduction

Cancer is a disease of aging, and the majority of cancer cases are diagnosed in older adults [1]. Older patients with cancer are at increased risk of treatment-related toxicity and other adverse outcomes including hospitalizations, functional and cognitive decline, and death [2–6]. They are also largely excluded from oncology clinical trials, limiting generalizability of available data [7]. Given their complex medical needs and the lack of evidence-based data to

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guide management, the care of older adults with cancer is often challenging, requiring coordination of multiple healthcare teams and caregivers.

To maximize outcomes for older adults with cancer, it is important to identify individual needs and underlying impairments in order for healthcare professionals to assist with decision-making and guide supportive interventions during treatment [2]. A comprehensive geriatric assessment (CGA) can be helpful in this setting.[8] CGA is a set of validated tools to assess domains such as physical function, nutritional status, medications, social support, cognitive function, and psychological health [9]. Studies have shown that a CGA provides a more accurate determination of functional age in older patients with cancer compared to chronological age or physician-assigned performance status alone [2]. A CGA has also been shown to predict risk of severe chemotherapy toxicity in older adults [2, 10]. For example, the presence of hearing impairment on a CGA was shown to predict grade 3–5 toxicities in older patients receiving chemotherapy, suggesting that the ability to receive and adhere to treatment plan recommendations (such as appropriate use of supportive care medications) can significantly impact outcomes. Older adults also have a higher prevalence of depression, anxiety and cognitive impairment compared to younger patients, which is associated with underreporting of symptoms and medication non-adherence [11–13]. Medication adherence and symptom reporting are both potentially modifiable risk factors for adverse events in older adults with cancer, but data on interventions to address these factors are very limited.

Both the National Comprehensive Cancer Network (NCCN) and International Society of Geriatric Oncology (SIOG) recommend that all older adults with cancer should routinely undergo a CGA to assist with treatment decision-making [14, 15]. However, the time and resources required to incorporate a CGA into clinic visits remain the primary barriers for implementation. Therefore, there is a need to increase the adoption of CGA among general oncologists and to address the associated resource limitations.

The advent of health information technologies can address multiple gaps in the care of older adults with cancer. Studies suggest that the uptake of technologies among older adults is rising, although it still lags behind that of younger adults. According to the Pew Research Center, the percentage of older adults who reported using the internet increased from 14% in 2010 to 58% in 2015 [16]. In the National Health and Aging Trends Study, 64% and 76% of older adults used computers and cellphones, respectively [17]. From 2011 to 2014, an increasing number of older adults used technologies to obtain health information (16% to 18%), fill prescriptions (8% to 10%) and contact clinicians (7% to 12%). Some potential applications are shown in Table 1 [18]. With the increasing adoption of technologies in older adults and the aging of the baby boomer generation, the use of technology applications for health purposes is likely to increase, thus targeting aging specific issues (Table 2). In this paper, we review the role of existing and emerging technologies in facilitating the use of CGA, enhancing patient reporting of symptoms, and medication adherence.

Using electronic geriatric assessment to guide decision-making and interventions

Oncologists routinely use performance status scales to guide management in patients with cancer. The most commonly used scales are the Eastern Cooperative Oncology Group (ECOG) score and Karnofsky Performance Scale (KPS) Index [19, 20]. Both of these scales are based on physician's perception of a patient's functionality. Although they are highly prognostic, they do not accurately predict treatment tolerance and toxicity [2]. On the other hand, CGA domains such as functional and cognitive impairment, weight loss, lack of social support and increased comorbidity burden are associated with treatment toxicity [2, 10, 21–23]. Depression, polypharmacy, and burden of symptoms, in addition to the aforementioned domains, are also associated with poorer overall survival [24–28]. For older patients with cancer undergoing surgery, CGA domains also predict a higher risk of post-operative complications, hospitalizations and mortality [29–31]. Despite the value of CGA for predicting adverse outcome, only 19% of community oncologists reported using it in routine practice [32, 78]. The lack of success is partially due to the time and resources needed for incorporation of a CGA into clinic visits; the addition of even 5–10 more minutes can be challenging in clinical practice. The mean time for CGA completion for both physician or physician designee (i.e., staff, nurse) and patient is 24 minutes (physician: 7 minutes; patient: 17 minutes) [9, 33]. There is also a lack of guidance for general oncologists on how to tailor treatment based on the CGA information, as most are not trained to interpret these data, and clinical trials evaluating CGA-based interventions are ongoing. Referring all older patients to a geriatric oncologist or a geriatrician is not practical given the limited number of these experts, and most institutions do not have these resources available.

The use of an electronic CGA may potentially address some of these gaps. In a feasibility study, Hurria and colleagues administered a CGA to 100 older patients with solid tumors (median age=71 years) via a virtual web server developed at City of Hope [34]. Patients completed the CGA using a touchscreen technology (iPad). Compared to the conventional method, no significant differences in the completion times were found with the electronic CGA (median 15 vs. 16 minutes; P=0.50). However, almost two-thirds of the patients reported that they preferred the electronic system versus the conventional method, and fewer than 10% required assistance using it. In a similar study conducted in a group of patients with hematologic malignancies reported by Bhatt and Colleagues, 97% required no assistance when electronic CGA was administered using an iPad [35]. However, the mean time required to complete the patient portion of the CGA was 36 minutes.

A third study by McCleary and colleagues assessed the feasibility of a computer-based CGA in 38 older patients (median age=77 years) with gastrointestinal cancer [36]. All of the CGA domains were self-administered and were performed in clinic prior to their provider visit or during chemotherapy infusion. A research assistant was available to help if needed. The CGA was not integrated into the EMR. The authors reported that 49% of patients required assistance completing the CGA (in contrast to less than 10% in the aforementioned two studies) due to lack of computer familiarity or needing assistance with the computer mouse. Median time to completion was 23 minutes.

Although both studies by Hurria and Bhatt failed to demonstrate reduced completion time using the electronic CGA, they prove its feasibility in older patients with cancer and introduce the potential for a home-based CGA. Oncologists can then review this prior to in-person clinic visits. The difference in median time to completion of CGA is likely secondary to the varying number of self-reported vs. objective assessments included. The study by McCleary and colleagues also highlights the importance of the usability of a technology device in the older population. The Alliance A171603 study is currently ongoing to determine the feasibility of electronic CGA in both academic and community clinics. However, the tool is currently not integrated into the electronic medical record (EMR). This is an important consideration in the design of any electronic assessment and reporting tools given the widespread adoption of EMR by office-based physicians. Integration of CGA into the EMR allows these variables to be captured easily in the clinic notes and provides the ability to track outcomes over a period of time for quality improvement and health services research.

Shahrokni and colleagues at Memorial Sloan Kettering Cancer Center developed an abbreviated version of the electronic CGA known as the Electronic Rapid Fitness Assessment (eRFA) for older patients with cancer [37]. They tested this tool in 1024 older patients with cancer (mean age=80 years). Of these, 636 patients were referred for pre-operative evaluation. The eRFA is partially integrated with the EMR where patients' information and their medical record number are pulled from the EMR when questionnaires are generated. Patients then complete the CGA on computers, tablets, or smartphones either at home or prior to being seen in the clinic, and physicians are able to copy and paste the report into their clinic notes. The authors reported that the median time to completion of the eRFA was 11 minutes. Thirty-seven percent required assistance and 59% completed the assessment at home. This study supports the feasibility of an electronic CGA and provides a stepping-stone to the development of an electronic CGA. A CGA that is electronic and integrated to the EMR provides for easy data capturing and accessibility outside of a clinical encounter.

In multiple myeloma, there is an ongoing study assessing the use of a touchscreen tablet-based brief geriatric assessment in older patients and its influence on decision-making (NCT03068637). The brief geriatric assessment collects information on comorbidities, activities of daily living (ADLs) and instrumental activities of daily living (IADLs), and categorized patients as frail, intermediate or fit. Preliminary findings showed that it is feasible, usable and acceptable to older patients with multiple myeloma, and that influences decision-making more than half of the time [38].

At the University of Rochester, we are in the process of integrating the CGA into our EMR (Epic by Epic Systems Corporation, Wisconsin). The goal is to facilitate completion of the CGA by patients via the EMR patient portal, thereby allowing physicians to review these remotely prior to the clinical encounters. For oncologists who do not have access to experts in geriatric oncology, the ability to review data remotely will also promote the platform for telehealth encounters and e-consults. Automated decision support tools to assist with interpretation of CGA and targeted recommendations may also be integrated into the system,

therefore overcoming the challenge with data interpretation. If successful, this will promote the uptake of CGA in routine oncology care.

Symptom reporting and management

Older patients can derive the same benefits from cancer treatments but even those in the fittest group who are typically enrolled on oncology treatment trials experience increased toxicity [39–42]. In addition, older patients are more likely to under-report symptoms such as pain, as they may view these as a normal part of aging or worry that their oncologist may discontinue treatment [43, 44]. Symptoms may also be under reported due to cognitive impairment and depression, both of which are prevalent in older adults. Patients may forget to mention the side effects that they experience early in the chemotherapy cycle that have since resolved, and thus may benefit from close and continuous monitoring of symptoms related to their underlying cancer and cancer treatment. Identifying toxicities early in the treatment course allows oncologists to intervene by adding or increasing supportive care medications, modifying the chemotherapy dose, referring to the appropriate specialists such as a palliative care provider and potentially a reduction in hospitalizations and ED visits.

To allow for continuous symptom monitoring, a number of electronic patient-reported outcome (PRO) systems have been developed and shown to be feasible for use in the clinical care setting. A 2014 meta-analysis identified 33 PRO systems that have been designed for patients with cancer [45]. Six systems were excluded from the analysis as the system features were not provided. Of the 27 systems, breast, prostate, gastrointestinal, gynecological and lung were the most common cancer subtypes included. Eight PRO systems monitor symptoms during active cancer treatment, and eleven capture data across treatment and survivorship periods. Most systems (78%) are designed for use in medical oncology clinics, and a majority are computer (63%) and tablet-based (52%) systems. The PRO systems differ in function and design, with various systems having the ability to be accessed from home and the clinic (33% from home, 30% from clinic and 37% from both) and some generating alerts and reports for physicians (67%), staff (59%), patients (29%) and caregivers (11%). Twelve systems were linked to an EMR. PRO reports were accessible immediately in 70%, and 93% displayed current as well as longitudinal PRO scores. Clinical responses to the PRO reporting most commonly included healthcare team follow-up (74%) and patient education (26%).

Two examples of PRO systems that have been tested in randomized clinic trials of patients with cancer, but are not specific for older patients, are the Symptom Tracking and Reporting (STAR) and advanced symptom management systems (ASyMS). STAR is a web-based interface developed at Memorial Sloan Kettering Cancer Center to monitor patient symptoms during chemotherapy, and is primarily used for detection and communication of serious adverse events during clinical trials [46]. The platform includes a simple data entry interface, real-time report generation, and an alert system to e-mail clinicians when patients self-report serious toxicities. This PRO system is not integrated into the EMR. In the study, 766 patients were divided into subgroups based on level of prior computer and email use. The median age of the patients in the computer-experienced and –inexperienced groups were 60 (range 26–85) and 67 (range 38–91) years, respectively. Compared to the usual care

group, patients who used the system had better health-related quality of life, fewer emergency room visits and fewer hospitalizations. They also received a longer duration of palliative chemotherapy (mean, 8.2 vs. 6.3 months, P=0.002) and had superior overall survival (mean, 31.2 vs. 26.0 months, P=0.03) [46, 47]. The benefits were seen in both computer-experienced and -inexperienced groups, but greater in those lacking prior computer experience. The authors hypothesized that inexperienced computer users may have less-developed health communication skills and a structured program for eliciting symptoms thus benefitted them more, but this needs further investigation. The authors did not provide a breakdown of the age groups of patients in the study and therefore the differential effects on younger and older patients are unclear.

ASyMS is a mobile phone-based remote symptom monitoring and management system that enables patients to track symptoms and quality of life and report these to their clinical teams [48]. Patients also instantly receive tailored self-care advice for managing chemotherapy side effects. The mobile application provides valuable support to patients on chemotherapy for symptom management and also improves patient-provider communication [48, 49]. In a study of 112 patients with breast, lung or colorectal cancer receiving outpatient chemotherapy (median age 56, SD 10.5; 28% received 5-flurouracil, epirubicin and cyclophosphamide, 20% received doxorubicin and cyclophosphamide) evaluating the effect of ASyMS on six common chemotherapy-related symptoms (nausea, vomiting, fatigue, mucositis, hand-foot syndrome and diarrhea), those who were randomized to the ASyMS arm reported less fatigue (67% vs. 81%, p=0.04) and hand-foot syndrome (12% vs. 24%, p=0.03) compared to the usual care arm. Similar to the prior study, the effects of the intervention by age groups were not provided. A larger study is currently ongoing to assess the effects of ASyMS on symptom burden, quality of life, supportive care needs, anxiety, self-care, self-efficacy, work limitations and cost effectiveness [50].

The benefits of these systems include the ability to electronically collect, store, and report PRO data in real time. However, the availability of a variety of PRO systems makes it challenging for oncologists to select one, and the logistics of integrating a PRO system into routine oncology workflow needs to be studied further. In older patients who live alone, the ability for caregivers to remotely monitor these symptoms is important to enhance caregiver engagement, although there are limited studies on this. In addition to symptom monitoring, collecting longitudinal geriatric assessment as part of PROs may provide valuable information in older patients as a comprehensive symptom assessment is not routinely incorporated into CGA.

Medication adherence

There is a growing use of oral cancer agents due to their efficacy, ease of administration, patient preference, increased availability and perceived better tolerability [51]. However, ensuring adherence to oral cancer agents is more challenging compared to parenteral therapy. Ensuring adherence to supportive care medications is also important to reduce treatment-related toxicities. Multiple studies have demonstrated that adherence rates to oral chemotherapies in the cancer population ranged from 46% to 80% in all patients [52–54]. In older adults, several factors contribute to medication non-adherence. For example, older

adults are less likely than younger adults to ask questions about cancer therapies,[41] leading providers to assume they have a better grasp of how and why to take their medications than they may actually have; cognitive impairment (present in about 25–47% of older patients with cancer)[55, 56] and hearing loss (present in 25% of older patients with cancer)[2] can magnify this issue. Older patients often have difficulties with transportation, leading to missed appointments or unfilled prescriptions [57, 58]. Older patients have more comorbidities, putting them at increased risk of side effects and hospitalizations that lead to non-adherence [59, 60]. Polypharmacy, partially a result of comorbidity burden, is independently associated with non-adherence [61]. In the general geriatric population, 22% to 39% of older adults are on 5 or more medications, and in the older cancer population, prevalence of polypharmacy varies from 11% to 96% [62]. A retrospective study demonstrated that patients with breast cancer who were non-adherent to their chronic medications were associated with an increased risk for non-adherence to oral hormonal therapy, which suggests the potential need for intervention in this group of patients [63]. Non-adherence correlates with worse outcomes in cancer and other chronic conditions [64, 65]. Given increased risk of non-adherence in older patients with cancer on oral therapies, improved monitoring of treatment adherence may improve outcomes.

Interventions to promote medication adherence have been studied extensively in other chronic illnesses. In a systematic review, multicomponent interventions were identified to be most effective [66]. These interventions included patient education and counseling in combination with other interventions, such as reminder devices, prefilled medications in blister packaging, automated telephone calls for missed doses or refills, and physician or patient feedback. Some of these interventions may be achieved through smartphones, text messaging, computer or tablet devices. Applications available on electronic devices can compile adherence reports, contain photos to help with identification and promote medication management [66, 67].

In 2017, the International Society of Geriatric Oncology (SIOG) published its recommendations on adherence to oral cancer therapy in older adults [68]. In line with the aforementioned systematic review, SIOG recommends that an integrated multicomponent intervention should be considered that includes patient education, monitoring and support. The society also recommends that technological methods such as audio-visual or text messaging, electronic mail and other automated alert systems may be used to promote adherence of oral cancer agents in older adults.

Two examples of technology devices that have been studied in the cancer population are the Medication Event Monitoring Systems (MEMS®) and GlowCap© [13, 69, 70]. The MEMS® is a medication bottle cap that keeps a record of the time and date the medication bottle is opened and closed, and this information can be assessed remotely using a mobile technology. GlowCap© is comprised of a cap and a bottle [71]. Similar to MEMS®, GlowCap© allows remote monitoring of adherence and provides reminder alerts. In a study of patients with gastrointestinal stromal tumors, the adherence rate to imatinib was 83% in the patients assigned to the GlowCap© group compared to 73.3% in the control group [72].

Design Considerations for Older Adults

To increase the feasibility of technology devices for capturing patient-reported outcomes in older adults, the design of these devices needs to be tailored to the needs of the population. Rogers and colleagues proposed that successful design of technology depends on the match between the capabilities of the user and both the demands imposed by the system and of the task being performed [73]. It is important to understand age-related changes in motor control, perceptual function, and cognitive abilities when designing a system for older adults [73]. For example, using audio prompts to encourage symptom reporting using a technology device will likely be more effective in older adults with vision impairment but not in those with hearing impairment, who will benefit more from image or video prompts. The font size should also be appropriately large. For older adults who are health illiterate, picture and picture symbols can be more effective than words. A number of functions may also be considered when technology devices are designed for older adults. For example, the ability for older adults to record questions on the application so they can access these questions in future clinic visits. They will also benefit from the ability to access an up-to-date medication list from the technology device. Both of these functions will be very helpful especially in older adults on multiple medications or those with memory concerns.

Although studies are limited in older adults with cancer, the use of technology devices to assist with care has been investigated for older adults with other chronic illnesses. For example, one study in older adults with heart failure utilized a wireless wristwatch monitoring device that continuously collected temperature and motion data and a tablet device to track their weight and blood pressure. The adherence rate to the technology devices was at least 75%. A number of issues were identified including a small power button that was difficult for older adults to find and unreliable Wi-Fi hotspots that made it difficult for older adults to connect the devices to the internet [74]. A systematic review that included 92 studies evaluating fall detection devices identified other challenges including subjects not remembering to use/wear the device, short battery power and intrusiveness [75]. These studies emphasize the importance of needs assessment with the patients, reliable cellular connectivity if real-time information is required and a simple and user-friendly design in technology devices. At our institution, we are currently conducting a pilot feasibility study to assess the use of a tablet-based system in the care of older patients with cancer receiving treatment. The system enables remote monitoring of symptoms and medication adherence by the providers as well as the caregivers. The tablet-based system consists of a touchscreen tablet with a stylus attached (for older adults who prefer tactile feedback) and has a reliable data plan for Internet access. It also provides visual prompts in writing with large font size and audio prompts with adjustable volume. All of these functions and design considerations may make older adults more amenable to using a technology device.

Research gaps

Many gaps remain in our understanding of the use of information technologies in older adults with cancer. First, existing studies on the use of information technology in cancer care were not limited to older adults, and therefore not focused on age-related changes in perceptual, cognitive, and motor systems which would impact uptake of the tools by older

adults with cancer [76]. Continuous needs assessment is crucial to understand older adults' heterogeneous spectrum of capabilities and barriers to the use of technology devices due to underlying health status, health literacy and cognition so these can be tailored and individualized. Second, studies should focus on how interventions can promote and increase the uptake of the use of information technology tools in older adults, potentially through education and peer motivation. Third, randomized controlled trials need to investigate if older adults will derive the same benefits compared to their younger counterparts by conducting age-specific analyses when information technologies are incorporated in their care; for these studies, outcomes important to older adults such as quality of life should be included.

Conclusions

In summary, information technology can be used to assess and monitor older adults undergoing cancer treatments. Specifically, an increasing number of studies has demonstrated both the feasibility and the benefits of using technology devices in delivering CGA to assist with decision-making and intervention, monitoring symptoms and medication adherence. With the increasing complexity of cancer care, there are many opportunities for information technology to be integrated into the management of older adults with cancer. However, these technology devices need to be carefully studied in older adults with cancer to accommodate the unique needs of this population.

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References

1. Berger NA, Savvides P, Koroukian SM, Kahana EF, Deimling GT, Rose JH, Bowman KF, Miller RH. Cancer in the Elderly. Trans Am Clin Climatol Assoc. 2006; 117:147–156. [PubMed: 18528470]
2. Hurria A, Togawa K, Mohile SG, et al. Predicting chemotherapy toxicity in older adults with cancer: a prospective multicenter study. J Clin Oncol Off J Am Soc Clin Oncol. 2011; 29:3457–3465.
3. Mandilaras V, Wan-Chow-Wah D, Monette J, Gaba F, Monette M, Alfonso L. The impact of cancer therapy on cognition in the elderly. Front Pharmacol. 2013; 4:48. [PubMed: 23626575]
4. Repetto L. Greater risks of chemotherapy toxicity in elderly patients with cancer. J Support Oncol. 2003; 1:18–24. [PubMed: 15346996]
5. Loh KP, Janelsins MC, Mohile SG, et al. Chemotherapy-related cognitive impairment in older patients with cancer. J Geriatr Oncol. 2016; 7:270–280. [PubMed: 27197918]
6. Karuturi M, Wong ML, Hsu T, et al. Understanding cognition in older patients with cancer. J Geriatr Oncol. 2016; 7:258–269. [PubMed: 27282296]
7. Herrera AP, Snipes SA, King DW, Torres-Vigil I, Goldberg DS, Weinberg AD. Disparate Inclusion of Older Adults in Clinical Trials: Priorities and Opportunities for Policy and Practice Change. Am J Public Health. 2010; 100:S105–S112. [PubMed: 20147682]

8. Loh KP, Soto-Perez-de-Celis E, Hsu T, de Glas NA, Battisti NML, Capucine B, Rodrigues M, Lichtman SM, Wildiers H. What every oncologist should know about geriatric assessment for older patients with cancer: Young SIOG position paper. J Oncol Pract. In Press.
9. Hurria A, Gupta S, Zauderer M, et al. Developing a cancer-specific geriatric assessment: a feasibility study. Cancer. 2005; 104:1998–2005. [PubMed: 16206252]
10. Extermann M, Boler I, Reich RR, et al. Predicting the risk of chemotherapy toxicity in older patients: the Chemotherapy Risk Assessment Scale for High-Age Patients (CRASH) score. Cancer. 2012; 118:3377–3386. [PubMed: 22072065]
11. Brody EM, Kleban MH. Physical and mental health symptoms of older people: who do they tell? J Am Geriatr Soc. 1981; 29:442–449. [PubMed: 7276408]
12. Broderick JE, Schwartz JE, Vikingstad G, Pribbernow M, Grossman S, Stone AA. The accuracy of pain and fatigue items across different reporting periods. Pain. 2008; 139:146–157. [PubMed: 18455312]
13. Bender CM, Gentry AL, Brufsky AM, et al. Influence of Patient and Treatment Factors on Adherence to Adjuvant Endocrine Therapy in Breast Cancer. Oncol Nurs Forum. 2014; 41:274–285. [PubMed: 24769592]
14. Extermann M, Aapro M, Bernabei R, et al. Use of comprehensive geriatric assessment in older cancer patients: recommendations from the task force on CGA of the International Society of Geriatric Oncology (SIOG). Crit Rev Oncol Hematol. 2005; 55:241–252. [PubMed: 16084735]
15. The National Comprehensive Cancer Network®. [Accessed 09 January 16] Older Adult Oncology: NCCN Guidelines. 2015. [ONLINE] Available at: http://www.nccn.org/professionals/physician_gls/pdf/senior.pdf
16. Pew Research Center. Americans' Internet AccessL 2000–2015. 2015 Jun. Available at: http://www.pewinternet.org/2015/06/26/americans-internet-access-2000-2015/
17. Levine DM, Lipsitz SR, Linder JA. Trends in seniors' use of digital health technology in the united states, 2011–2014. JAMA. 2016; 316:538–540. [PubMed: 27483069]
18. Clauser SB, Wagner EH, Bowles EJA, Tuzzio L, Greene SM. Improving Modern Cancer Care Through Information Technology. Am J Prev Med. 2011; 40:S198–S207. [PubMed: 21521595]
19. Karnofsky, D., Burchenal, J. The clinical evaluation of chemotherapeutic agents in cancer. In: MacLeod, C., editor. Evaluation of Chemotherapeutic Agents. New York, NY: Columbia University Press; 1949. p. 191-205.
20. Oken MM, Creech RH, Tormey DC, Horton J, Davis TE, McFadden ET, Carbone PP. Toxicity and response criteria of the Eastern Cooperative Oncology Group. Am J Clin Oncol. 1982; 5:649–655. [PubMed: 7165009]
21. Puts MTE, Monette J, Girre V, et al. Are frailty markers useful for predicting treatment toxicity and mortality in older newly diagnosed cancer patients? Results from a prospective pilot study. Crit Rev Oncol Hematol. 2011; 78:138–149. [PubMed: 20444620]
22. Audisio RA, Pope D, et al. PACE participants. Shall we operate? Preoperative assessment in elderly cancer patients (PACE) can help. A SIOG surgical task force prospective study. Crit Rev Oncol Hematol. 2008; 65:156–163. [PubMed: 18082416]
23. Kothari A, Phillips S, Bretl T, Block K, Weigel T. Components of geriatric assessments predict thoracic surgery outcomes. J Surg Res. 2011; 166:5–13. [PubMed: 20828735]
24. Efficace F, Novik A, Vignetti M, Mandelli F, Cleeland CS. Health-related quality of life and symptom assessment in clinical research of patients with hematologic malignancies: where are we now and where do we go from here? Haematologica. 2007; 92:1596–1598. [PubMed: 18055981]
25. Elliot K, Tooze JA, Geller R, Powell BL, Pardee TS, Ritchie E, Kennedy L, Callahan KE, Klepin HD. The prognostic importance of polypharmacy in older adults treated for acute myelogenous leukemia (AML). Leuk Res. 2014; 38:1184–1190. [PubMed: 25127690]
26. Pinquart M, Duberstein PR. Depression and cancer mortality: a meta-analysis. Psychol Med. 2010; 40:1797–1810. [PubMed: 20085667]
27. Soubeyran P, Bellera C, Goyard J, et al. Screening for Vulnerability in Older Cancer Patients: The ONCODAGE Prospective Multicenter Cohort Study. PLoS ONE. 2014; doi: 10.1371/journal.pone.0115060

28. Ferrat E, Paillaud E, Caillet P, et al. Performance of Four Frailty Classifications in Older Patients With Cancer: Prospective Elderly Cancer Patients Cohort Study. J Clin Oncol. 2017; 35:766–777. [PubMed: 28095145]
29. Feng MA, McMillan DT, Crowell K, Muss H, Nielsen ME, Smith AB. Geriatric Assessment in Surgical Oncology: A Systematic Review. J Surg Res. 2015; 193:265–272. [PubMed: 25091339]
30. Neuman HB, Weiss JM, Leverson G, O'Connor ES, Greenblatt DY, LoConte NK, Greenberg CC, Smith MA. Predictors of short-term post-operative survival after elective colectomy in colon cancer patients ≥80 years of age. Ann Surg Oncol. 2013; 20:1427–1435. [PubMed: 23292483]
31. Courtney-Brooks M, Tellawi AR, Scalici J, Duska LR, Jazaeri AA, Modesitt SC, Cantrell LA. Frailty: an outcome predictor for elderly gynecologic oncology patients. Gynecol Oncol. 2012; 126:20–24. [PubMed: 22522190]
32. Loh KP, Magnuson A, Dale W, et al. Association of patient age, function and cognition with cancer treatment decisions: A University of Rochester NCORP study. J Clin Oncol. 2016; 34
33. Hurria A, Cirrincione CT, Muss HB, et al. Implementing a Geriatric Assessment in Cooperative Group Clinical Cancer Trials: CALGB 360401. J Clin Oncol. 2011; 29:1290–1296. [PubMed: 21357782]
34. Hurria A, Akiba C, Kim J, et al. Reliability, Validity, and Feasibility of a Computer-Based Geriatric Assessment for Older Adults With Cancer. J Oncol Pract. 2016; 12:e1025–e1034. [PubMed: 27624950]
35. Bhatt G, Hofmeister CC, Efebera YA, et al. A feasibility study of electronic geriatric assessment for real-time morbidity evaluation. J Clin Oncol. 2016; 34
36. McCleary NJ, Wigler D, Berry D, et al. Feasibility of Computer-Based Self-Administered Cancer-Specific Geriatric Assessment in Older Patients With Gastrointestinal Malignancy. The Oncologist. 2013; 18:64–72. [PubMed: 23287880]
37. Shahrokni A, Tin A, Downey RJ, Strong V, Mahmoudzadeh S, Boparai MK, McMillan S, Vickers A, Korc-Grodzicki B. Electronic Rapid Fitness Assessment: A Novel Tool for Preoperative Evaluation of the Geriatric Oncology Patient. J Natl Compr Cancer Netw JNCCN. 2017; 15:172–179.
38. Nathwani N, Mohile SG, Lipe B, Carig K, DiGiovanni L, Davis A, Wujcik D, Hurria A, Wildes TM. Integrating a touchscreen-based brief geriatric assessment in older adults with multiple myeloma. J Clin Oncol. 2017; 35:e21703–e21703.
39. Horgan AM, Seruga B, Pond GR, Alibhai SM, Amir E, De Wit R, Eisenberger MA, Tannock IF. Tolerability and efficacy of docetaxel in older men with metastatic castrate-resistant prostate cancer (mCRPC) in the TAX 327 trial. J Geriatr Oncol. 2014; 5:119–126. [PubMed: 24495703]
40. Muss HB, Berry DA, Cirrincione C, Budman DR, Henderson IC, Citron ML, Norton L, Winer EP, Hudis CA. Cancer and Leukemia Group B Experience. Toxicity of older and younger patients treated with adjuvant chemotherapy for node-positive breast cancer: the Cancer and Leukemia Group B Experience. J Clin Oncol Off J Am Soc Clin Oncol. 2007; 25:3699–3704.
41. Stinchcombe TE, Zhang Y, Vokes EE, et al. Pooled Analysis of Individual Patient Data on Concurrent Chemoradiotherapy for Stage III Non-Small-Cell Lung Cancer in Elderly Patients Compared With Younger Patients Who Participated in US National Cancer Institute Cooperative Group Studies. J Clin Oncol Off J Am Soc Clin Oncol. 2017 JCO2016714758.
42. Quoix E, Zalcman G, Oster J-P, et al. Carboplatin and weekly paclitaxel doublet chemotherapy compared with monotherapy in elderly patients with advanced non-small-cell lung cancer: IFCT-0501 randomised, phase 3 trial. Lancet Lond Engl. 2011; 378:1079–1088.
43. Cataldo JK, Paul S, Cooper B, et al. Differences in the symptom experience of older versus younger oncology outpatients: a cross-sectional study. BMC Cancer. 2013; 13:6. [PubMed: 23281602]
44. Von Roenn JH, Cleeland CS, Gonin R, Hatfield AK, Pandya KJ. Physician attitudes and practice in cancer pain management. A survey from the Eastern Cooperative Oncology Group. Ann Intern Med. 1993; 119:121–126. [PubMed: 8099769]
45. Jensen RE, Snyder CF, Abernethy AP, Basch E, Potosky AL, Roberts AC, Loeffler DR, Reeve BB. Review of Electronic Patient-Reported Outcomes Systems Used in Cancer Clinical Care. J Oncol Pract. 2014; 10:e215–e222. [PubMed: 24301843]

46. Basch E, Deal AM, Kris MG, et al. Symptom Monitoring With Patient-Reported Outcomes During Routine Cancer Treatment: A Randomized Controlled Trial. J Clin Oncol. 2015 JCO630830.
47. Basch E, Deal AM, Dueck AC, Scher HI, Kris MG, Hudis C, Schrag D. Overall Survival Results of a Trial Assessing Patient-Reported Outcomes for Symptom Monitoring During Routine Cancer Treatment. JAMA. 2017; doi: 10.1001/jama.2017.7156
48. Kearney N, McCann L, Norrie J, Taylor L, Gray P, McGee-Lennon M, Sage M, Miller M, Maguire R. Evaluation of a mobile phone-based, advanced symptom management system (ASyMS) in the management of chemotherapy-related toxicity. Support Care Cancer Off J Multinatl Assoc Support Care Cancer. 2009; 17:437–444.
49. McCann L, Maguire R, Miller M, Kearney N. Patients' perceptions and experiences of using a mobile phone-based advanced symptom management system (ASyMS) to monitor and manage chemotherapy related toxicity. Eur J Cancer Care (Engl). 2009; 18:156–164. [PubMed: 19267731]
50. Maguire R, Fox PA, McCann L, et al. The eSMART study protocol: a randomised controlled trial to evaluate electronic symptom management using the advanced symptom management system (ASyMS) remote technology for patients with cancer. BMJ Open. 2017; 7:e015016.
51. Increased Use of Oral Chemotherapy Drugs Spurs Increased Attention to Patient Compliance. J Oncol Pract. 2008; 4:175–177. [PubMed: 20856768]
52. Ziller V, Kalder M, Albert U-S, Holzhauer W, Ziller M, Wagner U, Hadji P. Adherence to adjuvant endocrine therapy in postmenopausal women with breast cancer. Ann Oncol Off J Eur Soc Med Oncol. 2009; 20:431–436.
53. Greer JA, Amoyal N, Nisotel L, Fishbein JN, MacDonald J, Stagl J, Lennes I, Temel JS, Safren SA, Pirl WF. A Systematic Review of Adherence to Oral Antineoplastic Therapies. The Oncologist. 2016; 21:354–376. [PubMed: 26921292]
54. Puts MTE, Tapscott B, Fitch M, Howell D, Monette J, Wan-Chow-Wah D, Krzyzanowska M, Leighl NB, Springall E, Alibhai SM. A systematic review of factors influencing older adults' decision to accept or decline cancer treatment. Cancer Treat Rev. 2015; 41:197–215. [PubMed: 25579752]
55. Stilley CS, Bender CM, Dunbar-Jacob J, Sereika S, Ryan CM. The Impact of Cognitive Function on Medication Management: Three Studies. Health Psychol Off J Div Health Psychol Am Psychol Assoc. 2010; 29:50–55.
56. Loh KP, Pandya C, Zittel J, et al. Associations of sleep disturbance with physical function and cognition in older adults with cancer. Support Care Cancer Off J Multinatl Assoc Support Care Cancer. 2017; doi: 10.1007/s00520-017-3724-6
57. Bennett JA, Cameron LD, Whitehead LC, Porter D. Differences between older and younger cancer survivors in seeking cancer information and using complementary/alternative medicine. J Gen Intern Med. 2009; 24:1089–1094. [PubMed: 19685099]
58. Fitzpatrick AL, Powe NR, Cooper LS, Ives DG, Robbins JA. Barriers to Health Care Access Among the Elderly and Who Perceives Them. Am J Public Health. 2004; 94:1788–1794. [PubMed: 15451751]
59. Maggiore RJ, Gross CP, Hurria A. Polypharmacy in Older Adults with Cancer. The Oncologist. 2010; 15:507–522. [PubMed: 20418534]
60. Lavan AH, Gallagher P. Predicting risk of adverse drug reactions in older adults. Ther Adv Drug Saf. 2016; 7:11–22. [PubMed: 26834959]
61. Marcum ZA, Gellad WF. Medication Adherence to Multi-Drug Regimens. Clin Geriatr Med. 2012; 28:287–300. [PubMed: 22500544]
62. Sharma M, Loh KP, Nightingale G, Mohile SG, Holmes HM. Polypharmacy and potentially inappropriate medication use in geriatric oncology. J Geriatr Oncol. 2016; 7:346–353. [PubMed: 27498305]
63. Neugut AI, Zhong X, Wright JD, Accordino M, Yang J, Hershman DL. Nonadherence to Medications for Chronic Conditions and Nonadherence to Adjuvant Hormonal Therapy in Women With Breast Cancer. JAMA Oncol. 2016; 2:1326–1332. [PubMed: 27281650]
64. DiMatteo MR, Giordani PJ, Lepper HS, Croghan TW. Patient adherence and medical treatment outcomes: a meta-analysis. Med Care. 2002; 40:794–811. [PubMed: 12218770]

65. Hershman DL, Tsui J, Wright JD, Coromilas EJ, Tsai WY, Neugut AI. Household net worth, racial disparities, and hormonal therapy adherence among women with early-stage breast cancer. J Clin Oncol Off J Am Soc Clin Oncol. 2015; 33:1053–1059.

66. Spoelstra SL, Given CW. Assessment and measurement of adherence to oral antineoplastic agents. Semin Oncol Nurs. 2011; 27:116–132. [PubMed: 21514481]

67. Burhenn PS, Smudde J. Using tools and technology to promote education and adherence to oral agents for cancer. Clin J Oncol Nurs. 2015; 19:53–59. [PubMed: 26030395]

68. Mislang AR, Wildes TM, Kanesvaran R, Baldini C, Holmes HM, Nightingale G, Coolbrandt A, Biganzoli L. Adherence to oral cancer therapy in older adults: The International Society of Geriatric Oncology (SIOG) taskforce recommendations. Cancer Treat Rev. 2017; 57:58–66. [PubMed: 28550714]

69. Figueiredo AG Junior, de Forones NM. Study on adherence to capecitabine among patients with colorectal cancer and metastatic breast cancer. Arq Gastroenterol. 2014; 51:186–191. [PubMed: 25296077]

70. Talati C, Ontiveros EP, Griffiths EA, Wang ES, Wetzler M. How we will treat chronic myeloid leukemia in 2016. Blood Rev. 2015; 29:137–142. [PubMed: 25555325]

71. [Accessed 7 Sep 2017] Vitality - NantHealth. https://nanthealth.com/vitality/

72. [Accessed 7 Sep 2017] Improving Medication Adherence for Oncology Patients Through High-Tech Interventions. Spec Pharm Times. https://www.specialtypharmacytimes.com/publications/specialty-pharmacy-times/2015/june-2015/improving-medication-adherence-for-oncology-patients-through-high-tech-interventions

73. Rogers WA, Fisk AD. Toward a Psychological Science of Advanced Technology Design for Older Adults. J Gerontol B Psychol Sci Soc Sci. 2010; 65B:645–653.

74. Evans J, Papadopoulos A, Silvers CT, Charness N, Boot WR, Schlachta-Fairchild L, Crump C, Martinez M, Ent CB. Remote Health Monitoring for Older Adults and Those with Heart Failure: Adherence and System Usability. Telemed J E Health. 2016; 22:480–488. [PubMed: 26540369]

75. Chaudhuri S, Thompson H, Demiris G. Fall Detection Devices and their Use with Older Adults: A Systematic Review. J Geriatr Phys Ther 2001. 2014; 37:178–196.

76. Charness N, Boot WR. Aging and Information Technology Use Potential and Barriers. Curr Dir Psychol Sci. 2009; 18:253–258.

77. Zhou C, Crawford A, Serhal E, Kurdyak P, Sockalingam S. The Impact of Project ECHO on Participant and Patient Outcomes: A Systematic Review. Acad Med J Assoc Am Med Coll. 2016; 91:1439–1461.

78. Mohile S, Magnuson S, Pandya C, Velarde C, Duberstein P, Hurria A, Loh KP, Wells M, Plumb S, Gilmore N, Flannery M, Wittink M, Epstein R, Heckler C, Janelsins M, Mustian K, Hopkins J, Liu J, Kang D, Peri S, Morrow G, Dale W. Community Oncologists' Decision-Making For Treatment of Older Patients with Cancer. J Natl Compr Canc Netw. [In Press].

Table 1

The use of information technology in cancer care [18]

Supporting and Empowering Patients • Online psychosocial support • Personal health information and diagnosis and treatment information • Automated reminders of appointments and medications • Decision aids for informed choice • Emergency alert system	**Between Providers** • Information exchange on work-up and treatment (such as electronic geriatric assessment) • Virtual consultations • Care coordination during diagnosis, treatment and survivorship phases • Tele-ECHO *
Between Provider and Patient • Information sharing on trial eligibility and treatment planning • Symptom management and reporting • Treatment and survivorship care plans • Telemedicine • Monitoring of medication adherence • Monitoring of activities of daily living and falls • Monitoring of exercise adherence	**Between Provider and System** • Automated pharmacy ordering • Communicating lab results • Surveillance of practice pattern

Abbreviation: ECHO, Extension for Community Healthcare Outcomes

* Tele-ECHO sessions bring together interdisciplinary specialists and community-based partners using web-based videoconferencing technology [77]

Table 2

Aging specific issues where technology tools can be helpful

Aging specific issues	Utility of technology tools
Polypharmacy	Access to the dose, frequency and indications for each medication Medication reminders Monitoring of medication adherence
Cognitive impairment	Monitoring of medication adherence Appointment reminders Medication reminders Ability to record symptoms and questions in real-time Delivery of cognitive rehabilitation
Nutritional impairment	Weight tracking Calories tracking Reminders to keep hydrated
Comorbidities	Blood pressure tracking Weight tracking Symptom monitoring Appointment reminders
Physical impairment	Delivery of exercise intervention Activity tracking/monitoring Emergency alert system for falls
Lack of social support	Social platform Education platform