Impact of Joint Lung Cancer Screening and Cessation Interventions Under the New Recommendations of the U.S. Preventive Services Task Force

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ABSTRACT

Introduction: In 2021, the U.S. Preventive Services Task Force (USPSTF) revised its lung cancer screening recommendations expanding its eligibility. As more smokers become eligible, cessation interventions at the point of screening could enhance the benefits. Here, we evaluate the effects of joint screening and cessation interventions under the new recommendations.

Methods: A validated lung cancer natural history model was used to estimate lifetime number of low-dose computed tomography screens, percentage ever screened, lung cancer deaths, lung cancer deaths averted, and life-years gained for the 1960 U.S. birth cohort aged 45 to 90 years (4.5 million individuals). Screening occurred according to the USPSTF 2013 and 2021 recommendations with varying uptake (0%, 30%, 100%), with or without a cessation intervention at the point of screening with varying effectiveness (15%, 100%).

Results: Screening 30% of the eligible population according to the 2021 criteria with no cessation intervention (USPSTF 2021, 30% uptake, without cessation intervention) was estimated to result in 6845 lung cancer deaths averted and 103,725 life-years gained (~28% increase versus USPSTF 2013, 30% uptake, without cessation intervention) and 322,785 life-years gained (~34% increase). Screening 100% of the eligible according to the 2021 guidelines with no cessation intervention (USPSTF 2021, 100% uptake, without cessation intervention) was estimated to result in 23,444 lung cancer deaths averted (~337% increase versus USPSTF 2013, 30% uptake, without cessation intervention) and 354,330 life-years gained (~359% increase). Adding a cessation intervention with 15% effectiveness (USPSTF 2021, 100% uptake, with cessation intervention with 15% effectiveness) would result in 31,998 lung cancer deaths averted (~497% increase versus USPSTF 2013, 30% uptake, without cessation intervention) and 1,086,840 life-years gained (~1309% increase).

Conclusions: Joint screening and cessation interventions would result in considerable lung cancer deaths averted and life-years gained. Adding a one-time cessation intervention would lead to a significant increase in the number of lung cancer deaths averted and life-years gained.
intervention of modest effectiveness (15%) results in comparable life-years gained as increasing screening uptake from 30% to 100% because while cessation decreases mortality from many causes, screening only reduces lung cancer mortality. This simulation indicates that incorporating cessation programs into screening practice should be a priority as it can maximize overall benefits.

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Keywords: Lung cancer screening; Cessation interventions within lung screening; Deaths averted; Life-years gained; Simulation modeling; CISNET

Introduction

The U.S. Preventive Services Task Force (USPSTF) recently updated its 2013 lung cancer screening recommendations expanding its eligibility criteria. Annual lung cancer screening with low-dose computed tomography (LDCT) is now recommended for adults aged 50 to 80 years who have a smoking history of at least 20 pack-years and currently smoke or have quit within the past 15 years. This expands eligibility to individuals of younger ages (50 versus 55 y of ages) and lower smoking exposures (20 versus 30 pack-years).

Since 2013, the USPSTF recommends that current smokers undergoing screening should receive smoking cessation interventions. Cessation interventions at the point of screening have the potential to enhance the benefits of LDCT screening resulting in additional premature deaths averted and life-years gained. The expansion of the eligibility criteria to include younger smokers with fewer pack-years has the potential to expand these additional benefits. Here, we quantify the potential impact.

Methods

We used a validated natural history model (MichiganLung) to evaluate the impact of joint LDCT screening and cessation interventions on lung cancer and overall mortality. It was one of four models commissioned by the USPSTF to evaluate the benefits and harms of LDCT screening.

Model Description

MichiganLung is a microsimulation model that uses individual smoking histories, including those of adults in the expanded eligibility groups, to simulate the natural history of lung cancer (onset, histologic type, stage progression, clinical detection, and mortality or survival), the outcomes from LDCT screening and any resulting follow-up and treatment interventions, and non-lung cancer-related deaths. The model uses a dose-response module to estimate annual age-specific lung cancer incidence as a function of individual smoking history, sex, and birth year. The model has been used to simulate the impact of screening for the U.S. population and the effectiveness and cost-effectiveness of cessation interventions at the point of screening under the 2013 USPSTF criteria.

Interventions

We used the MichiganLung to simulate the impact of screening with or without a one-time cessation intervention at the first screening. We simulated screening according to the 2021 and 2013 USPSTF recommendations and compared the results with a no screening scenario. We assumed the following two main screening random uptake scenarios: 30% and 100% of those eligible to actually participate in annual screening. We also considered 70% uptake in a sensitivity analysis. Every current smoker undergoing LDCT screening was assumed to receive the smoking cessation intervention. We considered the following two main cessation effectiveness scenarios (i.e., probability of permanently quitting owing to the intervention): 15% (realistic) and 100% (maximal) probabilities of quitting. We also considered 7% and 30% probabilities of quitting as sensitivity analysis. Although there are few trials published to date on cessation interventions in the lung cancer screening setting, these values (range: 7%-30%) are consistent with those of early studies.

Population and Outcomes

Consistent with previous work, we simulated outcomes for the 1960 U.S. birth cohort. We focus on this birth cohort as it is currently in the middle of its screening eligibility and is representative of the smoking patterns of the current screen-eligible population. We simulated the smoking histories of one million males and one million females using the CISNET Smoking History generator and then used the MichiganLung under different screening and cessation scenarios. In particular, we estimated the lifetime number of LDCT screens, percentage of the population ever screened, lung cancer deaths, lung cancer deaths averted, life-years, and life-years gained. Although deaths averted are lung cancer specific, life-years gained represent all tobacco-related causes of death. Outcomes are scaled to the 1960 U.S. birth cohort population (≈4.5 million at age 45 years).
### Table 1. Projected Lifetime Impact of Screening and Cessation Interventions for the 4.5 Million Individuals From the U.S. 1960 Birth Cohort

<table>
<thead>
<tr>
<th>Screening Criteria</th>
<th>Cessation Intervention</th>
<th>Percentage Increase in Lung Cancer Deaths Averted vs. 2013USPSTF Scenario</th>
<th>Percentage Increase in Life-Years Gained vs. 2013USPSTF Scenario</th>
<th>Percentage of Life-Years Gained Owing to Lung Cancer Deaths Averted or Delayed, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>No screening</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2013 USPSTF</td>
<td>30 Without</td>
<td>4.3</td>
<td>3,112,261</td>
<td>172,766</td>
</tr>
<tr>
<td></td>
<td>30 15</td>
<td>4.3</td>
<td>2,979,788</td>
<td>171,170</td>
</tr>
<tr>
<td></td>
<td>30 100</td>
<td>4.3</td>
<td>2,296,585</td>
<td>161,581</td>
</tr>
<tr>
<td></td>
<td>100 Without</td>
<td>14.3</td>
<td>10,348,862</td>
<td>160,313</td>
</tr>
<tr>
<td></td>
<td>100 15</td>
<td>14.3</td>
<td>9,946,827</td>
<td>154,523</td>
</tr>
<tr>
<td></td>
<td>100 100</td>
<td>14.3</td>
<td>7,640,316</td>
<td>123,077</td>
</tr>
<tr>
<td>2021 USPSTF</td>
<td>30 Without</td>
<td>6.9</td>
<td>5,725,895</td>
<td>171,285</td>
</tr>
<tr>
<td></td>
<td>30 15</td>
<td>6.9</td>
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<tr>
<td></td>
<td>100 Without</td>
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<tr>
<td></td>
<td>100 100</td>
<td>23.0</td>
<td>17,884,769</td>
<td>146,132</td>
</tr>
</tbody>
</table>

Note: Lifetime indicates ages from 45 to 90 years.

*aResults for additional scenarios are found in the Supplementary material.

*bNumber of LDCT screens decreases in the scenarios with cessation intervention because former smokers exit screening after 15 years since quitting.

*cNumber of lung cancer deaths averted and life-years gained compared with the no screening scenario.

*dPercentage of the life-years gained in the scenario owing to lung cancer deaths averted or delayed by screening or by smoking cessation owing to the intervention. The complement is the percentage of the life-years gained owing to averted premature deaths from all other smoking-related causes by cessation owing to the intervention. The complement is the percentage of the life-years gained owing to lung cancer deaths averted or delayed by screening or by smoking cessation owing to the intervention. The complement is the percentage of the life-years gained owing to averted premature deaths from all other smoking-related causes by cessation owing to the intervention.

LDCT: low-dose computed tomography; NA: not applicable; USPSTF: U.S. Preventive Services Task Force.
Results

Under USPSTF 2021 guidelines, 23% of the individuals from the 1960 U.S. birth cohort would be eligible for screening, a 60% increase over the 2013 guidelines (Table 1). Of these, 77% would enter screening eligibility as current smokers and thus would be eligible for a cessation intervention at the time of their first screen (Fig. 1).

Relative to the 2013 guidelines, screening according to the USPSTF 2021 is estimated to result in considerable gains, particularly when combined with cessation interventions (Table 1 and Fig. 2). For example, screening 30% of the eligible population born in 1960 according to the 2013 recommendations with no cessation intervention (USPSTF2013, 30% uptake, without cessation intervention) was estimated to result in 5363 lung cancer deaths averted and 77,130 life-years gained relative to no screening. Screening 30% of the eligible population according to the 2021 recommendations with no cessation intervention (USPSTF2021, 30% uptake, without cessation intervention) was estimated to result in 6845 lung cancer deaths averted (~28% increase versus USPSTF2013, 30% uptake, without cessation intervention) and 103,725 life-years gained (~34% increase). Adding a cessation intervention at the time of the first screen with a 15% effectiveness (USPSTF2021, 30% uptake, with cessation intervention with 15% effectiveness) would result in 2422 additional lung cancer deaths averted (9267 in total, ~73% increase versus USPSTF2013, 30% uptake, without cessation intervention) and in a total of 322,785 life-years gained (~318% increase). Screening 100% of the eligible individuals with no cessation intervention (USPSTF2021, 100% uptake, without cessation intervention) was estimated to result in 23,444 lung cancer deaths averted (~337% increase versus USPSTF2013, 30% uptake, without cessation intervention) and 354,330 life-years gained (~359% increase). Adding a cessation intervention at the time of the first screen with a 15% effectiveness (USPSTF2021, 100% uptake, with cessation intervention with 15% effectiveness) would result in 8554 additional lung cancer deaths averted (31,998 in total, ~497% increase versus USPSTF2013, 30% uptake, without cessation intervention) and a total of 1,086,840 life-years gained (~1309% increase). Table 1 and Figure 2 reveal the maximum lung cancer deaths averted and life-years gained with a cessation intervention with 100% quit probability (maximal potential reduction in premature mortality).

Sensitivity analyses with scenarios assuming 7% or 30% as probability of quitting are presented in the Supplementary content (Supplementary Table 1).
These reveal the range of potential health gains as a function of the effectiveness of the cessation intervention. Even with cessation interventions of limited effectiveness (7%), joint cessation and screening interventions could result in considerable increases in lung cancer deaths averted and life-years gained. For example, screening 30% of the eligible population according to the USPSTF 2021 with a one-time cessation intervention with a 7% effectiveness would result in 50% more lung cancer deaths averted and 161% more life-years gained than screening 30% of the eligible population according to the 2013 recommendations with no cessation intervention.

**Discussion**

Consistent with other studies, the analysis indicates that joint LDCT screening and cessation interventions could result in important reductions in lung cancer deaths averted and life-years gained. In particular, by expanding the number of smokers eligible for screening to include younger smokers with fewer pack-years, many of whom are projected to be women and racial/ethnic minorities, the 2021 USPSTF recommendations could result in more life-years gained than previous criteria and be more equitable.

Previous studies have projected the potential impact of cessation interventions at the point of LDCT screening under previous screening guidelines or the benefits and harms of expanding screening to individuals with 20 or more pack-years of smoking history, but without consideration of joint screening cessation interventions. Here, we extend previous studies by quantifying the potential impact of screening according to the 2021 USPSTF recommendations with joint cessation interventions.

The actual impact of these interventions will depend on screening uptake, overall and as a function of risk characteristics, the actual percentage of current smokers in the screened population, and the effectiveness and adoption of the specific cessation interventions. Furthermore, the impact might increase when engaging continuing smokers in cessation interventions at each successive screening visit. Although screening uptake has been relatively low, the percentage of eligible individuals receiving screening seemed to be increasing before the coronavirus disease 2019 pandemic. The 30% uptake used as baseline assumption in the
simulations should be reachable in the next few years given the increasing uptake rates and the reported levels before the pandemic (~20% in 2018\textsuperscript{15}). The efficacy of cessation interventions at the point of screening is being evaluated in several randomized controlled trials.\textsuperscript{2} Although awaiting these results, this simulation analysis reveals that even under conservative assumptions, adding a one-time cessation intervention at the baseline screen with modest effectiveness could result in considerable gains versus screening alone, especially in life-years gained from a reduction in all tobacco-related causes of death. Importantly, adding a cessation intervention with 15% effectiveness is estimated to result in similar increases in life-years gained as increasing screening uptake from 30% to 100% without cessation interventions. This is because a considerable percentage of the eligible population are current smokers and because cessation interventions decrease mortality for many causes of death, while screening only lowers lung cancer mortality. This indicates that incorporating cessation programs into the screening practice, together with efforts to increase the success of these programs, should be a priority to maximize the overall benefits.

Conclusions

LDCT screening, according to the new USPSTF guidelines, combined with joint cessation interventions, would result in considerable lung cancer deaths averted and life-years gained. In terms of life-years gained, adding a cessation intervention of modest effectiveness to LDCT screening results in comparable gains as increasing screening uptake from 30% to 100%. Both screening and cessation interventions are critical for lung cancer prevention; joint screening and cessation programs for those eligible would maximize health benefits.

CRediT Authorship Contribution

Rafael Meza: Conceptualization, Methodology, Writing - original draft, Supervision, Funding acquisition.

Pianpian Cao: Data curation, Formal analysis, Writing - review & editing, Visualization.

Jihyoun Jeon: Methodology, Writing - review & editing.

Kathryn Taylor, Jeanne Mandelblatt: Funding acquisition, Writing - review & editing.

Eric J. Feuer, Douglas R. Lowy: Conceptualization, Writing – review & editing.

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Supplementary Data

Note: To access the supplementary material accompanying this article, visit the online version of the Journal of Thoracic Oncology at www.jto.org and at https://doi.org/10.1016/j.jtho.2021.09.011.

References


