Title

Cancer Screening Among Older Adults: a Geriatrician's Perspective on Breast, Cervical, Colon, Prostate, and Lung Cancer Screening

Permalink

https://escholarship.org/uc/item/52n0c0m2

Journal

Current Oncology Reports, 22(11)

ISSN

1523-3790

Authors

Kotwal, Ashwin A
Walter, Louise C

Publication Date

2020-11-01

DOI

10.1007/s11912-020-00968-x

Peer reviewed

Cancer Screening Among Older Adults: A geriatrician's perspective on breast, cervical, colon, prostate, and lung cancer screening.

Ashwin A. Kotwal, MD, MS[1,2], **Louise C. Walter, MD**[1,2]

[1]Division of Geriatrics, Department of Medicine, University of California, San Francisco

[2]Geriatrics, Palliative, and Extended Care Service Line, San Francisco Veterans Affairs Medical Center

Abstract

Purpose of Review: We summarize the evidence of benefits, harms, and tools to assist in individualized-decisions among older adults in screening for breast, prostate, colon, lung, and cervical cancer.

Recent Findings: The benefits of cancer screening in older adults remain unclear due to minimal inclusion of adults >75 years old in most randomized controlled trials. Indirect evidence suggests that the benefits of screening seen in younger adults (<70 years old) can be extrapolated to older adults when they have an estimated life expectancy of at least 10 years. However, older adults, especially those with limited life expectancy, may be at increased risk for experiencing harms of screening, including overdiagnosis of clinically unimportant diseases, complications from diagnostic procedures, and distress after false positive test results.

Summary: We provide a framework to integrate key factors such as health status, risks and benefits of specific tests, and patient preferences to guide clinicians in cancer screening decisions in older adults.

Keywords

Older adults; Cancer Screening; Mammogram; PSA Test; Colon Cancer; Lung Cancer

Introduction

Cancer screening among older adults is pursued with good intentions, but screening can have unintended downstream harms that are often amplified in older adults. Unclear benefits of screening are due to the majority of randomized controlled trials (RCTs) lack of inclusion of adults over age 75 years and uncertainty about when trial results can be extrapolated to an individual older adult in clinical practice [1]. Clinicians and patients hope that screening will lead to the detection of cancers at earlier stages to optimize treatment strategies and outcomes. However, a major unintended consequence of screening older adults is

Corresponding Author: Ashwin Kotwal, San Francisco VA, 4150 Clement Street (181G), San Francisco, CA 94121, ashwin.kotwal@ucsf.edu Phone: 415-221-4810 x26626.

overdiagnosis, which is the diagnosis and treatment of cancers that would not have caused symptoms during a patient's lifetime [2]. Studies indicate that older adults with <10 years of estimated life expectancy are more likely to experience overdiagnosis and less likely to accrue the cancer-specific mortality benefits of screening [3-5]. In addition, older, frail adults have greater risks of complications from follow-up procedures to screening tests, and cognitive impairment can lead to barriers to informed consent and distress with subsequent "diagnostic cascades" after positive test results. A more immediate, but difficult to quantify, harm is the distraction cancer screening can create, taking time away from the preventive health interventions which have clear evidence of benefit in older adults such as reducing polypharmacy, fall prevention strategies, and healthy behavior counseling [6]. Taken together, the challenge of cancer screening in older adults is how to balance the potential immediate harms with the possibility of long-term benefit of reducing cancer mortality. In this article we summarize the evidence of the benefits, harms, and tools to assist in individualized cancer screening decisions in older adults using a conceptual framework and specific data for cancers whose screening tests have the greatest evidence of net benefit: breast, prostate, colon, lung, and cervical cancer.

Framework for Individualized Decision Making

Individualized decision making means accounting for factors relevant to the risks and benefits of an older patient's decision about whether to pursue cancer screening [3]. We suggest a structured approach focusing on estimated life expectancy, benefits and harms of individual screening tests, and patient preferences. First, clinicians should assess the patients' life expectancy and health. Clinicians can use clinical judgment about whether an individual is in the lowest quartile, middle two quartiles, or highest quartile of life expectancy for their age group, and match this to life table data for an estimated life expectancy (Figure) [7]. Clinicians can also enhance their clinical judgment by using online prognostic tools which are collected at eprognosis.org which can provide guidance based on the clinical setting, relevant time-interval, and patient population. Examples of prognostic calculators for 10 year life expectancy available on the e-prognosis website, for example, include the Lee index, Schonberg index, and Suemoto index, all of which can be conducted in less than a minute [8-10]. If patients have less than a 10 year life expectancy (i.e., they have more than a 50% chance of dying within the next 10 years), they are less likely to experience a reduction in cancer-specific mortality from cancer screening and more likely to experience immediate harms. Importantly, this assessment can provide insight as to whether they would be able to actively participate in informed consent, have other health priorities, or be a candidate for potential downstream interventions after a positive screening test (e.g. surgery, chemotherapy, biopsies, etc.). Second, the risks and benefits of specific cancer screening tests should be reviewed and individualized in the context of the patient's estimated life expectancy. This includes examining national guidelines and the lag-time for potential benefits and harms of screening. Third, clinicians should understand patients' overall values regarding their health and preferences for cancer screening, particularly if they have undergone screening in the past. Taken together, clinicians can provide an individualized recommendation as to whether harms clearly outweigh the benefits of a screening test or if the decision is highly sensitive to an individual patient's preferences (i.e.,

the likelihood that potential benefits of screening outweigh the risks depends on the importance a patient places on those benefits and risks), especially when national guidelines are conflicting or ambiguous.

Several communication strategies exist for delivering cancer screening recommendations to patients. First, if clinicians feel the harms of screening outweigh the benefits, they should lead the conversation with a discussion of the harms of the test to ensure that portion of the conversation "sticks." Second, positive messaging about "tailoring" preventive medical decisions should be used rather than a focus on "stopping screening." For example, clinicians can use the phrase "the test would not help you live longer" to incorporate life expectancy considerations rather than "you may not live long enough to benefit from this test"[11, 12]. Lastly, decision aids are available for each cancer screening test if patients prefer written material or illustrations. In some instances, patients may ask for a clear recommendation from a trusted clinician rather than a detailed conversation with decision aids and illustrations.

Breast Cancer Screening

Potential Benefits

Breast cancer is the second most common cause of cancer death for women in the US, representing 30% of incident cancers among women overall with the risk increasing with age [13]. Several risk factors increase the risk of breast cancer in older women, including prior use of hormone replacement therapy, age at menopause, age at first birth/parity, alcohol and cigarette use, obesity, a history of benign breast biopsy[14], and family history [15]. The lag time to benefit for breast cancer screening is approximately 10 years, suggesting those with less than a 10 year life expectancy are unlikely to benefit [5]. RCTs provide minimal guidance as to the benefit of mammography screening for women ≥ 70 years old. Of the 8 RCTs of mammography screening, only one trial included women 70-74 years old with a subgroup analysis finding no reduction in breast cancer mortality for that age group, and no trials included women ≥ 75. Two retrospective studies of cancer registry data are suggestive that mammography is associated with detection of earlier-stage breast cancer and reduced breast cancer-specific mortality in older women [16, 17]. In addition, simulation models have been used to estimate the benefits of screening mammography for older women. These studies have estimated 1-2 fewer breast cancer deaths per 1,000 women in their 70s who are screened biennially for 10 years [18, 19]. In addition, mammograms may detect cancers more frequently in older women [20].

Potential Harms

The risk of breast cancer overdiagnosis increases with age since older women often have competing mortality risks and may have indolent tumors [21]. This is particularly concerning given the increased risks of cancer treatment toxicity with age [22]. A recent Danish study found that approximately 1 in 3 women aged 50-69 years were diagnosed with a breast cancer that would not have caused symptoms in their lifetime if not for screening [23]. A study using different simulation models found that rates of overdiagnosis increase with age (74 years old: 12-39%, 80 years old: 17-41%, 90 years old: 32-48%) [24]. In

addition, 12-27% of women screened with mammography biennially over a 10 year range will experience a false positive test result which can lead to anxiety [25, 26, 19]. Approximately 10-20% of these women subsequently undergo benign breast biopsy, which can be uncomfortable and stressful [27].

Guidelines

The United States Preventive Services Task Force (USPSTF) recommends biennial mammograms for women 55-74 years, and that current evidence is insufficient to continue screening for women 75 years old (Table). The American Cancer Society (ACS) similarly recommends women 55 have biennial screening if they have a life expectancy 10 years, but does not have an age cut-off to stop screening. Despite these recommendations, a 2015 study found that among women >75 years old with <10 year estimated life expectancy, over 50% reported a screening mammogram in the last two years, over 50% intended on having regular mammograms in the future, and more than 75% reported never discussing with a doctor that screening may not be necessary [28]. These rates are consistent with prior studies of screening and reports of strong patient enthusiasm to continue screening [29, 30].

Geriatrics Recommendation

Given the unclear benefits and potential harms of breast cancer screening among older women, we suggest an individualized approach incorporating estimates of 10-year life expectancy, discussions of the risks and benefits of screening, and patient preferences. Patient preferences may be especially important to elicit given historically positive public messaging and patient enthusiasm [31, 28]. For women with a life expectancy less than 10 years, it may be helpful to frame recommendations by first discussing the harms of screening mammography and follow-up biopsies and employ positive communication strategies to redirect enthusiasm towards treating the patient's current life-limiting medical conditions. The ACS recommends decision aids be used to assist in shared decision making, and peer-reviewed decision aids specifically designed for women 75 years old are available [32].

Cervical Cancer Screening

Potential Benefits

There are no prospective trials of cervical cancer screening in any age group, and observational data of the benefits for screening in older women is limited [33]. In the United States and Europe, since the initiation of pap smears targeted to younger age groups, observational data from women 20 to 64 years old has shown that the incidence and mortality of cervical cancer has substantially decreased [34]. Consequently, cervical cancer is rare among women over 65 years old in the US, with incident cases primarily occurring in older women with no prior history of undergoing screening. However, racial disparities exist among older women diagnosed with cervical cancer [35], and women over 65 years old tend to have later stage disease [36] attributed to inadequate screening at recommended ages. Nevertheless, routine vaccination for Human Papilloma Virus (HPV) strains known to cause cervical cancer in younger adults are expected to further lower the incidence of cervical cancer for future generations.

Potential Harms

False positive are common among older women undergoing pap smears; in a cohort study of 2,561 post-menopausal women (mean age 67 years old) with a normal prior Pap smear, 110 women had an abnormal pap smear within the subsequent 2 years and only 1 was a true positive [37]. In addition, approximately 39 in 1000 older women who are screened require 1 follow-up procedure within 8 months [38]. Pap smears are associated with high anxiety and psychological distress during the physical exam [39]. Moreover, overdiagnosis is possible given the slow growing nature of cervical cancers over 10 to 30 years and the possibility of spontaneous regression of low-grade cervical lesions.

Guidelines

The USPSTF and ACS guidelines agree that women should stop cervical cancer screening at 65 years old if they have had adequate prior screening, regardless of life expectancy [40]. Adequate screening includes either three consecutive negative pap smear cytologies or two consecutive HPV co-tests within 10 years of stopping screening, with the most recent test occurring within 5 years of stopping. There is no indication to restart screening in older women even if they report a new sexual partner.

Geriatric Recommendations

There is minimal data concerning the benefits of screening for cervical cancer among women over 65 years old. However, cervical cancer has a low incidence among women over the age of 65 and when diagnosed it is not more aggressive than in younger women [41]. Moreover, anatomic changes with advancing age, including the movement of the squamo-columnar junction to a higher location in the cervical canal, can reduce the sensitivity of pap smears in older adults due to difficulty obtaining an adequate sample. We therefore agree with current guidelines of stopping screening at 65 years old among patients with a history of adequate screening. It is reasonable to continue screening past age 65 years if a woman has a positive screening result and to continue until adequate negative screening are completed or life expectancy is <10 years given the slow growing nature of cervical cancer.

Colon Cancer Screening

Potential Benefits

Colorectal cancer (CRC) is the second leading cause of cancer death in older adults and the third most common cancer in adults over age 70 [42]. In older adults, the majority of cases of CRC occur in the proximal colon or rectum [43]. Several tests are available for CRC screening including high-sensitivity fecal occult blood testing (FOBT), immunochemical-based fecal occult blood testing (FIT), fecal DNA testing, sigmoidoscopy, colonoscopy, or CT colonography. The lag-time to benefit for CRC screening is approximately 10 years [5], and several CRC screening trials have shown CRC-specific mortality benefits in older adults. For FOBTs, four RCTs found reductions in CRC-specific mortality over a range of follow-up of 11 to 30 years, including in adults age 70-80 years old (a combined 50,144 participants) [44]. Three studies in Europe found CRC-specific mortality reductions of 11-16% [45-47], and a US trial found a reduction of 22-32%, with a 53% reduction among

adults >70 years old [48, 49]. Sigmoidoscopy RCTs generally do not include adults >70 years old, but the Prostate, Lung, Colorectal, and Ovarian (PLCO) Cancer Screening Trial which had a median follow-up of 12 years (and updated reports with 17 years of follow-up) included 20,726 individuals   70 years old. Individuals 65-74 years old had 20% reduced CRC incidence and 35% reduced CRC mortality when screened every 3-5 years [50], although benefits were primarily seen for men and the cancers of the distal colon [51]. Colonoscopies are the definitive test for detection of adenomas and CRC, and have been shown to be cost-effective into older age groups [52]. For colonoscopies, there are no published RCTs, but one large prospective cohort showed that adults   75 years had a 50% reduction in rates of incident CRC diagnosis in both the proximal and distal colon if >5 years since the last endoscopy and 63% reduction if <5 years from last endoscopy [53].

Potential Harms

Harms of CRC screening depend on the screening modality. For FOBT or FIT screens, false-positive results are common; 86-98% of trial participants had a negative colonoscopy after a positive FOBT [33]. In cases of sigmoidoscopy, technical challenges with achieving adequate depth occur more frequently at older ages. Perforation (0.1 per 1000 sigmoidoscopies) is rare, but an important harm of sigmoidoscopy [44]. Estimated rates of adverse events in patients 65 or older undergoing colonoscopy include GI adverse events (26 in 1000), perforation (1 in 1000), post-polypectomy bleeding (3.6 in 1000), severe cardiac or pulmonary events (12.1 in 1000) and death (1 in 1000), and rates of adverse events increase with age [54]. Challenges with bowel prep in older adults are common and include dizziness, abdominal pain, fecal incontinence, and nausea, and individuals can experience confusion and falls with sedation post-procedure [55]. In autopsy studies of older adults, 10-33% are incidentally found to have colonic polyps and 2-3% have CRC suggesting older adults are at risk for overdiagnosis, especially if they have <10 year life expectancy [33].

National Guidelines

The USPSTF recommends routine screening for adults age 55-75 years old, and to consider screening as an individualized decision for adults age 76-85 years old. The ACS recommends routine screening start at age 45, that screening continue until age 75 for individuals with >10 year life expectancy, that clinicians individualize decisions for adults age 76-85, and discourage screening for individuals older than 85 years [56]. However, in 2010 an estimated 51% of adults >75 years with life expectancies <10 years reported being screened [55].

Geriatrics Recommendation

CRC screening has the greatest potential for benefit among older adults if they never were screened before, they are healthy enough to undergo treatment of colorectal cancer, and/or they do not have limited life expectancy. Moreover, many older adults remain enthusiastic about continuing screening even when the tests are low-value and unlikely to help them live longer [57]. Therefore, before initiating any CRC screening test in older adults, including FOBT or FIT, it is important to discuss what one would do with a positive result and whether patients would be willing to take the risks of undergoing colonoscopy. These include procedural risks as well as the burdens of bowel prep, sedation, and need for

arranging transportation in the context of an older adults health. Decision aids are effective at improving knowledge and reducing decisional conflict [58]. Several are available for guiding patients between various CRC screening options [59], and one decision aid is tailored to CRC screening in older adults [60].

Lung Cancer Screening

Potential Benefits

Lung cancer is the leading cause of cancer death in the US and the second most common cancer overall [61]. The primary risk factor for lung cancer is smoking, and the risk increases with age as 66% of lung cancer diagnoses are in adults 65 years [61]. Several trials have evaluated the benefits of lung cancer screening using chest x-rays or low-dose computed tomography (LDCT) among adults age 55-74 years old. The PLCO trial examined the effectiveness of a baseline chest x-ray followed by 3 annual screening chest x-rays among 154,942 adults age 55-74 years with no eligibility requirement regarding smoking [62]. After 13 years follow-up, there was no significant difference in lung cancer incidence rates or mortality between intervention and control. In addition, the National Lung Cancer Screening Trial (NLST) in the US examined the efficacy of LDCT in 53,454 participants age 55-74 years with a history of at least 30 pack years of smoking who were current smokers or had quit in the past 15 years. Participants were randomized to receive either LDCT or a chest x-ray annually for 3 screening rounds. After 6.5 years of follow-up, the trial found LDCT was associated with a 16% relative reduction in lung cancer mortality compared to chest x-rays alone. Extended follow-up NLST data was consistent suggesting an overall NNS of 303 to prevent one death from lung cancer after a lag-time of 11 years [63]. . In addition, the Dutch-Belgian Lung Cancer Screening (NELSON) Trial of LDCT was conducted on 15,792 current or former smokers (quit <10 years ago) age 50-74 years old who had smoked at least 15 cigarettes/day for 25 years or 10 cigarettes/day for 30 years. This trial found a 24% reduction in lung-cancer specific mortality at 10 year follow-up [64].

Potential Harms

False positive results are common with LDCT screening; in the NLST, 39% of people in the LDCT group had at least 1 positive test result and 96% of positive results were false positives [65]. Nearly all positive tests had follow-up imaging, 4.2% had surgical procedures, 2.2% had biopsies, and there was an 8.5 to 9.8% complication rate after invasive diagnostic procedures [66, 67]. Also, the complication rate after invasive procedures is likely higher among the general population of older adults compared with the specialty centers in the NLST. One recent retrospective study of 344,510 patients aged 55-77 years old undergoing diagnostic pulmonary procedures showed complication rates of 22% (more than twice that of NLST) with a cost of $56,845 for major complications [68]. In general, false positive results and complications from diagnostic interventions are higher among older adults compared to younger and among those in worse health [69-71]. Moreover, an implementation study of lung cancer screening in the eight Veterans Health Administration hospitals (N=93,033 primary care patients), found low participation rates (58%) and that the program was resource intensive (56% of those screened had nodules requiring tracking and 2% had false positives requiring an invasive diagnostic interventions) [72]. Overdiagnosis

may occur in approximately 20-25% of screen-detected lung cancers [73, 74], although a recent investigation of the Danish Lung Cancer Screening Trial found that up to 67% of cancers represented overdiagnosis [75]. Additional harms include radiation exposure, financial strain, and anxiety from false-positive results [67].

National Guidelines

Based on NLST results, the USPSTF and ACS recommend annual LDCT for lung cancer screening in adults 55-74 years old (or up to 80 in USPSTF guidelines) who have a 30 pack year history and currently smoke or quit within the last 15 years [76, 77]. Guidelines suggest avoiding screening in older adults with a short life expectancy or comorbidities that would make curative surgery not a reasonable option. Medicare covers lung cancer screening with LDCT, but requires shared decision making between patients and their physicians. Despite this requirement, rates of shared decision making are low with a rate of approximately 9% [78]. A qualitative study of 14 shared decision making conversations conducted by primary care physicians found they were often short (on average <60 seconds) and inadequately addressed potential harms of screening [79].

Geriatrics Recommendation

Among older adults, LDCT may be of most benefit when an older adult is at high risk of lung cancer (calculators available) [80-82], meets NLST or NELSON trial inclusion criteria, and has a lower risk of competing causes of death [83]. It is essential to have discussions about the high burden of follow-up nodule tracking, potential for false positive results, including lesions detected by LDCT in the thyroid and other organs, and downstream medical interventions. A decision support pamphlet developed by the VA is available to help educate adults about the risks and benefits of LDCT screening [84]. More research is needed on how to effectively engage older adults in the shared decision making process. Some evidence suggests educational videos can increase knowledge and reduce decisional conflict among adults eligible for lung cancer screening [85, 86].

Prostate Cancer Screening

Potential Benefits

Prostate cancer is the second leading cause of cancer-related death and the most common diagnosed cancer among men over age 70, affecting nearly 1 in 10 men [42]. Older men are more likely to have intermediate- or high-risk prostate cancer, with one study estimating 33% of men >80 years old with prostate cancer have high-risk disease compared with 6% of men <55 years old, and associated higher rates of mortality [87]. To date, RCTs of PSA screening have provided limited evidence of benefit and have not included men >75 years old. The US PLCO trial examined annual PSA screening over 6 years in 76,685 men aged 55-74 years old (approximately 10,000 men over age 70) [88]. This trial found no prostate cancer mortality reduction even at 15 years of follow-up, although there were high rates of PSA use in the control arm [89]. Post-randomization analysis by comorbidities showed a significant decrease in prostate cancer-specific mortality in men with minimal or no comorbidities with a NNS of 723, although the subgroup was significantly younger on average than trial participants [90]. The European Randomized Study of Screening for

Prostate Cancer (ERSPC) trial randomized men 50-74 years to PSA screening every 2-4 years and the control group received no PSA screening [91]. Results indicated an overall 20% reduction in prostate cancer-specific mortality after a lag-time of 13 years [92], however, benefits of screening were restricted to men 55-69 years at randomization. A recent UK trial of a single PSA screening test was conducted in 419,582 men 55-69 years old and found no prostate cancer-specific mortality benefit after 10 years of follow-up [93].

Potential Harms

False positive results are common from PSA tests (30-40% of tests) and can lead to both anxiety and unneeded prostate biopsies [94]. Prostate biopsies are associated with anxiety, moderate to severe pain (7%) during and immediately after the procedure, moderate to severe hematuria (6%), infection requiring hospitalization (0.4-1.3%), and hospitalizations (7%) [95-97]. More recently, MRI-guided biopsies have been found to reduce the risk of severe infectious complications, although minor complications remain common [98]. In addition, overdiagnosis represents a significant harm since prostate cancers detected through PSA screening are typically slow growing and may remain asymptomatic during a patient's lifetime; in the ERSPC and PLCO trials, it is estimated that 40-60% of screen-detected cancers were cases of overdiagnosis [2, 99]. Overdiagnosis of prostate cancer is associated with anxiety during watchful waiting for low-risk cancers. In addition, older men can experience adverse effects from unnecessary cancer treatments, including bowel dysfunction, urinary incontinence, erectile dysfunction, and premature death [100], although localized treatments, including IMRT or stereotactic radiosurgery, may be better tolerated among older men.

National Guidelines

The most recent, USPSTF 2017 guidelines encourage men 55-69 years old to make an individualized decision on screening after discussion with a clinician and men >70 years old not be screened [101]. The ACS recommended men over age 50 with at least a 10 year life expectancy have a chance to make an informed decision about whether to be screened after receiving information about the uncertainties, risks, and potential benefits of PSA screening [102]. Recent research has shown that PSA screening remains common [103], including in older men with limited life expectancy [28].

Geriatric Recommendation

PSA screening in asymptomatic older men should be rare and only considered in men with at least a 10-15 year life expectancy after a careful shared decision given the multiple known short-term harms [104]. Decision aids are available, and a recent systematic review of 19 decision aids found reductions in decisional conflict to screen. However, there was little evidence that decision aids facilitate shared decision making or impact screening choice [105].

Other Cancers

There are ongoing investigations into screening tests for other common cancers. A recent RCT of screening for ovarian cancer was conducted in England with 202,638 women 50-74

years old randomized to either an annual CA-125 level, annual transvaginal ultrasound, or no screening [106]. At 11.1 years of follow-up there was no significant mortality reduction. Given minimal inclusion of older adults and other similarly negative RCTs (most notably the PLCO trial) [107], there is no evidence to recommend ovarian cancer screening at this time among older women. Similarly, a recent USPSTF systematic review of screening interventions for pancreatic cancer targeting individuals at high familial risk found no evidence of benefit [108]. As new technologies for cancer screening emerge, it will be important to study the benefits and harms among older adults before implementation.

Conclusion

Cancer is common among older adults and cancer screening remains an important and appropriate strategy to identify disease early and reduce treatment-associated morbidity for many older adults with at least a 10-year life expectancy. However, cancer screening has real risks and should not be considered an automatic public health interventions, similar to the flu shot. Increasing evidence suggests increased downstream harms from cancer screening in older adults, especially those with significant comorbid diseases. An individualized decision-making approach with a geriatric lens integrates key factors such as a patient's overall health status and life expectancy, the risks and benefits of specific screening tests, and patient preferences into a tailored recommendation. This approach bridges the many differing guideline recommendations in older adults to focus on aligning cancer screening decisions with patient values and preferences when the evidence about benefits versus harms is uncertain.

References

Annotated reference list: "Bullet important(•) or very import ant(••) recent references (**within past 3 years**) and provide brief explanations of their importance."

1. Kotwal AA, Schonberg MA. Cancer Screening in the Elderly: A Review of Breast, Colorectal, Lung, and Prostate Cancer Screening. The Cancer Journal. 2017;23(4):246–53. [PubMed: 28731949]

2. Welch HG, Black WC. Overdiagnosis in cancer. Journal of the National Cancer Institute. 2010;102(9):605–13. [PubMed: 20413742]

3. Walter LC, Covinsky KE. Cancer screening in elderly patients: a framework for individualized decision making. Jama. 2001;285(21):2750–6. [PubMed: 11386931]

4. Lee SJ, Leipzig RM, Walter LC. Incorporating lag time to benefit into prevention decisions for older adults. Jama. 2013;310(24):2609–10. [PubMed: 24322396]

5. Lee SJ, Boscardin WJ, Stijacic-Cenzer I, Conell-Price J, O'Brien S, Walter LC. Time lag to benefit after screening for breast and colorectal cancer: meta-analysis of survival data from the United States, Sweden, United Kingdom, and Denmark. Bmj. 2013;346:e8441. [PubMed: 23299842]

6 •. Lee SJ, Kim CM. Individualizing Prevention for Older Adults. Journal of the American Geriatrics Society. 2018;66(2):229–34. [PubMed: 29155445] Authors present a framework for individualizing preventive medical interventions in older adults, including how to compare individual life expectancy with time to benefit for different medical tests.

7. Arias E, Xu J. United States Life Tables, 2017. National Vital Statistics Reports. 2017;68(7).

8. Suemoto CK, Ueda P, Beltrán-Sánchez H, Lebrão ML, Duarte YA, Wong R et al. Development and validation of a 10-year mortality prediction model: meta-analysis of individual participant data from five cohorts of older adults in developed and developing countries. Journals of Gerontology Series A: Biomedical Sciences and Medical Sciences. 2016;72(3):410–6.

9. Cruz M, Covinsky K, Widera EW, Stijacic-Cenzer I, Lee SJ. Predicting 10-year mortality for older adults. Jama. 2013;309(9):874–6.

10. Schonberg MA, Davis RB, McCarthy EP, Marcantonio ER. External Validation of an Index to Predict Up to 9-Year Mortality of Community-Dwelling Adults Aged 65 and Older. Journal of the American Geriatrics Society. 2011;59(8):1444–51. [PubMed: 21797837]

11 ••. Schoenborn NL, Lee K, Pollack CE, Armacost K, Dy SM, Bridges JF et al. Older adults' views and communication preferences about cancer screening cessation. JAMA internal medicine. 2017;177(8):1121–8. [PubMed: 28604917] Investigators conducted qualitative interviews of older adults to identify communication preferences in stopping cancer screening. They found participants were amenable stopping cancer screening, but often did not understand the role of life expectancy. Authors suggest incorporating individual health status is important in communication strategies, with positive messaging preferred such as "this test would not help you live longer" instead of "you may not live long enough to benefit."

12 •. Schoenborn NL, Janssen EM, Boyd CM, Bridges JF, Wolff AC, Pollack CE. Preferred clinician communication about stopping cancer screening among older us adults: Results from a national survey. JAMA oncology. 2018;4(8):1126–8. [PubMed: 29955796] A cross-sectional nationally-representative survey of 881 US adults testing 13 different phrases that a clinician may use to explain why a patient should not undergo a routine cancer screening tests. The most preferred phrase to stop cancer screening was "your other health issues should take priority," along with phrases referencing guidelines, older age, lack of benefit, and high risk for harm. The least preferred option was "the doctor does not give an explanation," along with discussions of life expectancy, discomfort or inconvenience of the test, and clinicians not bringing up a discussion of cancer screening.

13. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2019. CA: a cancer journal for clinicians. 2019;69(1):7–34. [PubMed: 30620402]

14. Schonberg MA, Li VW, Eliassen AH, Davis RB, LaCroix AZ, McCarthy EP et al. Accounting for individualized competing mortality risks in estimating postmenopausal breast cancer risk. Breast Cancer Res Treat. 2016;160(3):547–62. doi:10.1007/s10549-016-4020-8 10.1007/s10549-016-4020-8 [pii]. [PubMed: 27770283]

15 •. Braithwaite D, Miglioretti DL, Zhu W, Demb J, Trentham-Dietz A, Sprague B et al. Family history and breast cancer risk among older women in the breast cancer surveillance consortium cohort. JAMA internal medicine. 2018;178(4):494–501. [PubMed: 29435563] Authors demonstrate that family history should be considered when weighing risks and benefits of breast cancer screening in older women

16. McCarthy EP, Burns RB, Freund KM, Ash AS, Shwartz M, Marwill SL et al. Mammography use, breast cancer stage at diagnosis, and survival among older women. Journal of the American Geriatrics Society. 2000;48(10):1226–33. [PubMed: 11037009]

17. McPherson CP, Swenson KK, Lee MW. The effects of mammographic detection and comorbidity on the survival of older women with breast cancer. Journal of the American Geriatrics Society. 2002;50(6):1061–8. [PubMed: 12110066]

18. Barratt A, Howard K, Irwig L, Salkeld G, Houssami N. Model of outcomes of screening mammography: information to support informed choices. Bmj. 2005;330(7497):936. doi:bmj.38398.469479.8F [pii] 10.1136/bmj.38398.469479.8F. [PubMed: 15755755]

19. Walter LC, Schonberg MA. Screening mammography in older women: a review. JAMA. 2014;311(13):1336–47. doi:10.1001/jama.2014.2834 1853134 [pii]. [PubMed: 24691609]

20 •. Lee CS, Sengupta D, Bhargavan-Chatfield M, Sickles EA, Burnside ES, Zuley ML. Association of patient age with outcomes of current-era, large-scale screening mammography: analysis of data from the National Mammography Database. JAMA oncology. 2017;3(8):1134–6. [PubMed: 28426842] Authors evaluate the association between patient age and screening mammography performance metrics in women >40 years old using the National Mammography database. They find that mammography performance metrics (positive predictive value and negative predictive value) improve with age.

21. Schonberg MA, Marcantonio ER, Li D, Silliman RA, Ngo L, McCarthy EP. Breast cancer among the oldest old: tumor characteristics, treatment choices, and survival. J Clin Oncol.

2010;28(12):2038–45. doi:JCO.2009.25.9796 [pii] 10.1200/JCO.2009.25.9796. [PubMed: 20308658]

22. Hurria A, Brogan K, Panageas KS, Pearce C, Norton L, Jakubowski A et al. Patterns of toxicity in older patients with breast cancer receiving adjuvant chemotherapy. Breast cancer research and treatment. 2005;92(2):151–6. [PubMed: 15986124]

23 •. Jorgensen KJ, Gotzsche PC, Kalager M, Zahl PH. Breast Cancer Screening in Denmark: A Cohort Study of Tumor Size and Overdiagnosis. Ann Intern Med. 2017. doi:10.7326/M16-0270 2596394 [pii].Authors demonstrate that up to 1 in every 3 invasive tumors and cases of DCIS in women offered screening mammography represents overdiagnosis

24. Van Ravesteyn NT, Stout NK, Schechter CB, Heijnsdijk EA, Alagoz O, Trentham-Dietz A et al. Benefits and harms of mammography screening after age 74 years: model estimates of overdiagnosis. Journal of the National Cancer Institute. 2015;107(7):djv103. [PubMed: 25948872]

25. Braithwaite D, Zhu W, Hubbard RA, O'Meara ES, Miglioretti DL, Geller B et al. Screening outcomes in older US women undergoing multiple mammograms in community practice: does interval, age, or comorbidity score affect tumor characteristics or false positive rates? J Natl Cancer Inst. 2013;105(5):334–41. doi:10.1093/jnci/djs645. [PubMed: 23385442]

26. Schonberg MA, Silliman RA, Marcantonio ER. Weighing the benefits and burdens of mammography screening among women age 80 years or older. J Clin Oncol. 2009;27(11):1774–80. doi:JCO.2008.19.9877 [pii] 10.1200/JCO.2008.19.9877. [PubMed: 19255318]

27. Schonberg MA, Silliman RA, Ngo LH, Birdwell RL, Fein-Zachary V, Donato J et al. Older women's experience with a benign breast biopsy-a mixed methods study. J Gen Intern Med. 2014;29(12):1631–40. doi:10.1007/s11606-014-2981-z. [PubMed: 25138983]

28 •. Kotwal AA, Walter LC, Lee SJ, Dale W. Are We Choosing Wisely? Older Adults' Cancer Screening Intentions and Recalled Discussions with Physicians About Stopping. Journal of general internal medicine. 2019:1–8.In a cross-sectional nationally-representative survey, among women 75–84 years old with < 10-year life expectancy, 59% intend on future mammography and 81% recall no conversation with a doctor that mammography may no longer be necessary. Among men 75–84 years old with < 10-year life expectancy, 54% intend on future PSA screening and 77% recall no discussions that PSA screening may be unnecessary.

29. Schonberg MA, Breslau ES, McCarthy EP. Targeting of mammography screening according to life expectancy in women aged 75 and older. J Am Geriatr Soc. 2013;61(3):388–95. doi:10.1111/jgs.12123. [PubMed: 23414437]

30. Schoenborn NL, Huang J, Sheehan OC, Wolff JL, Roth DL, Boyd CM. Influence of Age, Health, and Function on Cancer Screening in Older Adults with Limited Life Expectancy. Journal of general internal medicine. 2019;34(1):110–7. [PubMed: 30402822]

31 •. Schoenborn NL, Xue Q-L, Pollack CE, Janssen EM, Bridges JF, Wolff AC et al. Demographic, health, and attitudinal factors predictive of cancer screening decisions in older adults. Preventive medicine reports. 2019;13:244–8. [PubMed: 30719405] In a cross-sectional nationally-representative survey, patients were extremely enthusiastic about continuing cancer screening with 30% of patients agreeing with the statement "I plan to be screened for cancer for as long as I live"

32. Schonberg MA, Hamel MB, Davis RB, Griggs MC, Wee CC, Fagerlin A et al. Development and evaluation of a decision aid on mammography screening for women 75 years and older. JAMA Intern Med. 2014;174(3):417–24. doi:10.1001/jamainternmed.2013.13639 1792914 [pii]. [PubMed: 24378846]

33. Walter LC, Lewis CL, Barton MB. Screening for colorectal, breast, and cervical cancer in the elderly: a review of the evidence. The American journal of medicine. 2005;118(10):1078–86. [PubMed: 16194635]

34. Eddy DM. Screening for cervical cancer. Annals of internal medicine. 1990;113(3):214–26. [PubMed: 2115753]

35. White MC, Shoemaker ML, Benard VB. Cervical cancer screening and incidence by age: unmet needs near and after the stopping age for screening. American journal of preventive medicine. 2017;53(3):392–5. [PubMed: 28473240]

36. Diver EJ, Hinchcliff EM, Gockley AA, Melamed A, Contrino L, Feldman S et al. Assessment of treatment factors and clinical outcomes in cervical cancer in older women compared to women under 65 years old. Journal of geriatric oncology. 2018;9(5):516–9. [PubMed: 29503115]

37. Sawaya GF, Grady D, Kerlikowske K, La Valleur J, Barnabei VM, Bass K et al. The positive predictive value of cervical smears in previously screened postmenopausal women: the Heart and Estrogen/progestin Replacement Study (HERS). Annals of internal medicine. 2000;133(12):942–50. [PubMed: 11119395]

38. Sirovich B, Gottlieb D, Fisher E. The burden of prevention: downstream consequences of Pap smear testing in the elderly. Journal of Medical Screening. 2003;10(4):189–95. [PubMed: 14738656]

39. Bell S, Porter M, Kitchener H, Fraser C, Fisher P, Mann E. Psychological response to cervical screening. Preventive Medicine. 1995;24(6):610–6. [PubMed: 8610085]

40 •. Curry SJ, Krist AH, Owens DK, Barry MJ, Caughey AB, Davidson KW et al. Screening for cervical cancer: US Preventive Services Task Force recommendation statement. Jama. 2018;320(7):674–86. [PubMed: 30140884] USPSTF recommends against screening for cervical cancer in women >65 who have had adequate prior screening and are not otherwise at risk for cervical cancer (D recommendation)

41. Sawaya GF, Sung HY, Kearney KA, Miller M, Kinney W, Hiatt RA et al. Advancing age and cervical cancer screening and prognosis. Journal of the American Geriatrics Society. 2001;49(11):1499–504. [PubMed: 11890589]

42. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2016. CA: a cancer journal for clinicians. 2016;66(1):7–30. [PubMed: 26742998]

43. Siegel R, DeSantis C, Jemal A. Colorectal cancer statistics, 2014. CA: a cancer journal for clinicians. 2014;64(2):104–17. [PubMed: 24639052]

44. Lin JS, Piper MA, Perdue LA, Rutter CM, Webber EM, O'connor E et al. Screening for colorectal cancer: updated evidence report and systematic review for the US Preventive Services Task Force. Jama. 2016;315(23):2576–94. [PubMed: 27305422]

45. Scholefield J, Moss S, Mangham C, Whynes D, Hardcastle J. Nottingham trial of faecal occult blood testing for colorectal cancer: a 20-year follow-up. Gut. 2012;61:1036–40. [PubMed: 22052062]

46. Faivre J, Dancourt V, Denis B, Dorval E, Piette C, Perrin P et al. Comparison between a guaiac and three immunochemical faecal occult blood tests in screening for colorectal cancer. European Journal of Cancer. 2012;48(16):2969–76. [PubMed: 22572481]

47. Kronborg O, Jørgensen O, Fenger C, Rasmussen M. Randomized study of biennial screening with a faecal occult blood test: results after nine screening rounds. Scandinavian journal of gastroenterology. 2004;39(9):846–51. [PubMed: 15513382]

48. Mandel JS, Church TR, Bond JH, Ederer F, Geisser MS, Mongin SJ et al. The effect of fecal occult-blood screening on the incidence of colorectal cancer. New England Journal of Medicine. 2000;343(22):1603–7.

49. Shaukat A, Mongin SJ, Geisser MS, Lederle FA, Bond JH, Mandel JS et al. Long-term mortality after screening for colorectal cancer. New England Journal of Medicine. 2013;369(12):1106–14.

50. Schoen RE, Pinsky PF, Weissfeld JL, Yokochi LA, Church T, Laiyemo AO et al. Colorectal-cancer incidence and mortality with screening flexible sigmoidoscopy. New England Journal of Medicine. 2012;366(25):2345–57.

51. Holme Ø, Løberg M, Kalager M, Bretthauer M, rn Schneede J, Tveit KM et al. Long-Term Effectiveness of Sigmoidoscopy Screening on Colorectal Cancer Incidence and Mortality in Women and Men. Annals of internal medicine. 2018;168(11):775–82. [PubMed: 29710125]

52. Sonnenberg A, Delcò F. Cost-effectiveness of a single colonoscopy in screening for colorectal cancer. Archives of internal medicine. 2002;162(2):163–8. [PubMed: 11802749]

53. Nishihara R, Wu K, Lochhead P, Morikawa T, Liao X, Qian ZR et al. Long-term colorectal-cancer incidence and mortality after lower endoscopy. New England Journal of Medicine. 2013;369(12):1095–105.
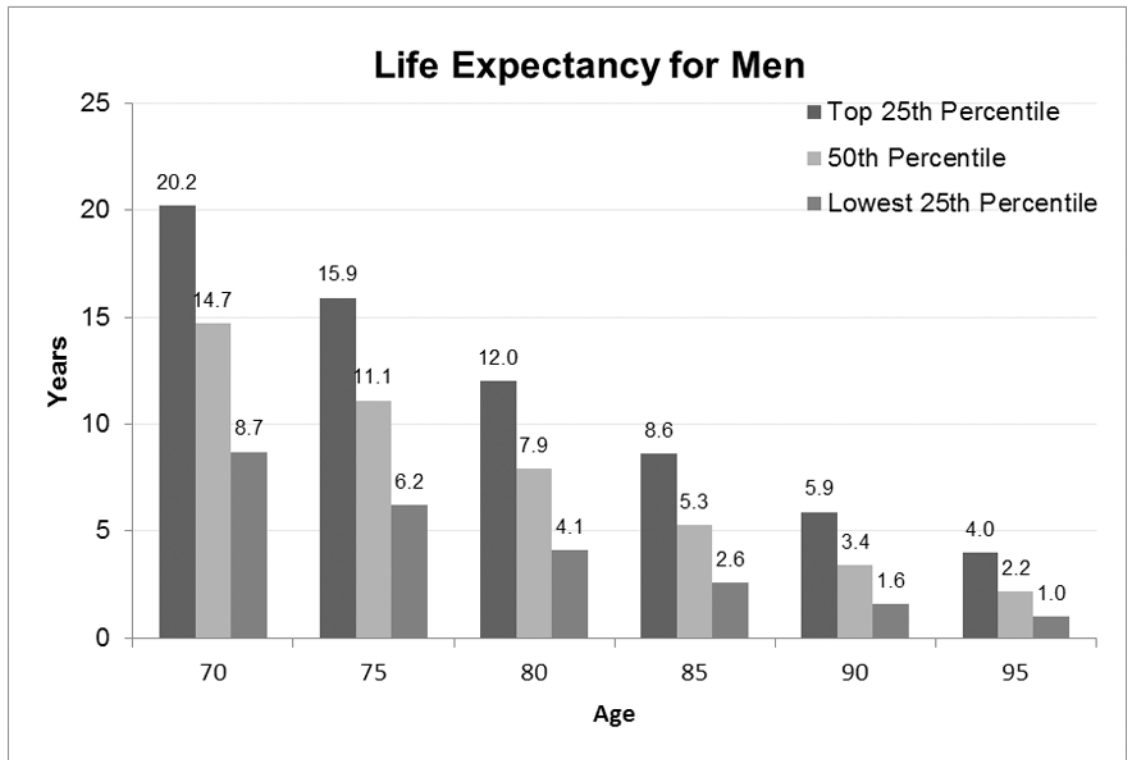
54. Day LW, Kwon A, Inadomi JM, Walter LC, Somsouk M. Adverse events in older patients undergoing colonoscopy: a systematic review and meta-analysis. Gastrointestinal endoscopy. 2011;74(4):885–96. [PubMed: 21951478]

55. Schonberg MA, Breslau ES, Hamel MB, Bellizzi KM, McCarthy EP. Colon cancer screening in US adults aged 65 and older according to life expectancy and age. Journal of the American Geriatrics Society. 2015;63(4):750–6. [PubMed: 25900488]

56. Wolf AM, Fontham ET, Church TR, Flowers CR, Guerra CE, LaMonte SJ et al. Colorectal cancer screening for average-risk adults: 2018 guideline update from the American Cancer Society. CA: a cancer journal for clinicians. 2018;68(4):250–81. [PubMed: 29846947]

57 •. Piper MS, Maratt JK, Zikmund-Fisher BJ, Lewis C, Forman J, Vijan S et al. Patient Attitudes Toward Individualized Recommendations to Stop Low-Value Colorectal Cancer Screening. JAMA network open. 2018;1(8):e185461–e. [PubMed: 30646275] Veterans enrolled in this study were worried about stopping colorectal cancer screening even when it was considered low-value and unlikely to help them live longer.

58. Volk RJ, Linder SK, Lopez-Olivo MA, Kamath GR, Reuland DS, Saraykar SS et al. Patient decision aids for colorectal cancer screening: a systematic review and meta-analysis. American Journal of Preventive Medicine. 2016;51(5):779–91. [PubMed: 27593418]

59. Volk RJ, Leal VB, Jacobs LE, Wolf AM, Brooks DD, Wender RC et al. From guideline to practice: New shared decision-making tools for colorectal cancer screening from the American Cancer Society. CA: a cancer journal for clinicians. 2018;68(4):246–9. [PubMed: 29846954]

60. Lewis CL, Golin CE, DeLeon C, Griffith JM, Ivey J, Trevena L et al. A targeted decision aid for the elderly to decide whether to undergo colorectal cancer screening: development and results of an uncontrolled trial. BMC medical informatics and decision making. 2010;10(1):1. [PubMed: 20067612]

61. ACS. Estimated New Cases for the Four Major Cancers by Sex and Age Group, 2016. Cancer Facts and Figures 2016. 2016. https://www.cancer.org/research/cancer-facts-statistics/all-cancer-facts-figures/cancer-facts-figures-2016.html. Accessed January 27, 2017.

62. Oken MM, Hocking WG, Kvale PA, Andriole GL, Buys SS, Church TR et al. Screening by chest radiograph and lung cancer mortality: the Prostate, Lung, Colorectal, and Ovarian (PLCO) randomized trial. Jama. 2011;306(17):1865–73. [PubMed: 22031728]

63 •. Team NLSTR. Lung Cancer Incidence and Mortality with Extended Follow-up in the National Lung Screening Trial. Journal of Thoracic Oncology. 2019;14(10):1732–42. [PubMed: 31260833] In the NLST trial, investigators reported on result from the extended follow-up of 11.3 years. Results were consistent with the original follow-up, with an NNS of 303 to prevent one lung cancer death

64. de Koning HJ, van der Aalst CM, de Jong PA, Scholten ET, Nackaerts K, Heuvelmans MA et al. Reduced lung-cancer mortality with volume CT screening in a randomized trial. New England Journal of Medicine. 2020;382(6):503–13.

65. Aberle D, Adams A, Berg C, Black W, Clapp J, Fagerstrom R et al. Reduced lung-cancer mortality with low-dose computed tomographic screening. The New England journal of medicine. 2011;365(5):395–409. [PubMed: 21714641]

66. Bach PB, Mirkin JN, Oliver TK, Azzoli CG, Berry DA, Brawley OW et al. Benefits and harms of CT screening for lung cancer: a systematic review. Jama. 2012;307(22):2418–29. [PubMed: 22610500]

67. Harris RP, Sheridan SL, Lewis CL, Barclay C, Vu MB, Kistler CE et al. The harms of screening: a proposed taxonomy and application to lung cancer screening. JAMA internal medicine. 2014;174(2):281–6. [PubMed: 24322781]

68 ••. Huo J, Xu Y, Sheu T, Volk RJ, Shih Y-CT. Complication rates and downstream medical costs associated with invasive diagnostic procedures for lung abnormalities in the community setting. JAMA internal medicine. 2019;179(3):324–32. [PubMed: 30640382] The study objective was to describe the rates of complications after invasive diagnostic pulmonary procedures and costs to patients to better inform patients of the risks of downstream medical procedures in lung cancer screening with LDCT. Authors conducted a retrospective study of 344,510 patients aged 55-77 years who underwent diagnostic procedures between 2008-2013 in order to determine complication rates and downstream medical costs. The complication rate was 22.2% (twice as

high as NLST rates) with cost of $6320 for minor complications and $56,845 for major complications.
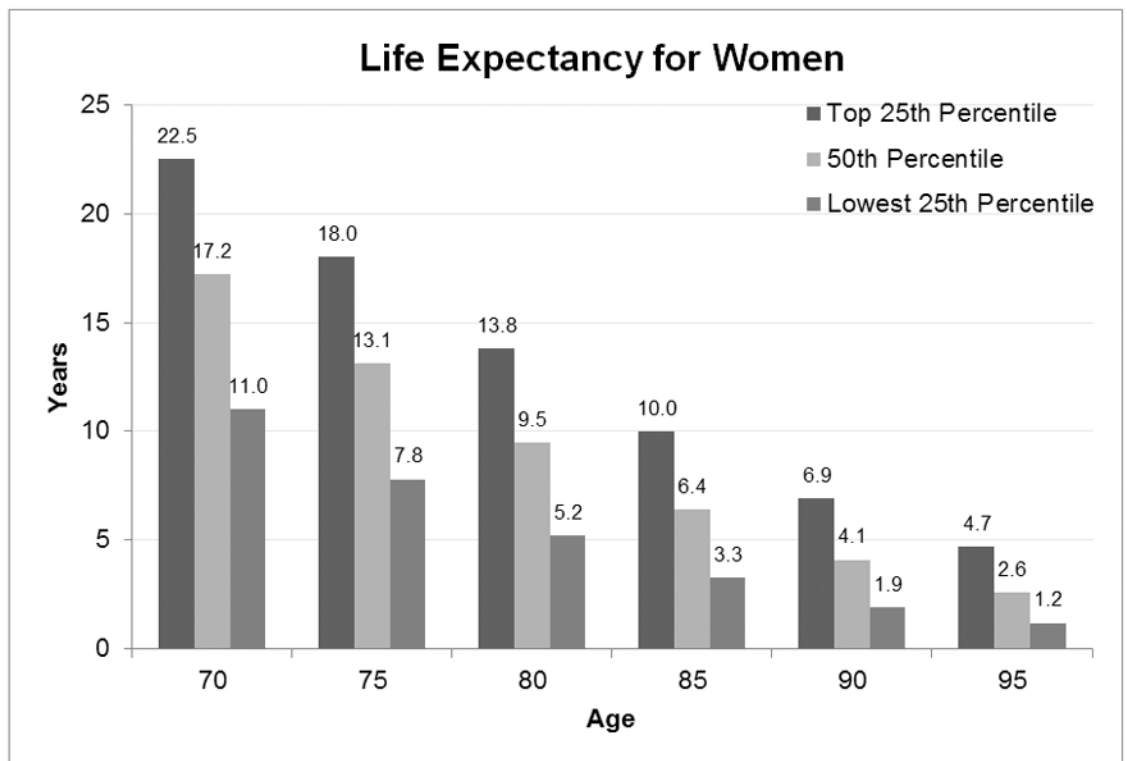
69. Wiener RS, Schwartz LM, Woloshin S, Welch HG. Population-based risk for complications after transthoracic needle lung biopsy of a pulmonary nodule: an analysis of discharge records. Annals of internal medicine. 2011;155(3):137–44. [PubMed: 21810706]

70. Kozower BD, Sheng S, O'brien SM, Liptay MJ, Lau CL, Jones DR et al. STS database risk models: predictors of mortality and major morbidity for lung cancer resection. The Annals of thoracic surgery. 2010;90(3):875–83. [PubMed: 20732512]

71. Pinsky PF, Gierada DS, Hocking W, Patz EF, Kramer BS. National Lung Screening Trial findings by age: Medicare-eligible versus under-65 population. Annals of internal medicine. 2014;161(9):627–33. [PubMed: 25199624]

72 ••. Kinsinger LS, Anderson C, Kim J, Larson M, Chan SH, King HA et al. Implementation of Lung Cancer Screening in the Veterans Health Administration. JAMA internal medicine. 2017;177(3):399–406. [PubMed: 28135352] Investigators describe the implementation process of a lung cancer screening (LCS) program at eight academic VHA hospitals among 93,033 primary care patients assessed for screening criteria. Of the 4,246 who met criteria for LCS, 2452 (58%) agreed to screening, 2106 underwent screening, 60% (n=1257) had nodules, 56% (n=1184) requiring tracking, 2% (n=42) had false-positive requiring invasive diagnostic interventions, and 1.5% (n=31) had lung cancer.

73. Patz EF, Pinsky P, Gatsonis C, Sicks JD, Kramer BS, Tammemägi MC et al. Overdiagnosis in low-dose computed tomography screening for lung cancer. JAMA internal medicine. 2014;174(2):269–74. [PubMed: 24322569]

74. Veronesi G, Maisonneuve P, Bellomi M, Rampinelli C, Durli I, Bertolotti R et al. Estimating Overdiagnosis in Low-Dose Computed Tomography Screening for Lung CancerA Cohort Study. Annals of internal medicine. 2012;157(11):776–84. [PubMed: 23208167]

75. Heleno B, Siersma V, Brodersen J. Estimation of overdiagnosis of lung cancer in low-dose computed tomography screening: a secondary analysis of the Danish lung cancer screening trial. JAMA internal medicine. 2018;178(10):1420–2. [PubMed: 30276415]

76. Moyer VA. Screening for lung cancer: US Preventive Services Task Force recommendation statement. Annals of internal medicine. 2014;160(5):330–8. [PubMed: 24378917]

77. Wender R, Fontham ET, Barrera E Jr., Colditz GA, Church TR, Ettinger DS et al. American Cancer Society lung cancer screening guidelines. CA Cancer J Clin. 2013;63(2):107–17. doi:10.3322/caac.21172. [PubMed: 23315954]

78 •. Goodwin JS, Nishi S, Zhou J, Kuo Y-F. Use of the shared decision-making visit for lung cancer screening among Medicare enrollees. JAMA internal medicine. 2019;179(5):716–8. [PubMed: 30640388] Authors evaluate Medicare enrollees who underwent LDCT and had a billed shared decision making (SDM) visit. Of 19,021 who underwent LDCT in 2016, only 9% had an SDM visit within 3 months prior to scan, with lower odds among black race, female sex, and higher education.

79 •. Brenner AT, Malo TL, Margolis M, Lafata JE, James S, Vu MB et al. Evaluating shared decision making for lung cancer screening. JAMA internal medicine. 2018;178(10):1311–6. [PubMed: 30105393] Investigators conducted a qualitative analysis of 14 conversations about initiating lung cancer screening (LCS) conducted by primary care physicians. The average time discussing LCS was <1 minute, no decision aids were used in any conversations, there was no discussion of harms, and physicians universally recommended LCS. No conversations met basic skill criteria for explaining pros and cons of LCS.

80. MSKCC. Lung Cancer Screening Decision Tool. 2014. http://nomograms.mskcc.org/Lung/Screening.aspx. Accessed January 27, 2017.

81. Kovalchik SA, Tammemagi M, Berg CD, Caporaso NE, Riley TL, Korch M et al. Targeting of low-dose CT screening according to the risk of lung-cancer death. New England Journal of Medicine. 2013;369(3):245–54.

82. Katki HA, Kovalchik SA, Berg CD, Cheung LC, Chaturvedi AK. Development and validation of risk models to select ever-smokers for CT lung cancer screening. Jama. 2016;315(21):2300–11. [PubMed: 27179989]

83 •. Caverly TJ, Fagerlin A, Wiener RS, Slatore CG, Tanner NT, Yun S et al. Comparison of observed harms and expected mortality benefit for persons in the Veterans Health Affairs Lung Cancer Screening Demonstration Project. JAMA internal medicine. 2018;178(3):426–8. [PubMed: 29356812] VA patients who participated in the lung cancer screening implementation study were stratified into quintiles of lung cancer risk from lowest to highest to determine whether the risk/benefit ratio differed. Harms were consistent across risk groups for lung cancer (56% rate of false positives with 2% rate of false positive requiring diagnostic evaluations), but benefits were highest for those at highest risk for lung cancer. Authors conclude that patients may benefit from further risk-stratification for lung cancer risk to further individualize decision making.

84. VA. Screening for Lung Cancer. 2014. http://www.prevention.va.gov/docs/LungCancerScreeningHandout.pdf. Accessed January 26, 2017.

85. Volk RJ, Linder SK, Leal VB. Feasibility of a patient decision aid about lung cancer screening with low-dose computed tomography. Preventive Medicine. 2014;62:60–3. [PubMed: 24518006]

86. Ruparel M, Quaife SL, Ghimire B, Dickson JL, Bhowmik A, Navani N et al. Impact of a Lung Cancer Screening Information Film on Informed Decision-making: A Randomized Trial. Annals of the American Thoracic Society. 2019;16(6):744–51. [PubMed: 31082267]

87. Bechis SK, Carroll PR, Cooperberg MR. Impact of Age at Diagnosis on Prostate Cancer Treatment and Survival. Journal of Clinical Oncology. 2011;29(2):235–41. doi:10.1200/jco.2010.30.2075. [PubMed: 21135285]

88. Andriole GL, Crawford ED, Grubb III RL, Buys SS, Chia D, Church TR et al. Mortality results from a randomized prostate-cancer screening trial. New England Journal of Medicine. 2009;360(13):1310–9.

89. Pinsky PF, Prorok PC, Yu K, Kramer BS, Black A, Gohagan JK et al. Extended mortality results for prostate cancer screening in the PLCO trial with median follow-up of 15 years. Cancer. 2017;123(4):592–9. [PubMed: 27911486]

90. Crawford ED, Grubb III R, Black A, Andriole GL Jr, Chen M-H, Izmirlian G et al. Comorbidity and mortality results from a randomized prostate cancer screening trial. Journal of Clinical Oncology. 2010;29(4):355–61. [PubMed: 21041707]

91. Schröder FH, Hugosson J, Roobol MJ, Tammela TL, Ciatto S, Nelen V et al. Screening and prostate-cancer mortality in a randomized European study. N Engl j Med. 2009;2009(360):1320–8.

92. Schröder FH, Hugosson J, Roobol MJ, Tammela TL, Zappa M, Nelen V et al. Screening and prostate cancer mortality: results of the European Randomised Study of Screening for Prostate Cancer (ERSPC) at 13 years of follow-up. The Lancet. 2014;384(9959):2027–35.

93 •. Martin RM, Donovan JL, Turner EL, Metcalfe C, Young GJ, Walsh EI et al. Effect of a low-intensity PSA-based screening intervention on prostate cancer mortality: the CAP randomized clinical trial. Jama. 2018;319(9):883–95. [PubMed: 29509864] An RCT of 419,582 men aged 50-69 years old in the United Kingdom with recruitment between 2001-2009 and follow-up ending in 2016 testing "an invitation to attend a PSA testing clinic and receive a single PSA test vs standard (unscreened) practice." In intervention versus control arms, prostate cancer mortality was similar (RR=0.96, CI 0.85-1.08) and prostate cancer was diagnosed more frequently in intervention group (RR=1.19, CI: 1.13-1.25), particularly low-grade cancers.

94. Brawer MK. Prostate-specific antigen: Current status. CA: a cancer journal for clinicians. 1999;49(5):264–81. [PubMed: 11198954]

95. Loeb S, Carter HB, Berndt SI, Ricker W, Schaeffer EM. Complications after prostate biopsy: data from SEER-Medicare. The Journal of urology. 2011;186(5):1830–4. [PubMed: 21944136]

96. Loeb S, Vellekoop A, Ahmed HU, Catto J, Emberton M, Nam R et al. Systematic review of complications of prostate biopsy. European urology. 2013;64(6):876–92. [PubMed: 23787356]

97. Rosario DJ, Lane JA, Metcalfe C, Donovan JL, Doble A, Goodwin L et al. Short term outcomes of prostate biopsy in men tested for cancer by prostate specific antigen: prospective evaluation within ProtecT study. Bmj. 2012;344:d7894. [PubMed: 22232535]

98. Borghesi M, Ahmed H, Nam R, Schaeffer E, Schiavina R, Taneja S et al. Complications after systematic, random, and image-guided prostate biopsy. European urology. 2017;71(3):353–65. [PubMed: 27543165]

99. Draisma G, Etzioni R, Tsodikov A, Mariotto A, Wever E, Gulati R et al. Lead time and overdiagnosis in prostate-specific antigen screening: importance of methods and context. Journal of the National Cancer Institute. 2009;101(6):374–83. [PubMed: 19276453]

100. Roussel B, Ouellet GM, Mohile SG, Dale W. Prostate cancer in elderly men: Screening, active surveillance, and definitive therapy. Clinics in geriatric medicine. 2015;31(4):615–29. [PubMed: 26476120]

101. USPSTF. Prostate Cancer Screening Draft Recommendations. 2017. https://screeningforprostatecancer.org/. Accessed 4-27-2017.

102. Smith RA, Andrews KS, Brooks D, Fedewa SA, Manassaram-Baptiste D, Saslow D et al. Cancer screening in the United States, 2018: a review of current American Cancer Society guidelines and current issues in cancer screening. CA: a cancer journal for clinicians. 2018;68(4):297–316. [PubMed: 29846940]

103 •. Bynum J, Passow H, Carmichael D, Skinner J. Exnovation of Low Value Care: A Decade of Prostate-Specific Antigen Screening Practices. Journal of the American Geriatrics Society. 2019;67(1):29–36. [PubMed: 30291742] Serial cross-sectional study of fee-for-service Medicare (2003-2013) in men >68 years old finding little reduction in PSA screening over time with heterogenous changes across different regions

104 •. Fenton JJ, Weyrich MS, Durbin S, Liu Y, Bang H, Melnikow J. Prostate-specific antigen–based screening for prostate cancer: evidence report and systematic review for the US Preventive Services Task Force. Jama. 2018;319(18):1914–31. [PubMed: 29801018] Review of the evidence showing that PSA screening is associated with reduced prostate cancer mortality risk in younger men, but associated with false positives, biopsy-complications, overdiagnosis (21-50% of screen-detected cancers), urinary incontinence, and erectile dysfunction for all men.

105 •. Riikonen JM, Guyatt GH, Kilpeläinen TP, Craigie S, Agarwal A, Agoritsas T et al. Decision aids for prostate cancer screening choice: A systematic review and meta-analysis. JAMA internal medicine. 2019.This study determined the association between decision aids and decisional outcomes for prostate cancer screening (knowledge, decisional conflict, screening discussion, and screening choice) in 19 eligible trials. Results provide moderate quality evidence that decision aids compared with usual care result in a small reduction in decisional conflict and low-quality evidence of increases in cancer screening knowledge. No evidence that decision aids facilitated shared decision making or screening choice, suggesting that future decision aids need to promote the shared-decision making process.

106 •. Jacobs IJ, Menon U, Ryan A, Gentry-Maharaj A, Burnell M, Kalsi JK et al. Ovarian cancer screening and mortality in the UK Collaborative Trial of Ovarian Cancer Screening (UKCTOCS): a randomised controlled trial. The Lancet. 2016;387(10022):945–56.In this English RCT of 202,638 women 50-74 years old, individuals were randomized (1:1:2) to annual CA-125 level, annual transvaginal ultrasound, or no screening with median follow-up of 11.1 years. There was no significant mortality reduction in the primary analysis.

107. Buys SS, Partridge E, Black A, Johnson CC, Lamerato L, Isaacs C et al. Effect of screening on ovarian cancer mortality: the Prostate, Lung, Colorectal and Ovarian (PLCO) cancer screening randomized controlled trial. Jama. 2011;305(22):2295–303. [PubMed: 21642681]

108. Henrikson NB, Bowles EJA, Blasi PR, Morrison CC, Nguyen M, Pillarisetty VG et al. Screening for pancreatic cancer: updated evidence report and systematic review for the US Preventive Services Task Force. Jama. 2019;322(5):445–54. [PubMed: 31386140]

Life Expectancy for Men

Top 25th Percentile / 50th Percentile / Lowest 25th Percentile

Age	70	75	80	85	90	95
Top 25th Percentile	20.2	15.9	12.0	8.6	5.9	4.0
50th Percentile	14.7	11.1	7.9	5.3	3.4	2.2
Lowest 25th Percentile	8.7	6.2	4.1	2.6	1.6	1.0

A.

Life Expectancy for Women

Top 25th Percentile / 50th Percentile / Lowest 25th Percentile

Age	70	75	80	85	90	95
Top 25th Percentile	22.5	18.0	13.8	10.0	6.9	4.7
50th Percentile	17.2	13.1	9.5	6.4	4.1	2.6
Lowest 25th Percentile	11.0	7.8	5.2	3.3	1.9	1.2

B.

Figure.

Upper, Middle, and Lower Quartiles of Life Expectancy for Men and Women at Selected Ages Based on 2017 United States Life Tables [7]

Table.

Cancer Screening Guidelines and Geriatric Recommendations for Older Adults at Average Risk of Cancer

	National Guidelines		Geriatric Recommendation
	USPSTF	**American Cancer Society**	
Breast Cancer (Mammography)	-Women 50-74 years: Biennial screening (Grade B). -Women 75 years: Current evidence is insufficient to assess the balance of benefits and harms of screening(Grade I)	-Women 45-54 years: Annual screening -Women 55 years with life expectancy of >10 years: Biennial screening	-Women 75 years with >10 year life expectancy: Individualized decision, screening is reasonable. -Women 75 years with <10 year life expectancy: recommend against screening
Cervical Cancer (Pap Smear)	-Women 21-64 years: Routine Screening (Grade A) -Women 65: Recommend against screening if adequate prior screening (Grade D)	-Women 21-64 years: Routine Screening (Grade A) -Women 65: Recommend against screening if adequate prior screening (Grade D)	-Women 65: Recommend against screening if adequate prior screening. Continue screening after 65 until adequate negative screening or life expectancy is <10 years.
Colorectal Cancer (FOBT, FIT, stool DNA, Sigmoidoscopy, CT Colonography, Colonoscopy)	-Adults 50-75 years: routine screening. Risks and benefits of different screening methods vary (Grade A). -Adults 76-85 years: Individualized decisions about continued screening. Adults in this age group are more likely to benefit if never screened. Consider if healthy enough to undergo treatment for colorectal cancer and if comorbid conditions limit life expectancy (Grade C)	-Adults 45-75 years: routine screening if a life expectancy > 10 years. -Adults 76-85 years: individualized decisions about continued screening based on patient preferences, life expectancy, health status, and prior screening history. -Adults > 85: Discourage continued screening	-Adults 75: Individualized decision about continued screening based on patient preferences, life expectancy >10 years, and prior screening history. Before any test, discuss with the patient what one would do with a positive result and their willingness to undergo a colonoscopy, including procedural risks and logistical challenges.
Lung Cancer (Low-dose tomography (LDCT)	-Adults 55-80 years: Consider screening if >30 pack year smoking history and either currently smoke or quit within the past 15 years. Discontinue screening once person has not smoked for 15 years or develops health problems limiting life expectancy or ability or willingness to have curative lung surgery (Grade B).	-Adults 55-74 years: Consider screening if in good health with >30 pack-year smoking history and either currently smoke or quit within the last 15 years	-Adults 55-74 years: Consider screening if in good health (>10 year life expectancy) and meeting trial criteria, including a >30 pack–uear smoking history and either currently smoking or quit within the last 15 years. -Adults 75: Individualized decision about continued screening based on patient preferences, life expectancy >10 years, and risk of lung cancer. -Before any test, discuss the burden of follow-up nodule tracking, potential for false positives, and downstream medical interventions, including an ability and willingness to undergo curative surgery.
Prostate Cancer (PSA Test)	-Men 55-69 years: Individualized decision making about screening. Men should have an opportunity to discuss the benefits and harms of screening with clinicians and incorporate their values and preferences. Consider family history, race/ethnicity, comorbid medical conditions, and patient values. (Grade C) -Men 70 years: recommend against screening (Grade D)	-Men >50 years with >10 years life expectancy: Informed decision about screening for prostate cancer after receiving information about uncertainties, risks, and potential benefits. Screening should not occur without an informed decision-making process. Discussions about pros and cons of testing should be repeated as new information about benefits and risks of testing become available.	-Men 70 years: Screening should be rare and only considered in men with at least a 10-15 year life expectancy after individual considerations and providing information on the multiple known short-term harms.
Ovarian Cancer	-Recommends against screening in all women (Grade D)	-No recommended screening tests.	-Recommend against screening.
Pancreatic Cancer	-Recommends against routine screening (Grade D)	-No recommended screening tests.	-Recommend against screening.
All Cancers	-	-	-Do not recommend screening without considering life expectancy, patient preferences, the specific test and the risks of testing, overdiagnosis, and overtreatment.