JOHNS HOPKINS MEDICINE

Insights on CT Lung Screening and Radiation Dose

M. Mahesh, MS, PhD, FAAPM, FACR, FACMP, FSCCT, FIOMP

Professor of Radiology and Cardiology
Johns Hopkins University School of Medicine
Joint Appointment - Johns Hopkins School of Public Health
Baltimore, MD, USA

@mmahesh1

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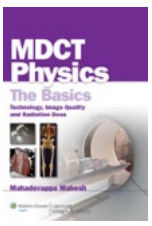

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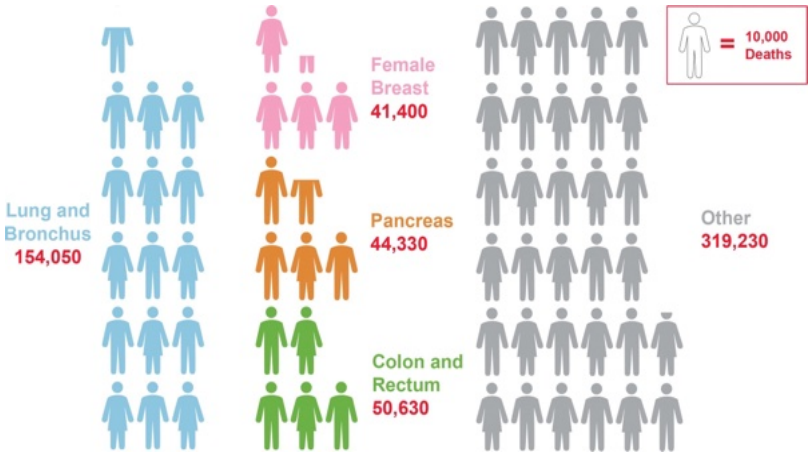
Estimated Cancer Deaths in the US in 2018



Radiology

https://doi.org/10.1148/radiol.2018180212

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Outline

- National Lung Screening Trial (NLST)
- Low Dose CT (LDCT) protocol
- Benefits vs Harms
- Radiation Exposure Concerns
- New USPSTF recommendations
- Barriers to lung cancer screening

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National Lung Screening Trial[1] (NLST)

- 53,400 with half assigned for LDCT and half for chest radiograph
- 55-74 years of age, history of smoking of ~30 pack years* and former smokers quit within 15 years
- 2002 -2004 enrollment – study stopped midway in 2010 since significant reduction in rates of death with LDCT arm
- 20.0% decrease in mortality from lung cancer observed in LDCT group as compared with radiography group (3 times higher)

(*one pack-year = smoking one pack per day for one year; 1 pack = 20 cigarettes)

[1] Mahesh M, Site Physicist - NLST Trial Research Team

NEJM 365 (5): 395-409, 2011

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NLST Low Dose CT (LDCT) Protocol

- Protocols developed by medical physicists* in the trial
- MDCT scanners with minimum of 4 channels included
- 1.5 mSv - average effective dose with low dose chest CT
- ~8 mSv - average effective dose for diagnostic chest CT
- Chest radiographs with screen-film or digital radiography

*Mahesh M, Site Physicist - NLST Trial Research Team

NEJM 365 (5): 395-409, 2011

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Screening for Lung Cancer with Low Dose CT

Radiology imaging facility eligibility criteria:

- Perform LDCT with $CTDI_{vol}$ of ≤ 3.0 mGy for standard size patients (5' 7" & ~ 155 lbs) with appropriate modifications in $CTDI_{vol}$ for smaller patients for larger patients
- Smoking cessation interventions for current smokers available
- Submits data to CMS-approved registry for each LDCT lung cancer screening performed

www.CMS.gov

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LDCT: Benefits vs Harms

Benefits

- 20% reduction in mortality (ACRIN-NLST trial)
- 62% of LDCT-arm screen-detected cancers were stage I
- 93.7% LDCT test sensitivity
- All-cause 5-year survival of screen-detected cancers was 55% for subjects >65 years

Harms

- False Positive - ~27% in NLST trial
- Overdiagnosis - ~11%
- Incidental Findings
- Radiation Dose – excess risk 0.23% for males & 0.85% for females – compared to 15% lifetime risk of future lung cancers for current smokers >55 years

Lung Cancer Manag. 2014; 3(6): 491-498

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LDCT Lung Cancer Screening: Radiation Exposure Concerns

- 1.5 mSv – average effective dose for annual screening of high-risk lung cancer subjects 50-75 years of age
- 0.07% - 0.23% for Males, 0.14% - 0.85% for Females – excess risk due to LDCT radiation
- 15% lifetime risk of future lung cancer for current smokers >55 years
- 1:20 – LDCT-caused (by radiation) to LDCT-averted lung cancer deaths

Lung Cancer Manag. 2014; 3(6): 491–498

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Johns Hopkins mmanesh@jhmi.edu

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When should screening stop?

Lung cancer screening stop, when person

- Turns 81 years old, or
- Has not smoked in 15 or more years, or
- Develops health problem that makes him or her unwilling or unable to have surgery if lung ca is found

www.CDC.org

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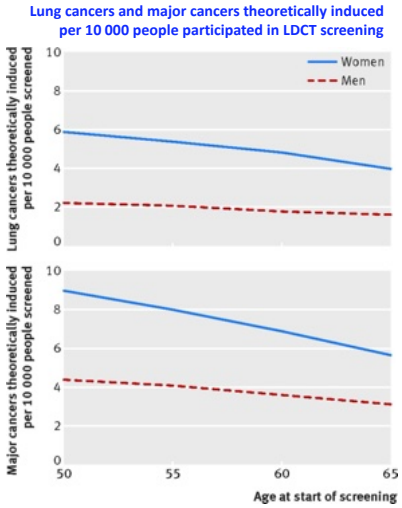
Exposure to LDCT for Lung Cancer Screening:
Risk-Benefit Analysis

- Median radiation exposure over 10 years:
  - 9.3 mSv for men and 13.0 mSv for women
- LAR of major cancers ranged
  - 2.6 to 8.1 major cancers per 10 000 participants
- One radiation induced cancer (theoretically) expected in every 108 lung cancers detected after 10 years of LDCT screening
- Risk of radiation induced cancer can be considered acceptable in-light of substantial mortality reduction associated with LDCT screening



BMJ 2017;356:j347

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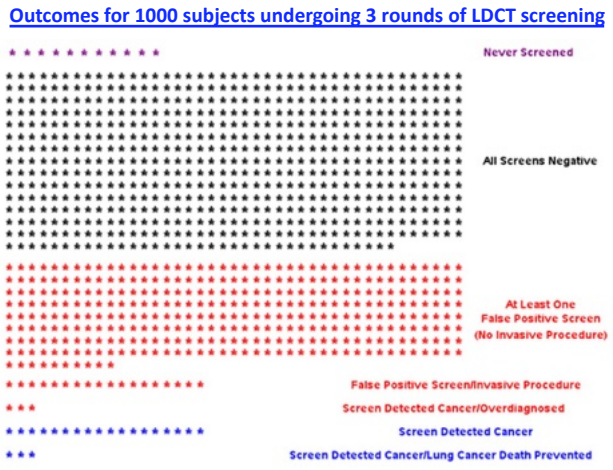
Benefits vs Harms of LDCT Lung Ca screening

- Due to high mortality rate from lung cancer, and the ability to easily identify a high-risk population, LDCT screening potentially has a favorable cost-effectiveness ratio (cost per quality adjusted life year gained)



Lung Cancer Manag. 2014; 3(6): 491–498

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Lung Cancer Screening CT

Radiation Dose Management

- **CTDIvol must be ≤ 3.0 mGy** for a standard sized patient, as measured using the 32-cm diameter CTDI phantom. By definition, a standard sized patient is approximately 5'7" and 155 pounds or 170 cm and 70 kg, with a BMI ≈ 24.

Dose Descriptor	Value	Reported at Scanner (Y/N)
CTDIvol*	≤ 3.0 mGy	Y
DLP*	≤ 75 mGy*cm	Y
Effective Dose (DLP x .014)**	≤ 1.0 mSv	N**

Approximate Volume CT Dose Index (CTDIvol) Values

- Approximate values for CTDIvol are listed for three different patient sizes:

	Approx. Weight (kg)	Approx. Weight (lbs)	Approx. CTDIvol (mGy)
Small Patient	50-70	110-155	0.25 - 2.8
Average Patient	70-90	155-200	0.5 - 4.3
Large Patient	90-120	200-265	1.0 – 5.6

www.AAPM.org

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LDCT Protocols

LUNG CANCER SCREENING CT (Selected GE scanners) with AEC (smartmA) on (Back to INDEX)

SCOUT: AP S60-I400; from top of shoulder through mid-liver, if automatic exposure control is used. PA scout if manual mA is used.

	LightSpeed 16	BrigthSpeed 16	LightSpeed VCT	Optima 660
Scan Type	Helical	Helical	Helical	Helical
Rotation Time (s)	0.5	0.5	0.5	0.5
Beam Collimation (mm)	43758	20	40	40
Detector Configuration	16x0.625 / 16x1.25	16x1.25	64x0.625	64x0.625
Pitch	1.375	1.375	0.984	0.984
Speed (mm/rot)	13.75 / 27.50	27.5	39.36	39.36
kV	120	120	120	120
min mA	40	40	30	30
max mA	130	130	110	110
Noise Index (smart mA)[1]	34	29.5	34	20
SFOV	Large Body	Large Body	Large Body	Large Body
CTDIvol	2.6 / 2.4 mGy	2.4 mGy	2.2 mGy	2.2 mGy

RECON 1

Plane	Axial	Axial	Axial	Axial
Algorithm	Lung or Bone	Lung or Bone	Lung or Bone	Lung or Bone
Recon Mode	Full or Plus	Full or Plus	Full or Plus	Full or Plus
Thickness (mm)	2.5	2.5	2.5	2.5
Interval (mm)	1.25	1.25	1.25	1.25
ASiR/ASIR-V (if used)			70	70

https://www.aapm.org/pubs/CTProtocols/

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LDCT Protocols

LUNG CANCER SCREENING CT (selected SIEMENS scanners, continued) (Back to INDEX)

TOPOGRAM: PA; scan from top of shoulder through mid-liver.

SIEMENS	Definition EdgePlus (128 slice)	Somatom Drive (Dual source 128-slice)	Definition Flash (Dual source 128-slice)	Definition Force (Dual source 192-slice)
Software version	VB20	VB20	VB20	VB20
Scan Mode	Spiral	Spiral	Spiral	Spiral
Rotation Time (s)	0.5	0.5	0.5	0.5
Detector Configuration	*128 × 0.6 mm (64 x 0.6 mm = 38.4 mm)	*128 × 0.6 mm (64 x 0.6 mm = 38.4 mm)	*128 × 0.6 mm (64 x 0.6 mm = 38.4 mm)	*192 × 0.6 mm (96 x 0.6 mm = 57.6 mm)
Pitch	1.2	1.2	1.2	1.2
kV	Sn100****	Sn100****	120	Sn100****
Quality ref. mAs	160	81	20	101
CARE Dose4D	ON	ON	ON	ON
CARE kV	ON	ON	ON	ON
CTDIvol***	0.6 mGy	0.6mGy	1.3 mGy	0.4 mGy
RECON 1				
Type	Axial	Axial	Axial	Axial
Kernel, IR	Bf37, strength =3**	Bf37, strength = 3**	Bf37, strength = 3**	Br40, strength = 3**
Slice (mm)	1.0	1.0	1.0	1.0
Increment (mm)	0.7	0.7	0.7	0.7

https://www.aapm.org/pubs/CTProtocols/

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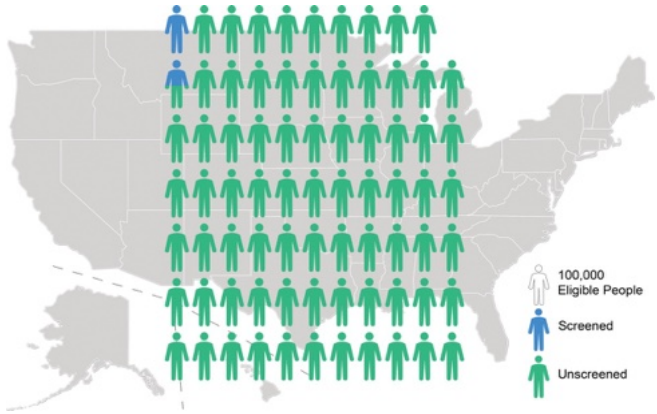
LDCT Lung Cancer Screening Rate in US in 2016



Only 5% - 6% of roughly 9 million individuals in US who are eligible undergo LDCT screening annually

Radiology

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New Recommendations from USPSTF

- Lung cancer 2nd most common cancer and leading cause of cancer death in US
- In 2020, ~228,820 persons diagnosed with lung cancer, and ~135,720 died
- Risk factors
  - Smoking (most)
  - Increasing age
- Generally poor prognosis, with an overall 5-year survival rate of 20.5% for lung cancer
- However, early-stage lung cancer has better prognosis and more amenable to treatment

Box. US Preventive Services Task Force Low-Dose Computed Tomographic Screening Recommendations for Lung Cancer

A-55-80-30-15
In 2013, The US Preventive Services Task Force (USPSTF) recommended annual screening for lung cancer with low-dose computed tomography (LDCT) for adults aged 55 to 80 years who have a 30 pack-year smoking history and currently smoke or have quit within the past 15 years (abbreviated as A-55-80-30-15).[23]

A-50-80-20-15
For this updated recommendation, the USPSTF has changed the age range and pack-year eligibility criteria and recommends annual screening for lung cancer with LDCT for adults aged 50 to 80 years who have a 20 pack-year smoking history and currently smoke or have quit within the past 15 years (abbreviated as A-50-80-20-15).

JAMA. 2021; 325(10): 962-970

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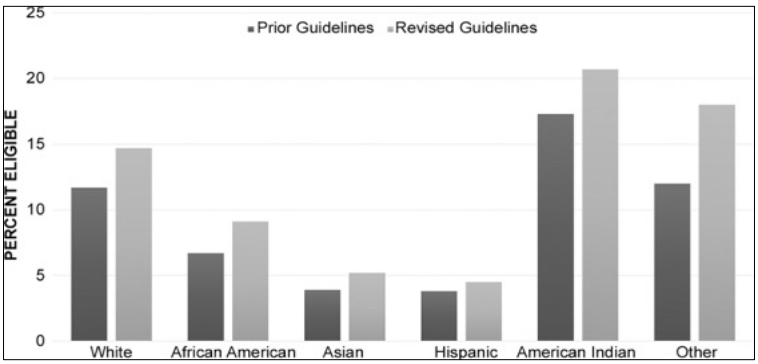
Eligible for Lung Cancer Screening with LDCT according to race and ethnicity in US



Higher percentages of all racial and ethnic groups are eligible for LCS under newly adopted LCS guidelines

Radiology, 2021; 301 (3): 712-720

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Barriers to Lung Cancer Screening

Radiology

https://doi.org/10.1148/radiol.2018180212

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Key elements for population-based lung cancer screening program

- Cost-effective way needs an organized approach:
  - Equitable recruitment
  - Identification of participants at sufficient risk
  - Nodule management protocol minimizing potential harms
  - Integration of smoking cessation

Eur Respir Rev 2021; 30: 200288

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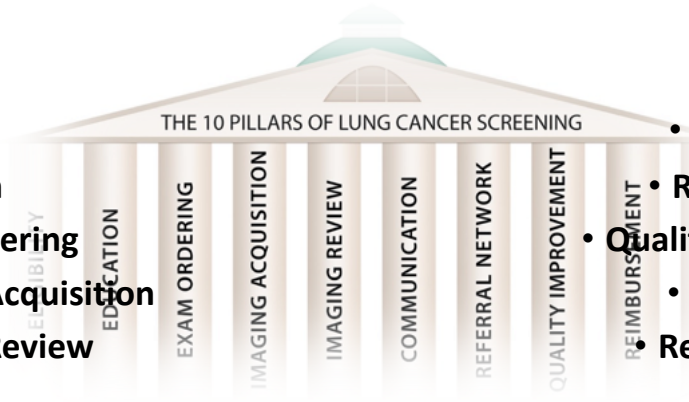
10 Pillars of Lung Cancer Screening

- Eligibility
- Education
- Exam Ordering
- Imaging Acquisition
- Imaging Review
- Communication
- Referral Network
- Quality Improvement
- Reimbursement
- Research/Frontier



RadioGraphics 2023; 44(3):e230057

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ACR: Pink & Pearl Campaign

Mammography Saves Lives and So Does Lung Screening

Risk Factors for Breast and Lung Cancer

Getting Older.

Family history of breast or ovarian cancer.

Early periods, before age 12.

Drinking alcohol.

Starting menopause after age 55.

Having first pregnancy after age 30.

Smoking or using tobacco products.

Not being physically active.

Family history of lung cancer.

Radon exposure.

Smoking and secondhand smoke exposure.

Exposure to other workplace hazards, such as asbestos, arsenic, diesel exhaust, and forms of silica and chromium.

https://www.acr.org/Clinical-Resources/Lung-Cancer-Screening-Resources

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Conclusions

- **~20% - Reduction in lung cancer mortality shown with LDCT**
- **~1:20 – LDCT-caused (radiation) to LDCT-averted lung cancer deaths) – benefit outweighs radiation risk from screening**
- **~6% - In spite, uptake of LDCT screening is still low**
- **Effective lung cancer screening programs are needed for equitable outreach and higher uptakes**

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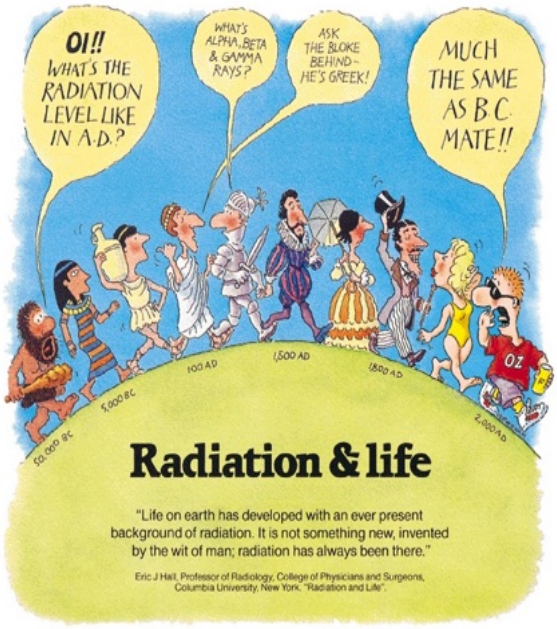

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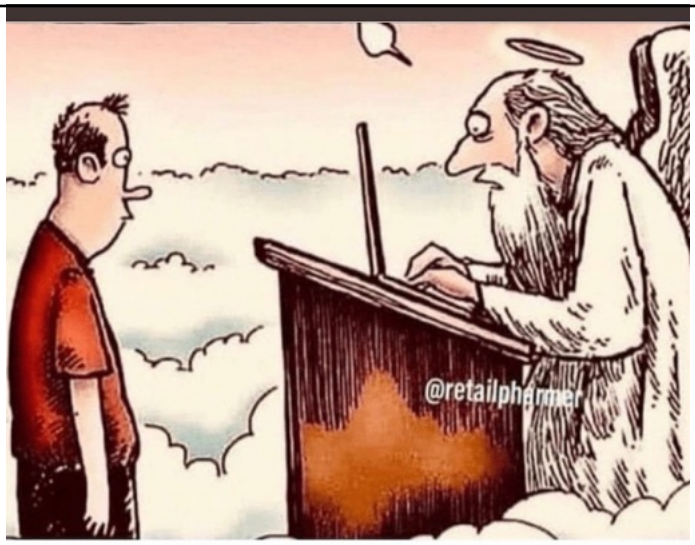

Says here you should go to hell but since you have a PhD we'll count that as time served

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Barriers to Lung Cancer Screening Engagement

- **Patient encountered barriers**
  - **Unawareness of screening programs (language barriers, lack of clinician)**
  - **Perceptual barriers (fear of lung cancer diagnosis and perceived stigma)**
  - **Cost concerns (underinsured, costs of further workup, loss of income)**
  - **Challenges in accessing screening sites (homelessness, lack of transportation, geographic access to medical centers)**
- **Providers encountered barriers**
  - **Unfamiliarity with eligibility criteria and insurance coverage**
  - **Challenges identifying eligible patients**
  - **Insufficient time and/or knowledge of how to conduct shared decision-making**
  - **Need for guidance with management of lung cancer screening findings**
  - **Skepticism about benefits of screening**
- **More research required to identify effective strategies to reach and engage target population and to ensure higher uptake in high-quality lung cancer screening programs**

Radiology 2019; 290:278–287

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