Προγράμματα προληπτικού ακτινολογικού ελέγχου (LDCT scan) στην πρώιμη διάγνωση του καρκίνου του πνεύμονα

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Επ. καθ. Πνευμονολογίας
Δημοκρίτειο Πανεπιστήμιο Θράκης
## Estimated new cases, 2018
by sex, for lung and bronchus

<table>
<thead>
<tr>
<th>Sex</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>121,680</td>
</tr>
<tr>
<td>Female</td>
<td>112,350</td>
</tr>
</tbody>
</table>

Data Sources: American Cancer Society, 2018
© 2018 American Cancer Society
Estimated deaths, 2018
by sex, for lung and bronchus

Male

83,550

Female

70,500

Data Sources: American Cancer Society, 2018
© 2018 American Cancer Society CancerStatisticsCenter.cancer.org
Estimated deaths, 2018
By cancer type, both sexes combined

Lung and bronchus

Colorectum

Pancreas

Breast

Liver and intrahepatic bile duct

Prostate
Estimated new cases, 2018
By cancer type, both sexes combined

Breast
268,670

Lung and bronchus
234,030

Prostate
164,690

Colorectum
140,250

Melanoma of the skin
91,270
Comparing Sources of Radiation

<table>
<thead>
<tr>
<th>Source</th>
<th>Millisieverts (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air travel, 10 hours</td>
<td>0.04 mSv</td>
</tr>
<tr>
<td>Chest x-ray</td>
<td>0.1 mSv</td>
</tr>
<tr>
<td>Mammogram</td>
<td>0.4 mSv</td>
</tr>
<tr>
<td>LDCT for lung cancer screening</td>
<td>1.4 mSv</td>
</tr>
<tr>
<td>Diagnostic CT</td>
<td>7 mSv</td>
</tr>
<tr>
<td>Average background radiation (U.S., 1 year)</td>
<td>3 to 5 mSv</td>
</tr>
</tbody>
</table>

mSv = millisievert, a measure of the amount of radiation absorbed by the body.

Harm:

Radiation exposure: Exposure to radiation increases a person's chance of developing cancer. LDCT screening for lung cancer exposes a person to radiation. If the screening test is positive, additional testing may involve higher doses of radiation. Researchers do not know how being exposed to radiation from LDCT scans and additional diagnostic imaging tests may affect people.
Το ιδανικό πρόγραμμα πρόληψης

- Υψηλή ευαισθησία και ειδικότητα
- Απλές και ασφαλείς εξετάσεις
- Αποτελεσματικό κόστος
- Εύκολα πραγματοποιήσιμο
Το ιδανικό πρόγραμμα πρόληψης

• Αριθμός των συμμετεχόντων για να προληφθεί 1 καρκίνος
• Η συχνότητα των ψευδώς θετικών αποτελεσμάτων
• Η θνητότητα σχετιζόμενη με τις χειρουργικώς αντιμετωπιζόμενες περιπτώσεις
• Η υπερδιάγνωση
• Η ψυχολογική επίπτωση λόγω των ψευδώς θετικών αποτελεσμάτων
• Το κόστος και η προσβασιμότητα
Τα πρώτα προγράμματα πρόληψης

- Mayo Lung Project
  - Ακτινογραφία θώρακος και κυτταρολογική πτυέλων
- Memorial Sloan-Kettering study
  - Ακτινογραφία θώρακος και κυτταρολογική πτυέλων
- PLCO cancer screening trial
  - Ακτινογραφία θώρακος
Table: European pilot trials for lung cancer low-dose CT screening

<table>
<thead>
<tr>
<th>Randomised controlled trials</th>
<th>Recruitment period</th>
<th>Recruitment criteria</th>
<th>Screening methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>NLST(^1)</td>
<td>2002–04</td>
<td>Age 55–75 years, ≥30 PY smoker, quit smoking &lt;15 years earlier</td>
<td>Annual low-dose CT vs chest x-ray for 3 years</td>
</tr>
<tr>
<td>MILD(^3)</td>
<td>2005–11</td>
<td>Age &gt;49 years, ≥20 PY smoker, quit smoking &lt;10 years earlier, no cancers within past 5 years</td>
<td>Three groups: no screen, annual screen, and biennial low-dose CT for 5 years</td>
</tr>
<tr>
<td>ITALUNG(^4)</td>
<td>2004–06</td>
<td>Age 55–69 years, ≥20 PY smoker</td>
<td>Annual low-dose CT for 4 years vs no screen</td>
</tr>
<tr>
<td>DANTE(^5)</td>
<td>2001–06</td>
<td>Age 60–75 years, ≥20 PY smoker, quit smoking &lt;10 years earlier, male</td>
<td>Annual low-dose CT for 4 years vs no screen</td>
</tr>
<tr>
<td>DLCST(^6)</td>
<td>2004–06</td>
<td>Age 50–70 years, ≥20 PY smoker, quit smoking &lt;10 years earlier, FEV(_1) ratio &gt;30%, able to climb two flights of stairs without pausing</td>
<td>Annual low-dose CT vs usual care for 5 years</td>
</tr>
<tr>
<td>NELSON(^7)</td>
<td>2003–06</td>
<td>Age 50–75 years, smoker or quit smoking ≤10 years earlier, &gt;15 cigarettes per day for &gt;25 years or &gt;ten cigarettes per day for &gt;30 years</td>
<td>Low-dose CT in year 1, year 2, year 4, and year 6.5 vs no screen</td>
</tr>
<tr>
<td>LUSI(^7)</td>
<td>2007–11</td>
<td>Age 50–69 years, heavy smoking history</td>
<td>Annual low-dose CT and smoking cessation for 5 years vs smoking cessation alone</td>
</tr>
<tr>
<td>UKLS(^8)</td>
<td>2011–14</td>
<td>Age 50–75 years, ≥5% of 5-year lung cancer risk as calculated by LLP(_{2.0}) scores</td>
<td>Wald single low-dose CT screen design vs no screen</td>
</tr>
<tr>
<td>Other studies</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I-ELCAP(^14)</td>
<td>1993–2006</td>
<td>Age &gt;60 years, ≥10 PY smoker</td>
<td>Annual low-dose CT and chest x-ray for 5 years</td>
</tr>
<tr>
<td>Mayo LDCT trial(^18)</td>
<td>1999</td>
<td>Age &gt;50 years, 20 PY smoker, quit smoking &lt;10 years earlier</td>
<td>Annual low-dose CT for 5 years</td>
</tr>
<tr>
<td>PANCAN(^19)</td>
<td>2008–11</td>
<td>Age 50–75 years, ≥2% of 3-year lung cancer risk as calculated by PLCO score</td>
<td>Low-dose CT in year 1, year 2, and year 4</td>
</tr>
<tr>
<td>COSMOS(^20)</td>
<td>2000–01</td>
<td>Age &gt;50 years, ≥20 PY smoker</td>
<td>Annual low-dose CT for 10 years</td>
</tr>
</tbody>
</table>

PY=pack-year. FEV=forced respiration volume. LLP\(_{2.0}\)=Liverpool Lung Project risk model, version 2. PLCO=Prostate, Lung, Colorectal, and Ovarian trial risk model.
TABLE 2 Selection criteria, number of enrolled individuals and the rate of diagnosed lung cancer of major randomised controlled trials

<table>
<thead>
<tr>
<th>Study</th>
<th>Selection criteria</th>
<th>Patients screened n (follow-up)</th>
<th>Lung cancer diagnosed at initial screening (total in follow-up)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DLCST</td>
<td>Age years: 50–70 Tobacco smoking (delay since weaning): ≥20 pack-years (0–9 years)</td>
<td>2052 (58 months)</td>
<td>0.8% (3.4%)</td>
</tr>
<tr>
<td>DANTE</td>
<td>Age years: 60–74; only men Tobacco smoking (delay since weaning): ≥20 pack-years (0–9 years)</td>
<td>1276 (34 months)</td>
<td>2.2% (4.7%)</td>
</tr>
<tr>
<td>ITALUNG</td>
<td>Age years: 55–69 Tobacco smoking (delay since weaning): ≥20 pack-years (active or former)</td>
<td>1406 (36 months)</td>
<td>1.5% (2.8%)</td>
</tr>
<tr>
<td>MILD</td>
<td>Age years: ≥49 Tobacco smoking (delay since weaning): ≥20 pack-years (0–9 years)</td>
<td>1190 (120 months); 1186 (53 months)</td>
<td>0.8% (2.4%); 0.8% (2.4%)</td>
</tr>
<tr>
<td>NELSON</td>
<td>Age years: 50–75 Tobacco smoking (delay since weaning): ≥15 pack-years (0–9 years)</td>
<td>7907 (60 months)</td>
<td>0.9% (2.6%)</td>
</tr>
<tr>
<td>NLST</td>
<td>Age years: 55–74 Tobacco smoking (delay since weaning): ≥30 pack-years (0–15 years)</td>
<td>26722 (78 months)</td>
<td>1.1% (2.4%)</td>
</tr>
</tbody>
</table>

*: annual computed tomography; †: biannual computed tomography; ‡: NELSON inclusion criteria: number of cigarettes smoked is ≥ 15 per day for 25 years OR ≥ 10 cigarettes per day for 30 years AND still smoking or have quit <10 years ago.
MILD Trial

- 4099 ασθενείς
- Τυχαιοποίηση σε 3 σκέλη
  - 1: ετήσια παρακολούθηση (1190 ασθενείς)
  - 2: 2ετής παρακολούθηση (1186 ασθενείς)
  - 3: καμία παρακολούθηση (1723 ασθενείς)
MILD Trial

- Καπνιστές ή πρώην καπνιστές ηλικίας τουλάχιστον 49 ετών
- 20 p/y
- 10 έτη διακοπή καπνίσματος
MILD Trial

- Δεν βρέθηκε διαφορά στην θνητότητα μεταξύ των σκελών της μελέτης
- Μικρός αριθμός των ασθενών ώστε να φανεί διαφορά
- Ο ρυθμός ανίχνευσης καρκίνου του πνεύμονα για την μονοετή ή δυετή παρακολούθηση δεν ήταν στατιστικά σημαντικός (3.6% vs 2.7%)
MILD Trial

- Stage I: 53.6% - 59.2%
- Stage IV: 26.8% - 22.2%
NLST

• Τυχαιοποίηση 1:1

• 3 ετήσιες LDCT

• 3 ετήσιες ακτινογραφίες θώρακα

• Αρνητική LDCT βάσης παρακολούθησης (T0): χωρίς ευρήματα ή μέγεθος όζου < 4mm
Reduced Lung-Cancer Mortality with Low-Dose Computed Tomographic Screening

The National Lung Screening Trial Research Team*

- Πολυκεντρική τυχαιοποιημένη ελεγχόμενη μελέτη
- 53454 συμμετέχοντες
- Αύγουστος 2002 - Απρίλιος 2004
- Ηλικία 55-74 έτη
- καπνιστές ή πρώην καπνιστές
- 30 p/y
- διακοπή < 15 έτη προ της εντάξεως στη μελέτη
Αποτελέσματα

- 20% μείωση στο ποσοστό θανάτου από καρκίνο του πνεύμονα στην ομάδα LDCT (356 - 443)

- 3 φορές περισσότερα θετικά αποτελέσματα στην ομάδα LDCT

- > 50% σταδίου IA

- 320 συμμετέχοντες παρακολουθήθηκαν για να προληφθεί 1 θάνατος κατά τα 6.5 έτη περιόδου παρακολούθησης
Reduced Lung-Cancer Mortality with Low-Dose CT Screening

The decrease in the rate of death from any cause with the use of low-dose CT screening suggests that such screening is not, on the whole, deleterious. A high rate of adherence to the screening, low rates of lung-cancer screening outside the NLST, and thorough ascertainment of lung cancers and deaths contributed to the success of the NLST. Moreover, because there was no mandated diagnostic evaluation algorithm, the follow-up of positive screening tests reflected the practice patterns at the participating medical centers. A multidisciplinary team ensured that all aspects of the NLST were conducted rigorously.

There are several limitations of the NLST. First, as is possible in any clinical study, the findings may be affected by the “healthy-volunteer” effect, which can bias results such that they are more favorable than those that will be observed when the intervention is implemented in the community. The role of this bias in our results cannot be ascertained at this time. Second, the scanners that are currently used are technologically more advanced than those that were used in the trial. This difference may mean that screening with today’s scanners will result in a larger reduction in the rate of death from lung cancer than was observed in the NLST; however, the ability to detect more abnormalities may result only in higher rates of false positive results.

Third, the NLST was conducted at a variety of medical institutions, many of which are recognized for their expertise in radiology and in the diagnosis and treatment of cancer. It is possible that community facilities will be less prepared to undertake screening programs and the medical care that must be associated with them. For example, one of the most important factors determining the success of screening will be the mortality associated with surgical resection, which was much lower in the NLST than has been reported previously in the general U.S. population (1% vs. 4%).

Finally, the reduction in the rate of death from lung cancer associated with an ongoing low-dose CT screening program was not estimated in the NLST and may be larger than the 20% reduction observed with only three rounds of screening.

Radiographic screening rather than community care (care that a participant usually receives) was chosen as the comparator in the NLST because radiographic screening was being evaluated in the PLCO trial at the time the NLST was designed. The designers of the NLST reasoned that if the PLCO trial were to show a reduction in lung-cancer mortality with radiographic screening, a trial of low-dose CT screening in which a community-care group was the control would be of less value, since the standard of care would have become screening with chest radiography. Nevertheless, the choice of radiography precludes a direct comparison of low-dose CT with community care.

Analysis of the subgroup of PLCO participants who met the NLST criteria for age and smoking history indicated that radiography, as compared with community care, does not reduce mortality from lung cancer.

**Figure 1. Cumulative Numbers of Lung-Cancer and of Deaths from Lung Cancer.** The number of lung cancers (Panel A) includes lung cancers that were diagnosed from the date of randomization through December 31, 2009. The number of deaths from lung cancer (Panel B) includes deaths that occurred from the date of randomization through January 15, 2009.
Αποτελέσματα

- Θετικές τομογραφίες: 27% των τομογραφιών στους δύο πρώτους κύκλους παρακολούθησης

- 96% ψευδώς θετικά αποτελέσματα (PPV 3.8%)
NELSON

• Πολυκεντρική τυχαιοποιημένη ελεγχόμενη μελέτη
• Ολλανδία και Βέλγιο
• 15792 συμμετέχοντες
• Ηλικία 55-75 έτη
• καπνιστές ή πρώην καπνιστές
• 15 cig/d για > 25 έτη ή > 10 cig/d για > 30 έτη
• διακοπή < 10 έτη προ της εντάξεως στη μελέτη
NELSON

- Τυχαιοποίηση 1:1
- LDCT 0, 1, 3, 5.5 έτη μετά την τυχαιοποίηση
- Ομάδα ελέγχου χωρίς ακτινολογική παρακολούθηση
- Θετική LDCT: 10mm διάμετρος (50mm³ όγκος) ενδιάμεση ομάδα 5-10 mm (50-500mm³)
**Non-actionable nodules** were defined as such with benign morphology (e.g. calcification), small size (<50 mm³), and lack of or very slow growth of the solid component of a nodule with a volume doubling time (VDT) >600 days. **Indeterminate nodules** were defined as nodules with a volume of the solid component between 50 and 500 mm³, sub-solid nodules with a diameter of the ground glass component >10 mm, or solid nodules with a VDT between 400 and 600 days. **Actionable nodules** were defined as solid components >500 mm³, more than 20% growth in diameter of a ground glass component or VDT <400 days of a solid component. Non-actionable, reportable nodules were kept on regular (yearly) follow-up, indeterminate nodules were put on a more rapid follow-up of 3–6 months, while actionable nodules led to direct medical work-up.

Xu DM. et al. Nodule management protocol of the Nelson randomised lung cancer screening trial Lung Cancer 2006; 54: 177-184
Αποτελέσματα

• 26% μείωση των θανάτων από καρκίνο του πνεύμονα στους άνδρες συμμετέχοντες

• 61%, 53%, 39% μείωση στην συχνότητα θανάτου από καρκίνο του πνεύμονα στα 8, 9, 10 έτη παρακολούθησης στις γυναίκες συμμετέχοντες

• το 69% των καρκίνων που ανευρέθησαν ήταν σταδίου ΙΑ, ΙΒ

• Η χειρουργική αντιμετώπιση ήταν 3 φορές συχνότερη στην ομάδα μελέτης σε σύγκριση με την ομάδα ελέγχου (67.7% vs 24.5%, P<0.001)
Αποτελέσματα

• Θετικές τομογραφίες: 2.7%

• Ψευδώς θετικά αποτελέσματα: 59% (PPV 40.4%)
were independently developed in five institutions: Erasmus Medical Center (Rotterdam), Fred Hutchinson Cancer Research Center (Seattle), Massachusetts General Hospital (Boston), Stanford University (Stanford), and University of Michigan (Ann Arbor). All account for the individual’s age-specific smoking-related risk for lung cancer, date and stage of lung cancer diagnosis, the corresponding lung cancer mortality and the individual’s life expectancy in the presence and absence of screening. The most advantageous strategy identified is the annual screening from ages 55 through 80 years for ever-smokers with a smoking history of at least 30 pack-years and ex-smokers with less than 15 years since quitting. That approach would lead to 50% of cases of cancer being detected at an early stage (stage I/II), 575 screening examinations per lung cancer death averted, a 14% reduction in lung cancer mortality, 497 lung cancer deaths averted, and 5250 life-years gained per the 100 000-member cohort. Harms would include 67 550 false-positive test results, 910 biopsies or surgeries for benign lesions, and 190 overdiagnosed cases of cancer (3.7% of all cases of lung cancer).

So far there are no good risk predictors for nonsmokers and no convincing data to recommend screening. Lung cancer in never smokers is the seventh leading cause of cancer mortality and therefore is a significant cause of death worldwide. The main risk factors include age, environmental tobacco exposure, cooking fumes, inherited genetic susceptibility, occupational and environmental exposure to carcinogens, hormonal factors, pre-existing lung disease and oncogenic viruses [40]. Nonsmall cell lung cancer (NSCLC) in never smokers is clinically characterised by an increased incidence in females and a higher occurrence of adenocarcinoma in comparison to NSCLC in ever smokers in both surgical patients and non-resectable advanced stage patients [41]. Even though those factors are known, there is no beneficial screening programme for lung cancer among this population.

False positives and complications during work-up

With modern multidetector CT, pulmonary nodules are detectable at a size of less than 2 mm. Small nodules are extremely common but the vast majority of these nodules are benign. Given this fact, the definition of a positive screening result determines the number of false-positive results. On average, about 25% of the thoracic surgical procedures performed during the various randomised controlled lung cancer screening trials were done for benign nodules [21]. If there are fewer false-positive nodules, there is less need for further work-up and the risk of complications, especially from invasive diagnostic examinations including surgery.

### TABLE 3 Risk prediction models used in different lung cancer screening trials

<table>
<thead>
<tr>
<th>Model</th>
<th>Risk factors included</th>
<th>Period of prediction of lung cancer diagnosis or death</th>
<th>Reference for algorithm</th>
</tr>
</thead>
<tbody>
<tr>
<td>LLP (detection)</td>
<td>Age, Sex, Years of smoking, Family history of lung cancer by age of affected relatives, History of a previous cancer, History of pneumonia, History of exposure to asbestos</td>
<td>5 years</td>
<td>RAJJEI et al. [36]</td>
</tr>
<tr>
<td>PLCO (detection)</td>
<td>Age, Race/ethnicity, Education, Body mass index, Chronic obstructive pulmonary disease, Personal history of cancer, Family history of lung cancer, Smoking status (current versus former), Smoking intensity [average cigarettes/day], Smoking duration, Smoking quit time</td>
<td>6 years</td>
<td>TAMMENAGI et al. [37]</td>
</tr>
<tr>
<td>NLST (death)</td>
<td>Age, Sex, Ethnicity, Body-mass index, Pack-years of smoking, Years since smoking cessation, Presence of emphysema, First-degree relative with lung cancer</td>
<td>5 years</td>
<td>KOVALCHIK et al. [38]</td>
</tr>
</tbody>
</table>

Liverpool Lung Project (LLP) risk prediction model is used in the UKLS screening trial

PLCO2012 (Prostate, Lung, Colorectal, and Ovarian) randomised trial

NLST trial.
controlled trials from Denmark (DLST) and Italy (Italung, DANTE and MILD). These trials involved approximately 1000–2000 patients in each arm [10]. Published results suggest no advantage for lung cancer screening. In fact, DLST and MILD even found a trend towards higher mortality in the yearly CT screening arms [11, 12]. Other current randomised controlled trials are the German Lung Screening and Intervention (LUSI) trial and the UK Lung Screening (UKLS) trial [13, 14].

Current recommendations

There is a wide range of acceptance of the general lung cancer screening algorithm using LDCT across the globe; however, different degrees of modification from the NLST algorithm seem to be required (table 1) [5]. From February 2012, the Lung Cancer Screening Panel of the National Comprehensive Cancer Network (NCCN) in the USA recommended annual LDCT screening of all high risk individuals between the age of 55 and 74 years, as defined in the NLST [15]. However, the NCCN guidelines expanded the NLST criteria based on non-randomised studies and observational data. Individuals 50 years of age or older with a tobacco smoking history of 20 or more pack-years and one additional risk factor should be annually screened. The suggested additional risk factors were history of cancer, history of lung disease (chronic obstructive pulmonary disease (COPD) or pulmonary fibrosis), family history of lung cancer, radon exposure and occupational exposure. The NCCN currently does not advise screening of individuals at moderate and low risk for lung cancer or for individuals with exposure to second-hand smoke [16].

A collaborative initiative of the American Cancer Society [17], the American College of Chest Physicians (ACCP), the American Society of Clinical Oncology [18], and the NCCN published a review of LDCT screening for lung cancer together with clinical practice guidelines in May 2012 [10]. They adopt the NLST eligibility criteria, but note that the duration and frequency of screening remain undetermined [18]. In June 2012, guidelines for lung cancer screening were issued by the American Association for Thoracic Surgery (AATS) [19], expanding the criteria beyond the NLST. The AATS guidelines consider the amount of tobacco exposure and age to be the most important risk factors and therefore do not restrict screening to patients who quit smoking in the previous 15 years. Since the risk of lung cancer does not decrease after 3 years of screening, the AATS recommends annual LDCT screening for high risk patients from age 55 to

<table>
<thead>
<tr>
<th>Guidelines by organisation</th>
<th>Date</th>
<th>Age years</th>
<th>Smoking history pack-years</th>
<th>Smoking cessation years</th>
<th>Category/level</th>
</tr>
</thead>
<tbody>
<tr>
<td>NCCN</td>
<td>Jan 2015</td>
<td>55–74</td>
<td>≥30</td>
<td>&lt;15</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥50</td>
<td>≥20 (and one additional risk factor#)</td>
<td></td>
<td>2A</td>
</tr>
<tr>
<td>ALA</td>
<td>Apr 2012</td>
<td>55–74</td>
<td>≥30</td>
<td>&lt;15</td>
<td>NA</td>
</tr>
<tr>
<td>Collaborative work of ACCP/ASCO/NCCN</td>
<td>May 2012</td>
<td>55–74</td>
<td>≥30</td>
<td>&lt;15</td>
<td>2B</td>
</tr>
<tr>
<td>AATS</td>
<td>June 2012</td>
<td>55–79</td>
<td>≥30</td>
<td>Any active or former smoker</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>50–79</td>
<td>≥20 and added risk ≥5% of developing lung cancer within 5 years¶</td>
<td>Any and ≥4 years remission after bronchogenic carcinoma</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Any</td>
<td>Any active or former smoker</td>
<td>Any and ≥4 years remission after bronchogenic carcinoma</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>ACS</td>
<td>Jan 2013</td>
<td>55–74</td>
<td>≥30</td>
<td>&lt;15</td>
<td>NA</td>
</tr>
<tr>
<td>ACCP</td>
<td>May 2013</td>
<td>55–74</td>
<td>≥30</td>
<td>&lt;15</td>
<td>2B</td>
</tr>
<tr>
<td>USPSTF</td>
<td>July 2013</td>
<td>55–79</td>
<td>≥30</td>
<td>&lt;15</td>
<td>B</td>
</tr>
</tbody>
</table>

European position statement on lung cancer screening

Figure 3: Nodule management protocol for screen-detected solid nodules at baseline
For nodules with a volume-doubling time (VDT) of 400–600 days (intermediate cancer risk of about 4%), a second repeat CT scan in 3 months should be considered as an initial work-up option.
Newly identified solid non-calcified nodule not present on the previous CT screening

Clear features of benign disease?

Yes

Next round of screening according to protocol

No

Volumetry (or diameter measurement if volumetry is not available or not technically possible)

<30 mm³ volume or <4 mm diameter

Nodule resolution, benign calcification, or significantly decreased size

30 to <200 mm³ volume or 4 to <8 mm diameter

Stable size on basis of volumetry or two-dimensional non-automated diameter value

≥200 mm³ volume or ≥8 mm diameter

Further work-up and consideration of definitive management

CT scan 3 months after detection

≥200 mm³ volume or ≥8 mm diameter

VDT >600 days and <200 mm³ volume or <8 mm diameter

Management according to category at 3 months

VDT ≤600 days or ≥200 mm³ volume or ≥8 mm diameter

Next round of screening according to protocol

Figure 4: Nodule management protocol for screen-detected incidental solid nodules at follow-up

VDT=volume doubling time.
European position statement on lung cancer screening

Baseline volumetric analysis (or diameter measurement if volumetric is not available or not technically possible)

- 5–6 mm diameter
- ≥80 mm³ volume or ≥6 mm diameter

CT scan 1 year after baseline

CT scan 3 months after baseline

CT scan 2 years after baseline

Stable on basis of two-dimensional non-automated diameter value

Stable size on basis of volumetry

VDT >600 days

VDT 400–600 days

VDT ≤400 days or clear evidence of growth

VDT assessment and manage according to VDT category at 1 year; discharge if stable

Discharge

Consider discharge (only if based on volumetry) or ongoing CT surveillance depending on patient preference

Consider biopsy or further CT surveillance depending on patient preference

Further work-up and consideration of definitive management

Figure 5: Nodule management protocol for clinically detected solid nodules according to British Thoracic Society guidelines

VDT = volume doubling time. Reproduced with permission from Callister and colleagues.⁶⁴
European position statement on lung cancer screening

Figure 6: Management protocol for sub-solid nodules for both screen-detected and clinically detected nodules according to British Thoracic Society guidelines

Reproduced with permission from Callister and colleagues. Change in mass or a new solid component. The Brock model can underestimate the risk of malignancy in sub-solid nodules that persist at 3 months. The size of the solid component in part-solid nodules, pleural indentation, and bubble-like appearance.
Next to LDCT characteristics of pulmonary nodules, presence of CT imaging biomarkers for COPD at the LDCT, expressed in emphysema score and bronchial wall thickness, might be helpful in identification of participants at highest lung cancer risk. Participants with more severe emphysema were found to be at higher risk of lung cancer development.

In the Brock model for the assessment of a lung nodule's cancer probability (28), presence or absence of emphysema on the CT scan as reported by a radiologist is included as an independent predictor. Additional studies have shown a strong correlation between CT imaging biomarkers for COPD and lung cancer diagnosis (29-31).

Recently, a study showed that selecting eligible lung cancer screening participants by adding the presence of CT-quantified emphysema to the NLST selection criteria lead to a decreased number needed to screen to select one lung cancer patient (32,33).

More knowledge on the relationship of the degree of CT-quantified emphysema and bronchial wall thickness and lung cancer probability and mortality is needed to evaluate its possible role in risk stratification of lung cancer screening participants.

**Conclusions**

Currently, evidence is available for lung cancer screening by annual LDCT alone. However, based on retrospective analyses of the largest randomized-controlled lung cancer screening trials, a subset of participants with a low 2-year lung cancer probability as extracted from their baseline screen may be safely followed after a prolonged screening interval (optimal screening interval probably between 1 and 2 years) until their risk profile changes. In case a new pulmonary nodule appears at subsequent screening, or a small baseline nodule starts growing, participants should always return to annual LDCT screening after the appropriate workup.

**Acknowledgements**

None.

**Footnote**

Conflicts of Interest: The authors have no conflicts of interest to declare.

**References**


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**Table 1** Risk stratification based on presence of pulmonary nodules

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-high lung cancer risk (consider prolonged screening interval between 1 and 2 years)</td>
<td>No baseline nodules&lt;br&gt; Solid baseline nodule (&lt;100 mm$^3$ or &lt;5 mm)&lt;br&gt; New nodule (&lt;30 mm$^3$ or &lt;4 mm)&lt;br&gt; Stable subsolid nodule, any size</td>
</tr>
<tr>
<td>High lung cancer risk (short-term follow-up, if negative annual screening interval)</td>
<td>Solid baseline nodule (100–300 mm$^3$ or 5–10 mm)&lt;br&gt; New solid nodule (30–200 mm$^3$ or 4–8 mm)&lt;br&gt; Growing solid nodule (VDT 400–600 days)&lt;br&gt; Subsolid nodule, baseline or new, any size*</td>
</tr>
<tr>
<td>Very high lung cancer risk (referral for workup, if negative annual screening)</td>
<td>Solid baseline nodule (&gt;300 mm$^3$ or &gt;10 mm)&lt;br&gt; New solid nodule (&gt;200 mm$^3$ or &gt;8 mm)&lt;br&gt; Growing solid nodule (VDT &lt;400 days)&lt;br&gt; Subsolid nodule showing growth or altered morphology</td>
</tr>
</tbody>
</table>

* in case of negative follow-up CT (no growth), consider prolonged screening interval between 1 and 2 years. VDT, volume doubling time.
Lung Cancer Screening

The NCCN Panel does not recommend lung cancer screening for individuals at low risk for lung cancer.

Risk Status

- Low Risk: Smoking status, age, and family history are the main factors associated with risk.
- Moderate Risk: Additional factors include history of exposure to other carcinogens, COPD, or pulmonary fibrosis.
- High Risk: Factors such as age, prior history of smoking, and family history of lung cancer.

LDCT in the NLST, new cases (367 cases) of lung cancer were diagnosed during the 3.5 years of follow-up (median of 6.5 years).

The NCCN Guidelines suggest annual screening LDCT for individuals at moderate risk for lung cancer. The NCCN Panel does not recommend lung cancer screening for these individuals at low risk for lung cancer.

The efficacy of screening is uncertain. Risk factors may change over time in individuals with high risk.

LDCT Protocols and Imaging Modalities

Nonsolid nodules are mainly composed of ground glass or ground glass and solid components. Most nodules are composed of ground glass opacities (GGOs) or glass and solid components. Many nonsolid nodules can resolve, although they need to be followed.

NCCN Guidelines Index

1. Assessing Risk for Malignancy in Nodules
2. LDCT Protocols and Imaging Modalities
3. Accuracy of Nodules
4. Nodules and Suspicion of Lung Cancer
5. Differentiation of Nodules
6. Risk Factors
7. Lung Cancer Screening
8. Risk Status
9. LDCT in the NLST
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**RISK**

- Disease history (COPD or)
- Family history of lung cancer
- Cancer history
- Smoking history
- Lung Cancer Survivors
- Absence of symptoms
- Pulmonary relatives

Cancer

Non-Small Cell Lung Cancer (see Surveillance in the Guidelines)

appropriate NCCN Guidelines (if symptoms, see or signs of lung cancer or smoking-related cancers).

Guidelines for Smoking Cessation.

Documented sustained and substantially elevated radon exposure.

There is increased risk of developing new primary lung cancer among all current smokers should be advised to quit smoking, and former smokers should be advised to remain abstinent from smoking. For smokers recommended for lung cancer screening.

 LTCG

Lung cancer screening is appropriate to consider for high-risk patients smoking history should to http://www.smokefree.gov

Use a multidisciplinary approach that includes the specialties of thoracic and other cancer-risk-calculator

Lung cancer-risk-calculator

Shared decision-making aids may assist in determining if screening should be considered. Chest x-ray is not used as a screening tool. Chest x-ray is not used to assist in quantifying risk for lung cancer. Therefore, second-hand smoke is not considered a substitute for smoking cessation. Smoking history should be included in the patient medical history. Lung cancer screening should not be recommended for lung cancer screening.

Shared patient/physician discussion of benefits and harms of screening should be discussed. Chest x-ray is not used as a screening tool. Chest x-ray is not recommended until patient is no longer a smoker.

**SCREENING FINDINGS**

- Lung nodule(s)
- Solid nodule
- Part-solid nodule
- Non-solid nodule
- Multiple non-solid nodules
- Solid nodule on initial screening LDCT
- Non-solid nodule on initial screening LDCT
- Solid nodule on follow-up or annual screening LDCT
- Non-solid nodule on follow-up or annual screening LDCT
- Part-solid nodule on follow-up or annual screening LDCT
- Multiple non-solid nodules

**ASSESSMENT**

- >20 pack-year history of smoking
- Age <50 y and/or additional risk factors (other than smoking)
- Age ≥ 50 y and ≥ 30 pack-year history of smoking
- Additional risk factors (other than smoking)

There should be a substantial uncertainty exists about the true benefit of screening. Therefore, second-hand smoke is not recommended until patient is no longer a smoker. For smokers recommended for lung cancer screening.

**SCREENING FINDINGS**

- Lung nodule(s)
- Solid nodule
- Part-solid nodule
- Non-solid nodule
- Multiple non-solid nodules
- Solid nodule on initial screening LDCT
- Non-solid nodule on initial screening LDCT
- Solid nodule on follow-up or annual screening LDCT
- Non-solid nodule on follow-up or annual screening LDCT
- Part-solid nodule on follow-up or annual screening LDCT
- Multiple non-solid nodules

**Initial screening LDCT**

- Lung nodule(s) on LDCT

**Follow-up or annual screening LDCT**

- Lung nodule(s) on LDCT

**LCS-2**

Lung nodule(s) on LDCT

**Initial screening LDCT**

- Lung nodule(s) on LDCT

**Follow-up or annual screening LDCT**

- Lung nodule(s) on LDCT

**LCS-2**
EVALUATION OF SCREENING FINDINGS

FOLLOW-UP OF SCREENING FINDINGS

≤5 mm

Annual screening LDCT until patient is no longer a candidate for definitive treatment

6–7 mm

LDCT in 6 mo

8–14 mm

LDCT in 3 mo

≥15 mm

LDCT in 3 mo

Solid nodule on initial screening LDCT

Low suspicion of lung cancer

High suspicion of lung cancer

Biopsy or Surgical excision

No cancer

Cancer confirmed

See appropriate NCCN Guidelines

Annual screening LDCT until patient is no longer a candidate for definitive treatment

≤≥5 mm

LDCT in 6 mo

LDCT in 3 mo

LDCT in 3 mo

Chest CT ± contrast and/or PET/CT

Solid endobronchial nodule

LDCT in 1 mo (immediately after vigorous coughing)

If no resolution

Bronchoscopy

See Evaluation (LCS-7†)
EVALUATION OF SCREENING FINDINGS

Part-solid nodule(s) on follow-up or annual LDCT

Unchanged on follow-up LDCT

Unchanged on annual LDCT

New

New or Growing (>1.5 mm in solid component)

FOLLOW-UP OF SCREENING FINDINGS

≤5 mm → Annual LDCT

≥6 mm with 6–7 mm solid component → Annual LDCT

≥6 mm with ≥8 mm solid component → Annual LDCT

≤5 mm → LDCT in 6 mo

≥6 mm with growing ≤3 mm solid component → LDCT in 6 mo

≥4 mm solid component → Chest CT ± contrast and/or PET/CT

Annual LDCT

Low suspicion of lung cancer → LDCT in 3 mo

High suspicion of lung cancer → LDCT in 3 mo

Biopsy or Surgical excision

No cancer → Cancer confirmed

See appropriate NCCN Guidelines
Lung Cancer Screening, Version 3.2018

Clinical trials: NCCN believes that the best management of any patient with cancer is in a clinical trial. Participation in clinical trials is especially encouraged.

All recommendations are category 2A unless otherwise indicated.

Without benign pattern of calcification, fat in nodule suggestive of hamartoma, or features suggesting inflammatory etiology.

When multiple nodules or other findings are present that suggest occult infection or inflammation is a possibility, suggest follow-up LDCT in 1–3 months.

Nodules should be measured on lung windows and reported as the average diameter rounded to the nearest whole number; for round nodules only a single diameter measurement is necessary. Mean diameter is the mean of the longest diameter of the nodule and its perpendicular diameter.

Rapid increase in size should raise suspicion of inflammatory etiology or malignancy other than non-small cell lung cancer (see LCS-6†).

It is crucial that all nonsolid lesions be reviewed at thin (<1.5 mm) slices to exclude any solid components. Any solid component in the nodule requires management of the lesion with the part-solid recommendations (see LCS-4 or LCS-8†).

All screening and follow-up chest CT scans should be performed at low dose (100–120 kVp and 40–60 mAs or less), unless evaluating mediastinal abnormalities or lymph nodes, where standard dose CT with IV contrast might be appropriate (see LCS-A).

There should be a systematic process for appropriate follow-up.

Non-solid nodule on initial screening LDCT:

- ≤19 mm
  - Annual screening LDCT until patient is no longer a candidate for definitive treatment

- ≥20 mm
  - LDCT in 6 mo
  - See Evaluation (LCS-9†)

See NCCN Guidelines for Non-Small Cell Lung Cancer†

†Available online, in these guidelines, at NCCN.org.

*To view the most recent version of these guidelines, visit NCCN.org.
EVALUATION OF SCREENING FINDINGS

FOLLOW-UP OF SCREENING FINDINGS

New

- ≤19 mm → Annual LDCT<sup>k,n</sup>
- ≥20 mm → LDCT in 6 mo<sup>k</sup> → Stable → Annual LDCT<sup>k,o</sup>

Stable

- ≤19 mm → Annual LDCT<sup>k,n</sup>
- ≥20 mm → LDCT in 6 mo<sup>k</sup> → Stable → Annual LDCT<sup>k,o</sup>

Growing (≥1.5 mm)

- ≤19 mm → LDCT in 6 mo<sup>k</sup>
- ≥20 mm → LDCT in 6 mo<sup>k</sup> or Consider biopsy<sup>r,s,t</sup> or Surgical excision<sup>t</sup>

No cancer
- No cancer → Annual LDCT until patient is no longer a candidate for definitive treatment<sup>k,n</sup>

Cancer confirmed
- Cancer confirmed → See appropriate NCCN Guidelines

Note: All recommendations are category 2A unless otherwise indicated.
Multiple nonsolid nodules

- Without benign pattern of calcification, fat in nodule suggestive of hamartoma, or features suggesting inflammatory etiology. When multiple nodules or other findings are present that suggest occult infection or inflammation is a possibility, suggest follow-up LDCT in 1–3 months.

Nodules should be measured on lung windows and reported as the average diameter rounded to the nearest whole number; for round nodules only a single diameter measurement is necessary. Mean diameter is the mean of the longest diameter of the nodule and its perpendicular diameter.

- Rapid increase in size should raise suspicion of inflammatory etiology or malignancy other than non-small cell lung cancer (see LCS-6).

- It is crucial that all nonsolid lesions be reviewed at thin (<1.5 mm) slices to exclude any solid components. Any solid component in the nodule requires management of the lesion with the part-solid recommendations (see LCS-4 or LCS-8).

See NCCN Guidelines for Non-Small Cell Lung Cancer

EVALUATION OF SCREENING FINDINGS

FOLLOW-UP OF SCREENING FINDINGS

<table>
<thead>
<tr>
<th>Pure nonsolid nodules</th>
<th>Measure the largest nodule and manage based on LCS-5 or LCS-9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple nonsolid nodules</td>
<td>Measure the largest nodule and manage based on LCS-4 or LCS-8</td>
</tr>
<tr>
<td>Dominant nodule(s) with part-solid component</td>
<td>Measure the largest nodule and manage based on LCS-5 or LCS-9</td>
</tr>
</tbody>
</table>

LCS-10
Lung Cancer Screening: A Clinician’s Checklist

This checklist was developed to help clinicians meet the Centers for Medicare & Medicaid Services (CMS) criteria for a lung cancer screening counseling and shared decisionmaking visit. All of the criteria listed below must be met for the screening to be covered as a preventive service benefit under Medicare.

Before…

The Clinical Encounter
Determine patient’s eligibility.
This checklist may be completed with the assistance of a nurse, physician assistant, or other medical assistant.

- Is the patient 55 to 77 years old? Yes No
  (55 to 80 years old for patients with private insurance)
- Is the patient a current smoker or former smoker who has quit within the past 15 years? Yes No
- Does the patient have at least a 30 pack-year smoking history? Yes No
  (See the calculator below.)
- Is the patient asymptomatic for lung cancer with no personal history of lung cancer? Yes No
- Is the patient healthy enough to have lung surgery? Yes No
- Is the patient willing to receive potentially curative treatment? Yes No

During…

The Clinical Encounter
Complete all of the following activities.

- Documented all elements in the patient’s medical chart.
  - Used a decision aid
- Discussed potential benefits of lung cancer screening:
  - Reduced mortality from lung cancer
- Discussed potential harms of lung cancer screening, including:
  - False-positive results
  - Followup testing if an abnormality is found (and the possible complications of invasive testing)
  - Overdiagnosis
  - Total radiation exposure (screening and diagnostic testing, cumulative)
- Discussed other issues:
  - The impact of comorbidities on screening (the benefit of screening is reduced in patients with poor health)
  - The patient’s ability or willingness to undergo invasive diagnostic procedures and treatment
- Counseled about:
  - The importance of adherence to annual lung cancer screening
  - The importance of maintaining cigarette smoking abstinence or smoking cessation, as applicable
  - Tobacco cessation interventions (provided information, if appropriate)

After…

The Clinical Encounter
Establish the next steps.
If the patient would like screening, provide a written order for the lung cancer screening visit with the following elements:

- Patient’s date of birth
- Actual pack-year smoking history
- Current smoking status; for former smokers, the number of years since quitting
- Statement that the patient is asymptomatic
- National Provider Identifier (NPI) of the ordering practitioner

If the patient declines screening, document the discussion and the patient’s decision in his or her medical record.

If the patient is unsure about screening or wants more time, consider scheduling a followup visit to discuss the patient’s screening decision.

For all patients, reinforce the importance of smoking cessation and abstinence.

Screening is not recommended. If the patient is a current smoker, encourage smoking cessation and provide resources. If the patient is a former smoker, encourage continued abstinence and provide additional support if needed.

Symptomatic patients may need followup and diagnostic testing, but not screening. Patients with a history of lung cancer need surveillance, but not screening.

Calculate Pack-Years
(20 cigarettes = 1 pack)

Number of years smoked × Average number of packs smoked per day = Pack-years
The importance of shared decisionmaking

Lung cancer screening with low-dose computed tomography (LDCT) reduces mortality from lung cancer. There are also potential harms associated with lung cancer screening, including a high-false positive rate and the associated need for diagnostic followup, known and unknown risks of additional testing associated with incidental findings, cumulative radiation exposure, and overdiagnosis. Shared decisionmaking is a collaborative patient-centered process in which patients and clinicians make decisions together, within the context of the best evidence and recommendations and based on the patient’s values and preferences.

Tips To Promote a Shared Decision

Below is a five-step process for shared decisionmaking that includes exploring and comparing the possible benefits and harms of each option through meaningful dialogue about what matters most to the patient.

**STEP 1:** Seek your patient’s participation in the decisionmaking process.

**STEP 2:** Help your patient explore and compare the potential benefits and harms of lung cancer screening, and assess your patient’s level of understanding. (See the teach-back examples in the box to the far right.)

**STEP 3:** Assess your patient’s values and preferences about lung cancer screening.

**STEP 4:** Reach a decision about lung cancer screening with your patient.

**STEP 5:** Evaluate your patient’s feelings about the decision by having a followup discussion.

Talking Points

Below are specific points to address during the clinical encounter.

- Lung cancer screening can be effective if patients 1) follow the screening protocol, 2) undergo diagnostic followup procedures after a positive screening result, and 3) receive treatment, which has potential harms.

- Screening does not mean that smoking is OK. Smoking still causes lung cancer, cardiovascular disease, and other lung disease.

- Screening can lead to early treatment that can prevent some, but not all, lung cancer deaths.

- False-positive results (“false alarms”) are common, and additional scans or invasive procedures may be needed. Less commonly, major complications of invasive procedures can occur, including bleeding, infection, or a collapsed lung.

- Lung cancer screening may find lung cancer that would not have ever caused symptoms or harmed the patient in his or her lifetime if the cancer had not been found. This could lead to treatment of people who do not really need treatment.

- Screening and followup testing exposes patients to radiation. The harms associated with cumulative radiation exposure are unknown.

- Screening should stop if the patient 1) exceeds the upper age criterion, 2) no longer wants screening, 3) has a worsening health condition that limits their life expectancy or increases the risk of complications from lung surgery, or 4) has not smoked for 15 years.

Teach-Back Examples

“I know I have given you a lot of information. Tell me in your own words what you have heard.”

“What are your thoughts about lung cancer screening?”

“Let’s stop right there for a moment. What questions or comments do you have about the information I have given you?”

Referral Information

To find a radiology imaging facility that meets the CMS eligibility criteria, please visit:

[www.cms.gov/Medicare/Medicare-General-Information/MedicareApprovedFacilities/Lung-Cancer-Screening-Registries.html](http://www.cms.gov/Medicare/Medicare-General-Information/MedicareApprovedFacilities/Lung-Cancer-Screening-Registries.html)

Ordering Information

*Lung Cancer Screening with Low-Dose Computed Tomography (LDCT): Tools for Primary Care Clinicians,* is a free multicomponent resource to support decisionmaking about lung cancer screening in the primary care setting. For electronic copies of this multicomponent resource, visit [www.effectivehealthcare.ahrq.gov/LCS/](http://www.effectivehealthcare.ahrq.gov/LCS/)

AHRQ Publication No. 16-EHC007-11
March 2016
Is Lung Cancer Screening Right for Me?

A decision aid for people considering lung cancer screening with low-dose computed tomography (LDCT). Before deciding, you should think about the possible benefits and harms of lung cancer screening. This decision aid will help prepare you to talk with your health care professional about whether lung cancer screening is right for you.

What are the facts about lung cancer?
- Lung cancer is the leading cause of cancer death in the United States. Each year, about 220,000 people are diagnosed with lung cancer and 150,000 people die from lung cancer.
- About half of the people diagnosed with lung cancer are 70 years of age or older. The typical age of death from lung cancer is 72 years.

What is lung cancer?
Lung cancer happens when abnormal cells form in the lungs and grow out of control. These cells can form a tumor and can spread to other parts of the body. Lung cancer is often diagnosed once it has spread outside the lungs. About 9 out of every 10 people with lung cancer die from the disease because it is found after it has spread.

Possible signs and symptoms of lung cancer
- A new cough that does not go away or gets worse
- Chest pain that is often worse when you breathe deeply, cough, or laugh
- A hoarse voice
- Unexplained weight loss and loss of appetite
- Coughing up blood or rust-colored spit or phlegm
- Shortness of breath
- Infections such as bronchitis and pneumonia that do not go away or keep coming back
- Wheezing

Many patients with lung cancer do not have any symptoms when the cancer first starts. It is best to find lung cancer early before symptoms start, when the cancer is more easily treated. This is why screening is important.

If you have any signs or symptoms of lung cancer, be sure to tell your health care professional.

Calculating pack-years

(20 cigarettes = 1 pack)

Number of years smoked

Average number of packs smoked per day

Pack-years

* Your health care professional can help you determine the number of pack-years you have smoked.

Remember, the best way to lower your chances of dying from lung cancer is to stop smoking.

More than 8 out of every 10 lung cancer cases in the United States are from smoking.

Lung cancer screening should not be done instead of quitting smoking. If you currently smoke, talk to your health care professional or call the nationwide quit line at 1-800-QUIT-NOW (1-800-784-8669).

Who should be screened for lung cancer?
The United States Preventive Services Task Force (USPSTF) is made up of experts in preventive medicine. Without pay, they review the current research to make recommendations about clinical preventive services such as screening, counseling, and preventive medications.

The USPSTF recommends lung cancer screening for individuals who:
- Are 55 to 80 years old
- Do not have any signs or symptoms of lung cancer (diagnostic testing may be recommended for people who do have signs or symptoms of lung cancer)
- Have not had lung cancer before
- Currently smoke or quit less than 15 years ago
- Are or were heavy smokers (30 pack-years history such as those who smoked 1 pack per day for 30 years or 2 packs per day for 15 years)

The USPSTF does not recommend lung cancer screening for individuals who:
- Have a condition that greatly limits how long they may live
- Are not willing to have surgery for lung cancer

Your health care professional can help you determine the number of pack-years you have smoked.

A new cough that does not go away or gets worse
Chest pain that is often worse when you breathe deeply, cough, or laugh
A hoarse voice
Unexplained weight loss and loss of appetite
Coughing up blood or rust-colored spit or phlegm
Shortness of breath
Infections such as bronchitis and pneumonia that do not go away or keep coming back
Wheezing

The best way to lower your chances of dying from lung cancer is to stop smoking.
What are the possible benefits and harms of lung cancer screening with LDCT?

**BENEFIT: Greater chance of not dying from lung cancer**
- If 1,000 people are not screened with LDCT for lung cancer, 21 will die from lung cancer.
- If 1,000 people are screened with LDCT once a year for 3 years, 18 will die from lung cancer.
- This means that with LDCT screening, 3 fewer people will die from lung cancer.

**BENEFIT: Greater chance of not dying from any cause (not just lung cancer)**
- If 1,000 people are not screened with LDCT for lung cancer, 75 will die from any cause.
- If 1,000 people are screened with LDCT once a year for 3 years, 70 will die from any cause.
- This means that with LDCT screening, 5 fewer people will die from all causes.

**HARM: False alarms and unneeded additional testing**
A false alarm happens when a person has a positive screening test but does not actually have lung cancer.
- If 1,000 people are screened every year for 3 years, about 356 will have a false alarm.
- Of these 356 people with a false alarm, 18 will have an invasive procedure such as a biopsy (a tiny piece of lung tissue is removed to test for cancer).
- Of these 18 people, less than 1 will have a major complication as a result of the procedure, such as bleeding in the lung, a collapsed lung, or an infection.

### Out of 1,000 people screened with LDCT for lung cancer:
- 3 lung cancer deaths will be prevented.
- 18 people will die of lung cancer.

### Out of 1,000 people not screened with LDCT for lung cancer:
- 21 people will die of lung cancer.

The benefits of lung cancer screening may be greater if your lung cancer risk is higher. For example, current smokers who smoke more than one pack a day have a higher risk for lung cancer than smokers who quit 10 years ago.

### Out of 1,000 people screened with LDCT for lung cancer:
- 356 people will get a "false alarm."
- 18 of the people who get a "false alarm" will have an invasive procedure like a biopsy.
- Less than 1 of the 18 people who have an invasive procedure will have a major complication (e.g., infection, bleeding in lung, collapsed lung).

### Out of 1,000 people not screened with LDCT for lung cancer:
- 21 people will die of lung cancer.

The harms of lung cancer screening may be greater if you have other health problems, such as heart disease or severe lung disease like asthma or chronic obstructive pulmonary disease (COPD). The risk of problems from biopsies may be higher in these people.

What is lung cancer screening with low-dose computed tomography?
During an LDCT scan, you lie on a table and an x-ray machine uses a low dose (amount) of radiation to make detailed images of your lungs. The scan only takes a few minutes and is not painful.
HARM: Overdiagnosis
Lung cancer screening may find a lung cancer that would not have ever caused symptoms or harmed the patient in his or her lifetime if the cancer had not been found. This could lead to treatment of people who do not really need treatment. At the time of diagnosis, there is no way for health care professionals to know if the lung cancer will cause health problems over a lifetime. For this reason, almost all people who are diagnosed with lung cancer are treated. Researchers found that out of every 10 people diagnosed with lung cancer after an LDCT scan, about 1 to 2 of those people are treated for cancer that likely never would have harmed them.

HARM: Radiation exposure
Exposure to radiation increases a person’s chance of developing cancer. LDCT screening for lung cancer exposes a person to radiation. If the screening test is positive, additional testing may involve higher doses of radiation. Researchers do not know how being exposed to radiation from LDCT scans and additional diagnostic imaging tests may affect people. The figure below shows the amount of radiation from one LDCT scan compared with other sources of radiation.

Finding other things that are not lung cancer
Screening can find heart disease or thickened tissue in the lungs from scarring. Researchers do not know the possible benefits or harms of finding other things about your health through lung cancer screening.

What is the difference between screening and diagnostic testing?
Screening is a medical term for testing to find a disease before it causes any symptoms or problems. Lung cancer screening is done to find lung cancer before it has spread.

Diagnostic testing is not the same as screening. Diagnostic testing is done when someone has signs or symptoms of lung cancer or when a screening test finds something that looks like cancer. In both cases, there is a higher chance the person has lung cancer, and additional testing is done to get a final diagnosis. It is different from screening because it can involve scans with higher amounts of radiation, other tests to look at the lungs, and taking samples of lung tissue.
ΣΑΣ ΕΥΧΑΡΙΣΤΩ