Using Prediction Models to Reduce Persistent Racial and Ethnic Disparities in the Draft 2020 USPSTF Lung Cancer Screening Guidelines

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Abstract

We examined whether draft 2020 United States Preventive Services Task Force (USPSTF) lung cancer screening recommendations “partially ameliorate racial disparities in screening eligibility” compared with the 2013 guidelines, as claimed. Using data from the 2015 National Health Interview Survey, USPSTF-2020 increased eligibility by similar proportions for minorities (97.1%) and Whites (78.3%). Contrary to the intent of USPSTF-2020, the relative disparity (differences in percentages of model-estimated gainable life-years from National Lung Screening Trial-like screening by eligible Whites vs minorities) actually increased from USPSTF-2013 to USPSTF-2020 (African Americans: 48.3%–33.4% = 15.0% to 64.5%–48.5% = 16.0%; Asian Americans: 48.3%–35.6% = 12.7% to 64.5%–45.2% = 19.3%; Hispanic Americans: 48.3%–24.8% = 23.5% to 64.5%–37.0% = 27.5%). However, augmenting USPSTF-2020 with high-benefit individuals selected by the Life-Years From Screening with Computed Tomography (LYFS-CT) model nearly eliminated disparities for African Americans (76.8%–75.5% = 1.2%) and improved screening efficiency for Asian and Hispanic Americans, although disparities were reduced only slightly (Hispanic Americans) or unchanged (Asian Americans). The draft USPSTF-2020 guidelines increased the number of eligible minorities vs USPSTF-2013 but may inadvertently increase racial and ethnic disparities. LYFS-CT could reduce disparities in screening eligibility by identifying ineligible people with high predicted benefit regardless of race and ethnicity.

The 2013 United States Preventive Services Task Force (USPSTF) guidelines (1) were criticized for inducing racial and ethnic disparities. In particular, African Americans have higher risk of lung cancer, despite smoking less than Whites, and develop cancer at younger ages (2–7). The USPSTF-2020 draft guidelines expanded the age range and lowered the pack-year limit to “partially ameliorate racial disparities in screening eligibility” (8,9). We estimated whether the 2020 guidelines truly reduce racial and ethnic disparities and examined whether using an individualized prediction model for life-years gained from screening could reduce racial and ethnic disparities by identifying high-benefit individuals who are ineligible under the 2020 draft guidelines.

We used previously published methodology (10) to empirically model the performance of National Lung Screening Trial

(NLST)-like screening (3 annual computed tomography [CT] screens, 5 years follow-up) among individuals aged 50–80 years who ever-smoked in the nationally representative US 2015 National Health Interview Survey (NHIS) (11). We considered eligibility by USPSTF-2013 guidelines (aged 55–80 years, ≥30 pack-years, ≤15 quit-years), USPSTF-2020 guidelines (aged 50–80 years, ≥20 pack-years, ≤15 quit-years), and augmenting USPSTF-2020 guidelines to also include individuals with at least 12 days of life gained, according to the life-years from screening-CT (LYFS-CT) model (12) (USPSTF-2020+LYFS-CT). LYFS-CT combines individualized lung cancer death risk with life expectancy to predict individualized life-years gained from NLST-like screening (12). We used LYFS-CT because basing eligibility on lung cancer risk models “might lead to screening

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Table 1. Characteristics of ever-smokers aged 50-80 years eligible for lung cancer screening by USPSTF-2013 guidelines, USPSTF-2020 draft guidelines, and USPSTF-2020 draft guidelines augmented with those eligible by LYFS-CT^a

Characteristics	USPSTF-2013, No. (%)	Added by USPSTF-2020, No. (%)	Total USPSTF-2020, No. (%)	Added by LYFS-CT, No. (%)	Total (USPSTF-2020 +LYFS-CT), No. (%)
Total	8 024 510 (100.0)	6 483 940 (100.0)	14 508 450 (100.0)	3 469 530 (100.0)	17 977 980 (100.0)
Age, y					
50–54	0 (0.0)	3 123 773 (48.2)	3 123 773 (21.5)	75 008 (2.2)	3 198 781 (17.8)
55–59	2 270 660 (28.3)	1 180 790 (18.2)	3 451 450 (23.8)	282 481 (8.1)	3 733 931 (20.8)
60–64	2 305 816 (28.7)	744 623 (11.5)	3 050 439 (21.0)	539 492 (15.5)	3 589 931 (20.0)
65–69	1 640 941 (20.4)	823 862 (12.7)	2 464 803 (17.0)	791 208 (22.8)	3 256 011 (18.1)
70–74	1 159 768 (14.5)	456 623 (7.0)	1 616 391 (11.1)	823 767 (23.7)	2 440 158 (13.6)
75–79	647 326 (8.1)	154 268 (2.4)	801 594 (5.5)	957 574 (27.6)	1 759 168 (9.8)
Race or ethnicity					
White	6 950 778 (86.6)	5 441 581 (83.9)	12 392 359 (85.4)	2 472 808 (71.3)	14 865 167 (82.7)
African American	572 485 (7.1)	588 792 (9.1)	1 161 277 (8.0)	750 507 (21.6)	1 911 784 (10.6)
Asian American	174 778 (2.2)	104 986 (1.6)	279 764 (1.9)	54 927 (1.6)	334 691 (1.9)
Hispanic American	326 469 (4.1)	348 581 (5.4)	675 050 (4.7)	191 289 (5.5)	866 338 (4.8)
Smoking status					
Current	3 970 650 (49.5)	4 307 187 (66.4)	8 277 837 (57.1)	1 823 418 (52.6)	10 101 255 (56.2)
Former	4 053 860 (50.5)	2 176 753 (33.6)	6 230 613 (42.9)	1 646 113 (47.4)	7 876 725 (43.8)
Sex					
Male	4 679 896 (58.3)	3 463 316 (53.4)	8 143 211 (56.1)	1 891 298 (54.5)	10 034 509 (55.8)
Female	3 344 614 (41.7)	3 020 624 (46.6)	6 365 239 (43.9)	1 578 233 (45.5)	7 943 471 (44.2)
Emphysema					
No emphysema	6 834 310 (85.2)	6 136 611 (94.6)	12 970 922 (89.4)	3 074 951 (88.6)	16 045 873 (89.3)
Emphysema	1 190 200 (14.8)	347 329 (5.4)	1 537 528 (10.6)	394 579 (11.4)	1 932 108 (10.7)
Body mass index, kg/m ²					
<18.5	179 828 (2.2)	120 137 (1.9)	299 965 (2.1)	154 006 (4.4)	453 971 (2.5)
18.5–24.9	2 331 970 (29.1)	2 086 774 (32.2)	4 418 744 (30.5)	1 405 007 (40.5)	5 823 751 (32.4)
25–29.9	2 815 792 (35.1)	2 232 053 (34.4)	5 047 844 (34.8)	1 216 189 (35.1)	6 264 033 (34.8)
30+	2 696 921 (33.6)	2 044 977 (31.5)	4 741 897 (32.7)	694 328 (20.0)	5 436 226 (30.2)
Quit-years among former smokers					
<1	283 475 (7.0)	224 992 (10.3)	508 467 (3.5)	107 613 (6.5)	616 080 (7.8)
1–4	1 201 839 (29.6)	544 737 (25.0)	1 746 576 (12.0)	114 444 (7.0)	1 861 020 (23.6)
5–9	1 198 614 (29.6)	677 533 (31.1)	1 876 148 (12.9)	51 499 (3.1)	1 927 647 (24.5)
10+	1 369 931 (33.8)	729 490 (33.5)	2 099 422 (14.5)	1 372 557 (83.4)	3 471 979 (44.1)
Pack-years among current smokers					
<20	0 (0.0)	0 (0.0)	0 (0.0)	1 823 418 (100.0)	1 823 418 (18.1)
20–29	0 (0.0)	2 679 027 (62.2)	2 679 027 (18.5)	0 (0.0)	2 679 027 (26.5)
30–49	2 462 409 (62.0)	1 372 043 (31.9)	3 834 452 (26.4)	0 (0.0)	3 834 452 (38.0)
50–69	886 078 (22.3)	180 114 (4.2)	1 066 192 (7.3)	0 (0.0)	1 066 192 (10.6)
70+	622 164 (15.7)	76 003 (1.8)	698 167 (4.8)	0 (0.0)	698 167 (6.9)
Pack-years among former smokers					
<20	0 (0.0)	0 (0.0)	0 (0.0)	373 827 (22.7)	373 827 (4.7)
20–29	0 (0.0)	1 559 416 (71.6)	1 559 416 (10.7)	0 (0.0)	1 559 416 (19.8)
30–49	2 290 645 (56.5)	470 318 (21.6)	2 760 964 (19.0)	704 239 (42.8)	3 465 203 (44.0)
50–69	905 761 (22.3)	87 478 (4.0)	993 239 (6.8)	283 799 (17.2)	1 277 037 (16.2)
70+	857 453 (21.2)	59 540 (2.7)	916 994 (6.3)	284 248 (17.3)	1 201 241 (15.3)

^aLYFS-CT = life-years from screening with computed tomography; USPSTF = United States Preventive Services Task Force.

patients with comorbidities and shorter life expectancy, thus adversely affecting the balance of the benefits and harms of screening,” as noted by USPSTF (8) and others (13–15), but LYFS-CT might optimize the life-years gained (12). The 12-day threshold corresponds to the 20th percentile of those eligible under USPSTF-2013, because no benefit of screening was observed below the 20th risk percentile in the NLST (16). See the [Supplementary Methods](#) (available online) for details and a review of LYFS-CT.

We calculated the number and proportion of US individuals aged 50–80 years who ever-smoked who are eligible for screening, sensitivity for preventable lung-cancer deaths (proportion

of preventable deaths classified as screening-eligible), and screening efficiency (number needed to screen [NNS] to prevent 1 lung cancer death). We also calculated the sensitivity and efficiency per 10 life-years gained. We define disparity as the absolute difference in percentages, between Whites and each minority, of preventable lung cancer deaths (or life-years gainable) classified as screening eligible. The National Institutes of Health Office of Human Subjects Research deemed this study exempt from institutional review board approval.

The 2015 NHIS reports 8.0 million individuals as screening-eligible under USPSTF-2013, which benefited Whites the most, with 19.9% of those who ever-smoked eligible, 54.5% sensitivity

Figure 1. The sensitivity of lung cancer screening among those eligible under United States Preventive Services Task Force (USPSTF)-2013 guidelines, USPSTF-2020 draft guidelines, and USPSTF-2020 draft guidelines augmented with those eligible by the life-years from screening with computed tomography (LYFS-CT) individualized model for life-years gained from screening, by race and ethnicity. A) Sensitivity of screening to gainable life-years gained, and absolute disparities, for Whites and African Americans. B) Sensitivity of screening to gainable life-years gained, and absolute disparities, for Whites and Hispanic Americans. C) Sensitivity of screening to gainable life-years gained, and absolute disparities, for Whites and Asian Americans. D) Sensitivity of screening to preventable lung cancer deaths prevented, and absolute disparities, for Whites and African Americans. E) Sensitivity of screening to preventable lung cancer deaths prevented, and absolute disparities, for Whites and Hispanic Americans. F) Sensitivity of screening to preventable lung cancer deaths prevented, and absolute disparities, for Whites and Asian Americans. Disparity estimates are rounded to the nearest percent.

for preventable lung cancer deaths, and 48.3% sensitivity for life gained. Sensitivities for preventable lung cancer deaths and life gained were substantially lower for African Americans (sensitivity for preventable lung cancer deaths = 39.8%, sensitivity for life gained = 33.4%), Asian Americans (sensitivity for preventable lung cancer deaths = 39.3%, sensitivity for life gained = 35.6%), and Hispanic Americans (sensitivity for preventable lung cancer deaths = 30.3%, sensitivity for life gained = 24.8%), as were the percentages of eligible (9.1%-13.8%) (Supplementary Table 1, available online). Under USPSTF-2020, an additional 6.5 million (80.8%) individuals were eligible for screening, including 3.1 million aged 50-54 years. As expected, the newly eligible tended to be younger, be current smokers, and have smoked 20-29 pack-years (Table 1). Overall sensitivity increased for preventable lung cancer deaths (from 51.4% to 64.3%) and life gained (from 45.2% to 60.9%) (Figure 1), but NNS per 10 life-years gained also increased from 146 to 196 (Supplementary Table 1, available online).

Those additionally eligible by USPSTF-2020 vs USPSTF-2013 were only 16.1% minority, including 9.1% African American (Table 1). Although the number of eligible minorities increased 97.1% in USPSTF-2020 vs USPSTF-2013, the number of eligible Whites also increased by 78.3% (Supplementary Table 1, available online). Thus, sensitivities for preventable lung cancer deaths and life gained improved for Whites (sensitivity for preventable lung cancer deaths = 67.4%, sensitivity for life gained = 64.5%, respectively; Figure 1) and also improved but remained lower for minorities (African Americans: sensitivity for preventable lung cancer deaths = 54.0%, sensitivity for life

gained = 48.5%; Asian Americans: sensitivity for preventable lung cancer deaths = 47.9%, sensitivity for life gained = 45.2%; Hispanic Americans: sensitivity for preventable lung cancer deaths = 40.6%, sensitivity for life gained = 37.0%). Sensitivities for preventable lung cancer deaths and life gained for Asian and Hispanic Americans remained lower than for Whites (sensitivity for preventable lung cancer deaths = 54.5%, sensitivity for life gained = 48.3%) under USPSTF-2013. Contrary to the intent, the disparities in benefits between Whites and Asian Americans and Hispanic Americans actually increased from USPSTF-2013 to USPSTF-2020, both in gainable life years (Asian Americans = 12.7% to 19.3%; Hispanic Americans = 23.5% to 27.5%) and preventable deaths (Asian Americans = 15.2% to 19.5%, Hispanic Americans = 24.3% to 26.8%). The disparities in lung cancer deaths prevented decreased slightly for African Americans, primarily due to lowering the pack-year criteria (Supplementary Table 2, available online). The proportion of high-benefit individuals (defined as ≥ 12 days of life gained by screening according to LYFS-CT) who are ineligible was substantially reduced from USPSTF-2013 to USPSTF-2020 for Whites (42.6% to 24.7%) and African Americans (68.4% to 46.4%) but only slightly reduced for Hispanic Americans (54.0% to 45.7%) and Asian Americans (41.7% to 34.7%).

Adding those who would gain at least 12 days of life by LYFS-CT to USPSTF-2020 (USPSTF-2020+LYFS-CT) would offer screening to an additional 3.5 million individuals, of whom 28.7% were minorities, including 21.6% African American (Table 1), at the same overall efficiency of USPSTF-2020 (Supplementary Table 1, available online). Compared with USPSTF-2020, the additional

people eligible under USPSTF-2020+LYFS-CT are frequently older and African American (Table 1). Of the extra former-smokers eligible by USPSTF-2020+LYFS-CT, 77.3% had at least 30 pack-years, and 83.4% had at least 10 quit-years.

Compared with USPSTF-2020, USPSTF-2020+LYFS-CT increased the number of African Americans eligible by 750 507 (64.6%; Table 1) and substantially increased the sensitivity for preventable deaths (81.8% vs 54.0%) and life-years gained (75.5% vs 48.5%) while maintaining the highest NNS among racial and ethnic groups (Supplementary Table 1, available online). Importantly, USPSTF-2020+LYFS-CT nearly eliminated the African American–White disparity for preventable lung cancer deaths (–0.1%) and life gained (1.2%) (Figure 1). For Asian Americans and Hispanic Americans, USPSTF-2020+LYFS-CT improved screening efficiency (NNS) but only slightly reduced disparities for Hispanic Americans, and the disparity for Asian Americans was unchanged (Figure 1). Finally, the proportion of high-benefit individuals (≥ 12 days of life) who are ineligible under USPSTF-2020+LYFS-CT is, by definition, 0%, representing a large reduction from USPSTF-2020 (Whites = 24.7%; African Americans = 46.4%; Hispanic Americans = 45.7%; Asian Americans = 34.7%).

USPSTF-2013 criteria performed better for Whites than minorities, inadvertently inducing racial and ethnic disparities. More minorities are indeed eligible under the draft USPSTF-2020 guidelines. However, because eligibility increases were similar between minorities and Whites, the draft guidelines may inadvertently increase racial and ethnic disparities. Augmenting USPSTF-2020 with LYFS-CT to include high-benefit individuals ineligible under USPSTF-2020 selected a greater fraction of additional African Americans than USPSTF-2020 (21.6% vs 9.1%) and nearly eliminated disparities for African Americans, although not for Asian Americans and Hispanic Americans.

Guidelines based purely on age, pack-years, and quit-years cannot eliminate disparities in preventable deaths or gainable life-years. Given only those 3 factors, it is not possible to identify individuals in whom the same proportion of lung cancer deaths are prevented across each race and ethnicity (Supplementary Table 2, available online). The use of prediction models could potentially reduce disparities, as demonstrated here, depending on the performance of the model and the threshold selected. Unlike individualized risk, individualized life gained explicitly quantifies into a single metric several implicit considerations: disease risk, life expectancy, comorbidity and performance status, and the probability of benefits and harms from screening (12,17).

Our screening-eligible population sizes are empirically estimated from NHIS. However, our findings for screening outcomes are based on empirical modeling of outcomes from an NLST-like program, not directly observed outcomes. We assumed that NLST-like CT screening achieves a 20.4% mortality reduction for all ever-smokers, regardless of race and ethnicity, in routine clinical practice (18). We focused on short-term outcomes to avoid extrapolation beyond NLST data and did not estimate screening harms. Implementation research is required to ensure model-based eligibility criteria would not impose barriers to screening or inadvertently increase disparities (7,8).

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Data Availability

NHIS data are available from <https://www.cdc.gov/nchs/nhis/index.htm>.

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