Special Communication | LESS IS MORE

The Harms of Screening
A Proposed Taxonomy and Application to Lung Cancer Screening

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IMPORTANCE Making rational decisions about screening requires information about its harms, but high-quality evidence is often either not available or not used. One reason may be that we lack a coherent framework, a taxonomy, for conceptualizing and studying these harms.

OBJECTIVE To create a taxonomy, we categorized harms from several sources: systematic reviews of screening, other published literature, and informal discussions with clinicians and patients. We used this information to develop an initial taxonomy and vetted it with local and national experts, making revisions as needed.

RESULTS We propose a taxonomy with 4 domains of harm from screening: physical effects, psychological effects, financial strain, and opportunity costs. Harms can occur at any step of the screening cascade. We provide definitions for each harm domain and illustrate the taxonomy using the example of screening for lung cancer.

CONCLUSIONS AND RELEVANCE The taxonomy provides a systematic way to conceptualize harms as experienced by patients. As shown in the lung cancer screening example, the taxonomy also makes clear where (which domains of harms and which parts of the screening cascade) we have useful information and where there are gaps in our knowledge. The taxonomy needs further testing and validation across a broad range of screening programs. We hope that further development of this taxonomy can improve our thinking about the harms of screening, thus informing our research, policy making, and decision making with patients about the wisdom of screening.

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Rational decision making about screening requires a consideration of the balance between benefits and harms.[1-4] Decisions made on the basis of evidence about benefits alone are unbalanced and run the risk of causing more harm than good. Yet evidence about harms is often less available and, when available, less used than evidence about benefits.[5] The lack of information about harms used in decision making may be partly responsible for the overuse of some screening tests,[6-8] for the lack of discussion about harms between patients and physicians,[9] and for the large number of "I" statements (for "insufficient evidence") by the US Preventive Services Task Force.[10]

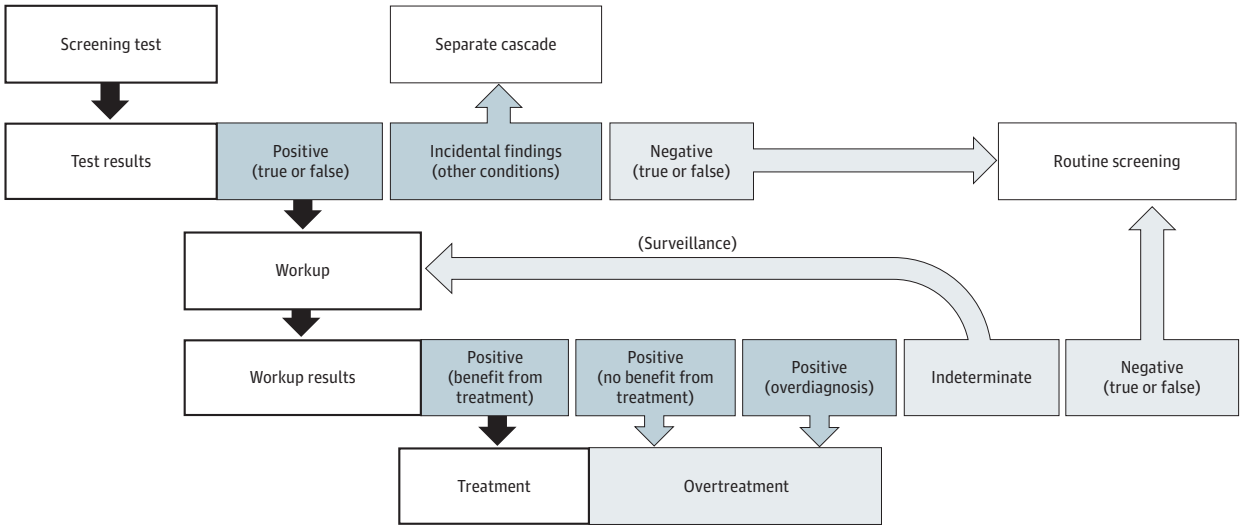
Although this absence of harms evidence in decision making about screening, whether due to no evidence or to nonuse of available evidence, has multiple causes, one contributing factor is the lack of a framework for conceptualizing and organizing our thinking about harms. A taxonomy of the harms of screening could assist researchers and systematic reviewers in asking the right questions, could assist guideline panels in better defining what harms to weigh against potential benefits, could encourage clinicians to discuss harms with patients, and could help patients and the public better understand the real trade-offs inherently involved with screening. We have been unable to identify a general taxonomy of the harms of screening.

The purpose of this article is to propose a taxonomy to conceptualize and define the harms of screening. We present this proposed taxonomy in the hope that it stimulates a discussion leading to a generally accepted framework.

Methods

We first reasoned that harms are experienced by patients, and thus the perspective of the taxonomy should be patient centered. We defined harm as any negative effect perceived by patients or significant others resulting from screening compared with not screening. We considered only whether it is reasonable to think that at least some patients would experience the harm as a negative effect in their

Figure. The Screening Cascade



lives, not whether the harm is well documented, frequent, or serious in medical terms. Harms are "potential" for an individual, since not everyone experiences them. We defined screening as pertaining to the "screening cascade" (**Figure**).

We developed an initial taxonomy from several sources: systematic reviews of screening, our own reviews of published literature, and informal discussions with both clinicians and patients. We then vetted the initial taxonomy with multiple groups, including both local and national experts (see the eAppendix in the Supplement), making revisions as needed.

Results

Overview

We arrived at a taxonomy of 4 domains: physical harms, psychological harms, financial strain, and opportunity costs, as defined in the **Table**. Although benefits from screening can only occur when the entire screening cascade is intact, specific harms within the domains occur at different steps throughout the screening cascade (Figure) and are additive in overall magnitude. We illustrate the taxonomy with the example of screening for lung cancer with low-dose computed tomographic scanning (LDCT), using recent systematic reviews and our own systematic searches to indicate harms for which evidence is or is not available.[11,12]

Physical Harms of LDCT Screening for Lung Cancer

Physical harms occur primarily when we perform a test or procedure or give a treatment to the patient (Figure). For LDCT screening, the first physical harm is exposure to radiation at the screening step. An individual undergoing annual screening from age 55 years to age 79 years could have as many as 25 LDCT scans, with additional full-dose computed tomographic (CT) scans for positive findings or for surveillance after indeterminate screening results. Over time, and for a large population, this radiation exposure may add up to measurable physical harm.[13] Although the exact magnitude of this harm is uncertain, reasonable estimates are available.[14]

A second physical harm from LDCT screening is in the workup for a positive screening test result. In the largest LDCT screening trial (the National Lung Screening Trial [NLST]), 39.1% of people in the LDCT group had at least 1 positive test result (noncalcified nodule at least 4 mm in diameter) over 3 annual screening tests; 96.4% of the positive results were falsely positive.[15] Almost all patients with positive test results had follow-up imaging; 4.2% had a surgical procedure and 2.2% had a biopsy. Although the rate of serious medical complications from this workup was low (approximately 1.4%), the harm associated with the workup goes beyond medical complications. The physical discomfort of having the workup is also a harm, regardless of whether there is a complication. It is also of note that almost twice as many NLST participants in the screening arm experienced a serious complication from the workup as had their lives extended by screening.[15] The percentage of people having a serious complication from the workup of a positive LDCT result will likely be greater in settings outside of a clinical trial.[16] We found no research evidence on the magnitude or "burden" of the physical harm that patients associate with having these workup procedures, with or without complications.

The third category of physical harm from screening is associated with treatment: either earlier treatment of a person with cancer that would have been found later without screening or overtreatment of a person with cancer that would not have been found without screening. As screening and earlier treatment delays death for only 20% of patients destined to die from lung cancer,[11] 80% of screened people with fatal cancer will die at the same time they would have without screening. Early detection from screening has caused these patients to live longer with the diagnosis, receiving treatment and follow-up for a longer time. They experience harm rather than benefit from screening. For patients with cancer that would not have become clinically important, screening leads to unnecessary treatment harms. Our best evidence shows that approxi-

mately 20% to 25% of people with lung cancers diagnosed via screening[17-19] are overdiagnosed and at risk of overtreatment.

Psychological Harms of LDCT Screening for Lung Cancer

Psychological harms of screening may occur at any of the steps of the screening cascade (Figure) but are especially salient at steps when people are given new information, such as receiving results of screening tests or workup. Overall, we found 13 publications from 11 studies,[20-32] all with varying limitations, that examined some aspect of the psychological harms of the screening cascade for lung cancer. Anticipation of having a screening test is stressful for some patients.[20,27,32] Another stressful period is after the screening test before the patient receives the results.[29]

As noted in the previous subsection, 39% of participants in the NLST had at least 1 positive screening test result, with a noncalcified nodule at least 4 mm in diameter. Many of these patients will have a nodule between 4 mm and 8 mm in diameter, an "indeterminate" category; recommendations are for these patients to undergo periodic repeated imaging to ascertain whether the nodule is growing.[33] This system of surveillance puts the patient (and their significant others) in an uncertain state for a prolonged period. We found no research exploring this harm for LDCT screening.

Some patients develop increased anxiety after receiving a positive or indeterminate screening result, although these anxiety levels may decline with time.[22,24,30,31,34] A larger number of patients experience other psychological harms, such as condition-specific distress, as thoughts of having lung cancer lead to sleepless nights, intrusive thoughts, and worries about the future.[21,27] We found only 3 studies that assessed condition-specific distress.[21,24,27]

Overlaying the psychological harms is the context of the screening situation. In the case of LDCT screening for lung cancer, eligible people, according to the draft US Preventive Services Task Force recommendations,[14] have at least 30 pack-years of smoking history. To the extent that these people see themselves as having a socially unacceptable personal behavior that may have caused lung cancer, they may experience feelings of guilt, shame, and anxiety in anticipation of possibly being diagnosed with lung cancer.[21,35] We found no studies that examined this issue for LDCT screening.

Another psychological harm from screening is the effect on individuals of receiving a diagnosis of lung cancer. Although we found little research documenting this effect,[28,36] it is likely that "labeling" the individual in this way plays a major role in how the individual thinks of himself or herself in the future. Labeling is due to screening in the 2 aforementioned situations: earlier detection of fatal cancers for which treatment is ineffective, and overdiagnosis of cancers that would not have caused the patient important health problems. In both situations, screening has caused psychological harm by labeling patients with a potentially fatal diagnosis. Although one can estimate the frequency of these situations, we found no studies of the psychological "burden" of labeling as experienced by patients.

Still another group of patients with an abnormal screening test result who may feel the psychological effects of a workup are those with "incidental" findings on screening CT, findings not indicative of lung cancer but that may indicate some other medical condition. In the NLST trial, more than 10% of all people screened had incidental findings on the first LDCT screen, and approximately 6% had an incidental finding on both screening rounds 2 and 3.[15,37] Still more people undergoing a workup for lung cancer may have an incidental finding from more intense imaging. Patients with incidental findings often go through a different type of workup, including sometimes invasive procedures, than that for lung cancer (Figure). Although some have tried to make the case that these incidental findings could be beneficial, it is much more likely that their overall effect is negative. The burden of proof for any benefit for these incidental findings lies with those proposing the benefit. We found no studies examining the psychological (or physical) effects of workup of incidental findings and discovery of incidental disease.

Finally, there are psychological harms of nonbeneficial treatment due to screening. As noted previously, this occurs with ineffective earlier treatment, with overtreatment in overdiagnosed patients, and in patients undergoing ineffective treatment for an incidental condition found by screening or workup. These treatments can include major surgery, radiation, and chemotherapy, all associated with known psychological harms.[25,26] The fact that these patients do not know that the harm they are experiencing is unnecessary does not reduce the magnitude of their suffering.

Table. Taxonomy of the Harms of Screening: Domains and Definitions

Domain and Definition	Can occur...
Physical harms: Physical problems, including discomfort, perceived by the patient or significant others	When something is done to a patient, such as a screening test, workup procedures, or treatment. Usually does not result from receiving information, such as screening test results; an exception would be if such information led to suicide or other self-harm. Harm goes beyond medical complications and includes discomfort.
Psychological harms: Psychological problems, including anxiety, depression, or condition-specific distress, perceived by the patient or significant others	At any step of the screening cascade. Includes effects of anticipation of discomfort from a procedure or from what might be found by a screening test or workup; reactions to results received from screening test or workup; effects of a positive screening test or "labeling" from receiving a diagnosis; and psychological effects of ineffective or unnecessary treatment due to screening.
Financial strain: Concern and relationship strain due to thinking about possible or actual financial consequences of screening and the potential of being diagnosed with a disease	At any step of the screening cascade. Can result from anticipated or real costs due to the cascade, plus the financial consequences of missing work or other expenses related to screening. Includes disruption of previous financial plans.
Opportunity cost: Activities forgone because of time, effort, and resources required to participate in the screening cascade	At any step of the screening cascade. Includes distraction from other health-related activities or self-care, such as exercise or seeking care for other health problems, as well as reduced time or energy for other important or meaningful activities. Not the same as cost of medical care or cost-effectiveness.

Financial Strain of LDCT Screening for Lung Cancer

Financial strain from screening comes not only from actual financial charges for the screening test, but also from concern about the anticipated financial cost of being diagnosed with and treated for lung cancer. Financial strain may start with the screening test itself and then increase with a positive result and anticipation of the cost of the workup. The patient often does not know ahead of time exactly what the cost will be and may expect the worst-case scenario. If the workup finds lung cancer, financial strain may encompass future lost wages and the effects on one's family. Previous financial plans may be thrown into disarray. We found no studies examining this type of harm.

Opportunity Costs of LDCT Screening for Lung Cancer

People undergoing LDCT screening and workup may experience harm through missed opportunities. Some of these missed opportunities have to do with health, including distraction from other important healthy activities or visits to clinicians for important health problems. Other missed opportunities may include time with friends and family. Finally, there is the missed opportunity of continuing progress at work and on one's own projects. We found no research evidence about this type of harm.

Discussion

The taxonomy encourages a systematic approach to thinking about harms, an approach that is needed to move research, discussion, and decision making about screening from an overemphasis on benefits alone to a focus on balancing benefits and harms.[1]

There are limitations to our approach. One criticism we have encountered is that our taxonomy overstates the importance of psychological harms. It is not our intention, however, to prioritize one type of harm over another. The effect of a particular harm on a screened population depends on the frequency of the harm as well as its burden for the individuals affected. By making sure that psychological effects are considered along with physical effects, we assert that both domains of harms are worthy of being considered in screening decisions.

Some have questioned our inclusion of financial strain under the rubric of "harms." For real people, however, the strain of anticipated financial problems can be important in weighing the decision whether to be screened. We believe it is easier to conceptualize financial strain alongside of but separate from other harms. We also distinguish "opportunity costs" from financial strain. By opportunity costs we do not mean financial costs but rather the loss of alternative activities that could have benefited the patient in multiple ways. Part of opportunity costs comes from the time required to participate in the screening cascade. Another part comes from the distraction of screening from other activities, both in terms of health and enjoyment of life.

Some clinicians have commented to us that harms are just the price we pay for the benefits of screening. It may be, however, that were we to fully appreciate the frequency and burden of harms, our enthusiasm for screening would decline. The taxonomy is designed to unveil the true extent of the problem of harms.

Finally, there are still further harms to be considered. For instance, another harm from screening is the strain on the medical care system. Organizing systematic screening requires careful planning and effort, including changing staff roles, increasing patient education, taking clinicians' time, working out referral patterns and follow-up, considering outreach, and changing documentation. Inevitably, such effort directed to screening means less effort directed toward other health issues. We have not captured this type of harm in our taxonomy.

A second type of harm that is not in our taxonomy is undermining a culture of wellness. That is, widespread screening sends the message to the public that we all have undiscovered health problems, that we are all "at risk," "unwell" in ways we do not even know. This has the potential to steadily degrade society's sense of its own health, with uncertain but probably negative implications for the way we live. If we were to take potential harms more into consideration in deciding about and promoting screening, we might limit screening to more targeted situations, perhaps reducing these negative social effects.

An earlier version of our taxonomy included the category of "hassles." We dropped this category because of the complaint that the word trivializes the concept and undermines the importance of harms. We remain impressed, however, by the difficulties many patients have in organizing their lives for the sometimes complex requirements of going through the screening cascade.

To some extent, any such taxonomy as ours is arbitrary; the question is whether it is useful in developing better research evidence and in improving discussions and decision making about screening. In applying our taxonomy to the current issue of lung cancer screening, we were struck by 2 observations. The first is that lung cancer screening can cause harm in multiple ways. The second is that, for many of these harms, we have little or no high-certainty evidence about the burden they cause to patients. For example, we know that positive test results (usually falsely positive) are common, but we have insufficient evidence about the full range of psychological harms (condition specific as well as generalized distress),[38] the opportunity costs, and the financial strain that these positive results, as well as incidental findings, cause. We have insufficient evidence about the burden caused by the physical discomfort of the multiple workup procedures and little evidence about the psychological harm caused by surveillance of indeterminate nodules. In addition, we have scant information about the psychological burden due to labeling and treating people for lung cancer with ineffective or unnecessary treatment. It is difficult to see how clear recommendations for LDCT screening for lung cancer can be made before these harms are more completely understood.

Conclusions

Our purpose in developing a taxonomy of the potential harms of screening is to help investigators, policy makers, clinicians, and the public think more clearly and systematically about harms and to consider harms equally with benefits in decisions about screening. We do not assert that harms always outweigh benefits, only that it is always necessary to weigh the two. We consider this a draft taxonomy, a work in progress that could contribute to our current public discussion about screening. In the end, we hope that a widely agreed-on taxonomy will eventually lead to more balanced decision making about the wisdom of screening.

ARTICLE INFORMATION

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Study concept and design: Harris, Sheridan, Lewis,

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Acquisition of data: Harris, Sheridan.
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Drafting of the manuscript: Harris, Sheridan, Brewer.
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REFERENCES

1. Harris R, Sawaya GF, Moyer VA, Calonge N. Reconsidering the criteria for evaluating proposed screening programs: reflections from 4 current and former members of the US Preventive Services Task Force. *Epidemiol Rev*. 2011;33(1):20-35.

2. US Preventive Services Task Force. Procedure Manual. July 2008. AHRQ Publication No. 08-05118-EF. http://www.uspreventiveservicestaskforce.org/uspstf08/methods/procmanual.htm. Accessed June 10, 2013.

3. Sawaya GF, Guirguis-Blake J, LeFevre M, Harris R, Petitti D; US Preventive Services Task Force. Update on the methods of the US Preventive Services Task Force: estimating certainty and magnitude of net benefit. *Ann Intern Med*. 2007;147(12):871-875.

4. Woolf SH, Harris R. The harms of screening: new attention to an old concern. *JAMA*. 2012;307(6):565-566.

5. Chou R, Helfand M. Challenges in systematic reviews that assess treatment harms. *Ann Intern Med*. 2005;142(12, pt 2):1090-1099.

6. Choosing Wisely: an Initiative of the ABIM Foundation. http://www.choosingwisely.org. Accessed June 10, 2013.

7. Schwartz LM, Woloshin S, Fowler FJ Jr, Welch HG. Enthusiasm for cancer screening in the United States. *JAMA*. 2004;291(1):71-78.

8. Sirovich BE, Woloshin S, Schwartz LM. Too little? too much? primary care physicians' views on US health care: a brief report. *Arch Intern Med*. 2011;171(17):1582-1585.

9. Hoffman RM, Lewis CL, Pignone MP, et al. Decision-making processes for breast, colorectal, and prostate cancer screening: the DECISIONS survey. *Med Decis Making*. 2010;30(5)(suppl):53S-64S.

10. US Preventive Services Task Force. Recommendations. http://www.uspreventiveservicestaskforce.org/recommendations.htm. Accessed June 10, 2013.

11. Humphrey L, Deffebach M, Pappas M, et al. *Screening for Lung Cancer: Systematic Review to Update the US Preventive Services Task Force Recommendation: Evidence Synthesis No. 105*. Rockville, MD: Agency for Healthcare Research and Quality; 2013. AHRQ Publication No. 13-05188-EF-1.

12. Bach PB, Mirkin JN, Oliver TK, et al. Benefits and harms of CT screening for lung cancer: a systematic review. *JAMA*. 2012;307(22):2418-2429.

13. Smith-Bindman R. Is computed tomography safe? *N Engl J Med*. 2010;363(1):1-4.

14. US Preventive Services Task Force. Primary care behavioral interventions to reduce illicit drug and nonmedical pharmaceutical use in children and adolescents: draft recommendation statement. AHRQ Publication No. 13-05196-EF-3. http://www.uspreventiveservicestaskforce.org/draftrec.htm. Accessed August 26, 2013.

15. Aberle DR, Adams AM, Berg CD, et al; National Lung Screening Trial Research Team. Reduced lung-cancer mortality with low-dose computed tomographic screening. *N Engl J Med*. 2011;365(5):395-409.

16. 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. *Ann Intern Med*. 2011;155(3):137-144.

17. Veronesi G, Maisonneuve P, Bellomi M, et al. Estimating overdiagnosis in low-dose computed tomography screening for lung cancer: a cohort study. *Ann Intern Med*. 2012;157(11):776-784.

18. Kubík AK, Parkin DM, Zatloukal P. Czech Study on Lung Cancer Screening: post-trial follow-up of lung cancer deaths up to year 15 since enrollment. *Cancer*. 2000;89(11)(suppl):2363-2368.

19. Marcus PM, Bergstralh EJ, Fagerstrom RM, et al. Lung cancer mortality in the Mayo Lung Project: impact of extended follow-up. *J Natl Cancer Inst*. 2000;92(16):1308-1316.

20. Aggestrup LM, Hestbech MS, Siersma V, Pedersen JH, Brodersen J. Psychosocial consequences of allocation to lung cancer screening: a randomised controlled trial. *BMJ Open*. 2012;2(2):e000663.

21. Brodersen J, Thorsen H, Kreiner S. Consequences of screening in lung cancer: development and dimensionality of a questionnaire. *Value Health*. 2010;13(5):601-612.

22. Byrne MM, Weissfeld J, Roberts MS. Anxiety, fear of cancer, and perceived risk of cancer following lung cancer screening. *Med Decis Making*. 2008;28(6):917-925.

23. Kaerlev L, Iachina M, Pedersen JH, Green A, Nørgård BM. CT-Screening for lung cancer does not increase the use of anxiolytic or antidepressant medication. *BMC Cancer*. 2012;12(1):188.

24. McGovern PM, Gross CR, Krueger RA, Engelhard DA, Cordes JE, Church TR. False-positive cancer screens and health-related quality of life. *Cancer Nurs*. 2004;27(5):347-352.

25. Nekolaichuk CL, Cumming C, Turner J, Yushchyshyn A, Sela R. Referral patterns and psychosocial distress in cancer patients accessing a psycho-oncology counseling service. *Psychooncology*. 2011;20(3):326-332.

26. Reeve BB, Potosky AL, Smith AW, et al. Impact of cancer on health-related quality of life of older Americans. *J Natl Cancer Inst*. 2009;101(12):860-868.

27. Sinicrope PS, Rabe KG, Brockman TA, et al. Perceptions of lung cancer risk and beliefs in screening accuracy of spiral computed tomography among high-risk lung cancer family members. *Acad Radiol*. 2010;17(8):1012-1025.

28. Steinberg T, Roseman M, Kasymjanova G, et al. Prevalence of emotional distress in newly diagnosed lung cancer patients. *Support Care Cancer*. 2009;17(12):1493-1497.

29. van den Bergh KA, Essink-Bot ML, Bunge EM, et al. Impact of computed tomography screening for lung cancer on participants in a randomized controlled trial (NELSON trial). *Cancer*. 2008;113(2):396-404.

30. van den Bergh KA, Essink-Bot ML, Borsboom GJ, et al. Short-term health-related quality of life consequences in a lung cancer CT screening trial (NELSON). *Br J Cancer*. 2010;102(1):27-34.

31. van den Bergh KA, Essink-Bot ML, Borsboom GJ, Scholten ET, van Klaveren RJ, de Koning HJ. Long-term effects of lung cancer computed tomography screening on health-related quality of life: the NELSON trial. *Eur Respir J*. 2011;38(1):154-161.

32. Vierikko T, Kivistö S, Järvenpää R, et al. Psychological impact of computed tomography screening for lung cancer and occupational pulmonary disease among asbestos-exposed workers. *Eur J Cancer Prev*. 2009;18(3):203-206.

33. Detterbeck FC, Mazzone PJ, Naidich DP, Bach PB. Screening for lung cancer: diagnosis and management of lung cancer, 3rd ed: American College of Chest Physicians evidence-based clinical practice guidelines. *Chest*. 2013;143(5)(suppl):e78S-e92S.

34. Bunge EM, van den Bergh KA, Essink-Bot ML, van Klaveren RJ, de Koning HJ. High affective risk perception is associated with more lung cancer-specific distress in CT screening for lung cancer. *Lung Cancer*. 2008;62(3):385-390.

35. Marlow LA, Waller J, Wardle J. Variation in blame attributions across different cancer types. *Cancer Epidemiol Biomarkers Prev*. 2010;19(7):1799-1805.

36. Zabora J, BrintzenhofeSzoc K, Curbow B, Hooker C, Piantadosi S. The prevalence of psychological distress by cancer site. *Psychooncology*. 2001;10(1):19-28.

37. Church TR, Black WC, Aberle DR, et al; National Lung Screening Trial Research Team. Results of initial low-dose computed tomographic screening for lung cancer. *N Engl J Med*. 2013;368(21):1980-1991.

38. Salz T, Richman AR, Brewer NT. Meta-analyses of the effect of false-positive mammograms on generic and specific psychosocial outcomes. *Psychooncology*. 2010;19(10):1026-1034.