Predictors of Lung Cancer Screening Recommendation in Virginia Using the Community Health Assessment Survey

Aashish Batheja[1], Carrie Miller[2], Sunny Jung Kim[1], Bernard Fuemmeler F[1], Rajsh Balkrishnan[2]

[1]Virginia Commonwealth University
[2]University of Florida

Abstract

Purpose: The purpose of this analysis was to determine the factors that may influence the probability of being recommended a lung cancer screening by a health professional in Virginia.

Methods: Data were obtained from the Community Health Assessment Survey conducted by the University of Virginia (UVA) Health System and Cancer System in collaboration with Virginia Commonwealth University (VCU) Cancer Center. SAS software was used to conduct a logistic regression with the following variables: age, sex, race, current smoking status, cancer history, education level, income level, insurance, and rurality.

Results: Statistically significant positive predictors included being a current smoker (OR: 3.504, CI: 1.576 - 7.794), having previous cancer history (OR: 2.159, CI: 1.090 - 4.278), and living in an urban environment (OR: 1.939, CI: 1.009 - 3.724).

Conclusion: Smoking, cancer history, and rurality were considered significant predictors of lung cancer screening recommendations by a health professional in Virginia while age, sex, race, education level, income level, and insurance were not considered significant predictors in this model. This study suggests that key mechanisms underlying lung cancer outcome disparities among racial minorities and socioeconomically disadvantaged groups may lie beyond the level of screening recommendations. Further research investigating when along the disease progression these disparities tend to arise could help in creating more targeted public health interventions and improving health equity.

Background

Lung cancer is a significant problem in the U.S., ranking third in prevalence and first in deaths among all forms of cancer (Centers for Disease Control and Prevention [CDC], 2022a). Recommending lung cancer screenings in appropriate situations is an important tool to identify cases of lung cancer and initiate appropriate treatment. The U.S. Preventive Services Task Force (USPSTF) guidelines endorse annual lung cancer screening for individuals who meet all the following criteria: (a) between 50 and 80 years old, (b) smoking history of at least 20-pack years, and (c) currently smoke or have previously smoked within the past 15 years (2021). Three major risk factors arise when considering susceptibility for lung cancer: smoking, radon exposure, and family history.

Smoking

Smoking constitutes the greatest risk factor for lung cancer with up to 90% of lung cancer deaths in the U.S. being attributed to cigarette smoking (CDC, 2022b). A smoker has up to a 30-fold risk of developing or dying from lung cancer compared to a non-smoker (CDC, 2022b). Smoking exerts deleterious effects on non-smokers as well, as a quarter of non-smokers experienced secondhand smoke exposure between 2013 and 2014 (CDC, 2022b). Since smoking rates also vary by various factors such as income status, disability status, sexual orientation, and education level (Jamal et al., 2018), the disproportionate distribution of smoking rates among the U.S. population may be a contributing factor to the disproportionate distribution of lung cancer diagnoses among the same. Due to its direct and severe association with lung cancer, smoking represents a significant public health concern.

Radon exposure

The second most common risk factor of lung cancer in the U.S. after smoking is radon exposure, resulting in roughly 21,000 deaths annually (United States Environmental Protection Agency [EPA], 2023). While current public health recommendations encourage testing in homes, nearly 7% of U.S. homes have radon levels that exceed safe limits (EPA, 2023). While this may not seem like a large portion of U.S. homes, the strong association between radon exposure and lung cancer underlines the need to tackle this problem.

Family History

An individual with first-degree relatives who have lung cancer is at a higher risk of developing lung cancer themselves, compared to an individual who does not have any first-degree relatives with lung cancer (CDC, 2022b). Certain genetic regions have been associated with an increased risk of developing lung cancer (Schwartz & Cote, 2015). In addition to genetic factors, socioeconomic determinants of health may also explain some of the association between lung cancer and family history. Numerous models of socioeconomic determinants of health emphasize the role of the family in shaping an individual's health behaviors as they mature (Ramos–Morcillo et al., 2019). For instance, adolescents with parents who smoke are more likely to be smokers compared to adolescents with parents who do not smoke (Alves et al., 2022). The environment a family shares can also be a risk factor. A common factor between an individual and their first-degree relative with lung cancer may be living together in housing with elevated radon levels (CDC, 2022b). In this case, the same risk factor that resulted in lung cancer for the first-degree relative exists for others who live with them.

Lung cancer screening allows healthcare providers to discover lung cancer before it progresses to later stages that are more difficult to treat (CDC, 2022c1). Screening tests for lung cancer include low-dose computed tomography (LDCT), chest x-

rays, and sputum cytology (PDQ Screening and Prevention Editorial Board, 2021). The first two screening methods expose patients to radiation, a risk factor for cancer. For low-risk patients, the health risks of radiation outweigh the benefits of lung cancer screening (PDQ Screening and Prevention Editorial Board, 2021). Treatment options for patients who screen positive include surgery, chemotherapy, and radiation therapy (CDC, 2022c1).

There is much health inequity associated with lung cancer in the U.S., such as racial and socioeconomic disparities (Borondy Kitts, 2019). The lung cancer mortality rate is highest among African Americans, even though smoking rates do not significantly differ between the African American and White populations (Borondy Kitts, 2019). One contributing factor could be that African Americans are "diagnosed at a statistically significant later stage (III/IV versus I/II) than Whites for all insurance types, with the exception of Medicaid" (Efird et al., 2014). Potential reasons for this difference include socioeconomic disparities and lack of trust with healthcare providers (Borondy Kitts, 2019). Distrust of the healthcare system has further been suggested as a barrier to lung cancer screening (Carter-Harris et al., 2015). One study at a safety net hospital demonstrated lower lung cancer screening rates for African Americans compared to other races (Steiling et al., 2020). Thus, healthcare system distrust may contribute to both lower screening rates and later-stage diagnoses for African American populations.

A lower household income level and government-based health insurance is also associated with lower rates of lung cancer screening, with lack of awareness cited as a possible explanation (Carter-Harris et al., 2018; Sosa et al., 2021). Among patients referred for lung cancer screening, a lower education level is associated with decreased understanding of the rationale behind this referral (Hall et al., 2018). This decreased understanding could result in reduced lung cancer screening rates among this population, although further research is needed to clarify the role of education in lung cancer screening (Sosa et al., 2021). While research affirms that lung cancer disproportionately affects racial minorities and socioeconomically disadvantaged individuals, results are mixed when comparing urban, suburban, and rural areas. Residents of urban areas tended to have less awareness of lung cancer screening, but were more likely to have undergone LDCT screening for lung cancer compared to their suburban and rural counterparts (Carter-Harris et al., 2018). Future investigations in this area could help define the association between rurality and lung cancer screening.

The aim of this study is to model the probability of being recommended a lung cancer test by a health professional in Virginia based on the variables of age, sex, race, current smoking status, cancer history, education level, income level, insurance, and rurality. Findings can provide insight into healthcare outcome disparities between racial and socioeconomic groups.

Methods

Data were obtained from the Community Health Assessment Survey conducted by the University of Virginia (UVA) Health System and Cancer System in collaboration with Virginia Commonwealth University (VCU) Cancer Center (UVA Cancer Center, n.d.). Collaboration between these two systems allowed for combining the catchment areas of each institution to cover most of Virginia. Counties that were not included in either catchment area were separately sampled to ensure all of Virginia was represented (Appendix A). The survey results are intended to be analyzed by the UVA Cancer System and Health System to adapt current programs to the specific needs

of their patients (UVA Cancer Center, n.d.). IRB approvals were obtained at UVA and VCU and a data use agreement (DUA) was executed to share data between these institutions.

The outcome of interest was receipt of recommendation of lung cancer screening by a health professional. Respondents were queried using a single item: "Has a doctor or other health professional EVER advised you to have a test to check for lung cancer? This would involve a scan of the lungs that produces pictures to look for lung cancer." Response options included "Yes" or "No". The target age demographic for this study is individuals aged 50-80, since this is the target age range for lung cancer screenings as recommended by the USTSPF (2021). However, there was no data category to isolate individuals below the age of 80, so individuals aged 50 and up (50+) were included in this study. The 50+ age demographic constituted 960 out of the 1496 survey responses. Variables for age, sex, race, current smoking status, past cancer status, income level, rurality, and being recommended a lung cancer screening were dichotomized. The American Cancer Society reports lung cancer diagnoses occur predominantly among those aged 65 years or older (2023). Accordingly, respondents' age was categorized as either 50-65 or 65+. Because the dataset did not include smoking history, respondents were classified based on their responses to the survey question, "How often do you now smoke cigarettes?" Participants who responded that they smoked either every day or some days were categorized as current smokers, while those who responded they do not currently smoke at all were categorized as current non-smokers. The past cancer status item asked if respondents had previously been diagnosed with cancer and did not distinguish between types of cancer. Income level was split into two levels with an attempt to categorize each level as above or below the poverty limit. In 2021, the poverty threshold in Virginia was $17,420 for a 2-person household and $21,960 for a 3-person household (Office of the Assistant Secretary for Planning and Evaluation, 2021). The average household size in Virginia between 2017 and 2021 was 2.57 (United States Census Bureau, 2022). An attempt was made to select a value collected in survey responses that fell between the two aforementioned poverty thresholds. The $20,000 threshold was the closest approximation. Those with a household combined annual income below this threshold were considered below the poverty level, while those above were considered above the poverty level.

Education was split into 3 different levels: High school or less, some college or post-high school training, and college graduate or higher. Insurance status also utilized 3 levels: Employer-based or self-purchased plan; Medicare, Medicaid, or another state program, and other (TRICARE, VA, Military, Alaska Native, Indian Health Service, Tribal Health Services, "Some other source," or no healthcare coverage). SAS software was utilized to create a model using logistic regression.

Results

Table 1. Demographic Characteristics of Study Participants

Characteristic	Percent	95% Confidence Interval
Age (n = 960)		
50-65	49.69%	46.48% - 52.90%
65+	50.31%	47.10% - 53.52%
Sex (n = 960)		
Male	50.21%	47.00% - 53.42%
Female	49.79%	46.58% - 53.00%
Race (n = 960)		
Black	10.83%	8.94% - 12.97%
Non-black	89.17%	87.03% - 91.06%
Current smoking status (n = 442)		
Smoker	19.68%	16.08% - 23.70%
Non-smoker	80.32%	76.30% - 83.92%
Ever had cancer (n = 943)		
Yes	27.15%	24.33% - 30.11%
No	72.85%	69.89% - 75.67%
Education level (n = 924)		

College Graduate or Higher	50.22%	46.94% - 53.49%
Some College or Post-High School Training	26.30%	23.49% - 29.96%
High School or Less	23.48%	20.79% - 26.35%
Income Level (n = 769)		
$<20,000	12.22%	9.99% - 14.75%
$≥20,000	87.78%	85.25% - 90.01%
Insurance Status (n = 877)		
Employer/Self	43.10%	39.79% - 46.45%
Medicare/Medicaid/State Program	47.89%	44.54% - 51.26%
Other	9.01%	7.20% - 11.10%
Rurality (n = 960)		
Urban	36.88%	33.82% - 40.02%
Non-urban	63.13%	59.98% - 66.18%
Been Recommended Lung Cancer Screening (n = 919)		
Yes	12.73%	10.64% - 15.06%
No	87.27%	84.94% - 89.36%

Table 1 shows the distribution of demographic characteristics of study participants. Because of the substantial number of respondents, confidence intervals estimating the corresponding population proportion could be calculated for each parameter (Boston University School of Public Health, 2017). Among those over the age of 50, 49.69% were in the 50-65 age range, while 50.31% were in the 65+ age range. Sex distribution in the study population did not significantly differ, with 50.21% being male and 49.79% being female. As for race, 10.83% of the study population was classified as "Black" and 89.17% was classified as "Non-Black." Current smokers constituted 19.68% of the study population while current non-smokers constituted 80.32%. In addition, 27.15% of the participants in the study had previously been diagnosed with cancer. With regard to education level, the majority of participants (50.22%) were college graduates or higher. The amount with some college/post-high school training (26.30%) or high school education or less (23.48%) were similar. In terms of income level, 12.22% of participants fell in the $0 - $19,999 range while 87.78% were in the $20,000+ group. Lastly, employer-based and self-purchased insurance comprised 43.10% of the study population. Medicare, Medicaid, and other state programs made up 47.89%, while "Other" made up the remaining 9.01%. Rurality was designated based on the 2013 U.S. Department of Agriculture Rural-Urban Continuum Codes (2020). Of the study participants, 36.88% live in an urban environment while 63.13% live in a non-urban environment. 919 individuals reported if they had been recommended a lung cancer test by a health professional, with 12.73% reporting they had and 87.27% reporting they had not.

All variance inflation factors of the tested variables were less than 5, indicating no multicollinearity between independent variables (Kim, 2019). A correlation matrix shows the highest correlation exists between education and income with a Pearson Correlation Coefficient of 0.51395 (Appendix B). When education was excluded in the regression model, goodness-of-fit only changed from an AIC of 299.411 to 300.831. However, when income was excluded, goodness-of-fit was worsened with an AIC increase to 360.493. Thus, a regression model excluding education was chosen to increase model parsimoniousness while preserving goodness-of-fit (Portet, 2020).

Table 2. Logistic Regression Model of Being Recommended a Lung Cancer Test Based on Age, Sex, Race, Current Smoking Status, Cancer History, Education, Income, and Insurance (n = 288)

	Model 1: Including Education		**Model 2: Excluding Education**	
Parameter	**Estimate**	**Odds Ratio**	**Estimate**	**Odds Ratio**
Intercept	**-2.0408 **** (0.7200)		**-1.9846 **** (0.6939)	
Age 50-65 Ref = 65+	-0.6489 (0.4646)	0.523 (0.209 – 1.304)	-0.6716 (0.4684)	0.511 (0.203 – 1.284)

Female Ref = Male	-0.5314 (0.3471)	0.588 (0.297 - 1.164)	-0.5525 (0.3372)	0.575 (0.296 – 1.117)
Black Ref = Non-black	0.4333 (0.4663)	1.542 (0.616 – 3.861)	0.4216 (0.4557)	1.524 (0.622 – 3.738)
Current smoker Ref = No	**1.2540 **** (0.4061)	3.504 (1.576 – 7.794)	**1.2493 **** (0.3988)	3.488 (1.591 - 7.646)
Ever Had Cancer Ref = No	**0.7882 *** (0.3606)	2.199 (1.082 - 4.472)	**0.7699 *** (0.3473)	2.159 (1.090- 4.278)
Education College Graduate or Higher Some College or Post-High School Training Ref = High School or Less	 0.1399 (0.4109) -0.0546 (0.4430)	 1.150 (0.512 - 2.582) 0.947 (0.396 - 2.265)		
Income ≥$20,000 Ref = <$20,000	 -0.0391 (0.4358)	 0.962 (0.408 – 2.267)	 -0.0130 (0.4129)	 0.987 (0.438 – 2.225)
Insurance Medicare/Medicaid/State Program Other Ref = Employer-based or self-purchased	 0.4356 (0.4830) 0.8656 (0.5616)	 1.546 (0.597 – 4.000) 2.376 (0.787 – 7.178)	 0.4054 (0.4835) 0.7785 (0.5481)	 1.500 (0.579 - 3.885) 2.178 (0.741 - 6.406)
Rurality Urban Ref = Non-urban	 0.6491 (0.3370)	 1.914 (0.986 - 3.715)	 **0.6620 *** (0.3317)	 1.939 (1.009 - 3.724)

* = statistically significant result at $p < 0.05$, ** = statistically significant result at $p < 0.01$

Table 2 shows the results of a logistic regression modeling the probability

of participants being recommended a lung cancer test based on the variables of sex, race, current smoking status, previous cancer status, education level, income level, insurance status, and rurality. While there were 919 responses for being recommended a lung cancer test or not, 288 data points were used for the logistic regression as all variables were not answered for all individuals. Specifically, many individuals did not disclose their current smoking status, as only 415 of the aforementioned 919 individuals provided this information. Statistically significant positive predictors included being a current smoker (OR: 3.504, CI: 1.576 – 7.794), having previous cancer history (OR: 2.159, CI: 1.090- 4.278), and living in an urban environment (OR: 1.939, CI: 1.009 - 3.724).

Discussion

The logistic regression suggests there are numerous factors that influence how likely one is to be recommended a lung cancer test. While differences in healthcare experiences are expected due to the unique circumstances of each patient, some differences could be indicative of certain disparities that may pervade the medical field. Age, sex, race, education, and income were not considered significant predictors in this model while current smoking status, previous cancer history, and rurality were considered significant predictors.

Current Smoking Status

The odds that an individual who had been recommended a lung cancer test was a current smoker was 3.488 (CI: 1.591 - 7.646) times greater than the odds that the individual was not a current smoker. Smoking is a well-defined risk factor for lung cancer, so it is appropriate that it is associated with being recommended a lung cancer test (CDC, 2022b). This study could only assess current smoking status and not history of smoking. However, smoking history is a significant criterion for being recommended a lung cancer test (USPSTF, 2021), so individuals who were recommended a lung cancer test and were not current smokers likely have smoking history. Nonetheless, smoking history in pack-years was not collected in the survey and would be a valuable addition to future analyses. Including medical record data on smoking history is one avenue to accomplish this. Notably, less than half of patient visits are accompanied by adequate documentation of smoking history (Volk et al., 2020). Respondents' self-reported smoking status in this survey might not correspond with the smoking status listed in their medical records. In turn, healthcare providers that rely on medical records may not have complete patient data when assessing lung cancer risk. Analyzing smoking history from patient medical records as well as self-reported smoking status could bridge this disconnect. Furthermore, only 415 out of 919 respondents chose to disclose their current smoking status, indicating many people could be uncomfortable providing this information. Patients who smoke frequently face stigma, especially when they are concurrently diagnosed with lung cancer (Williamson et al., 2020). In fact, one study of lung cancer patients reports that patients "who currently smoked reported significantly higher total, internalized, and perceived lung cancer stigma compared to those who formerly or never smoked" (Williamson et al., 2020). Such stigma could be a contributing factor why some respondents feel uncomfortable disclosing their smoking history, although this may be mitigated by the confidential nature of the survey. Non-response bias is a concern and those who responded to this survey item might not be a fully representative sample for smoking status.

Previous Cancer History

The odds that an individual who had

been recommended a lung cancer test had previously had cancer was 2.159 (CI: 1.090-4.278) times greater than the odds that the individual had not previously had cancer. Presumably, healthcare providers who learn of a patient's history of cancer are more likely to consider the potential for cancer and recommend a lung cancer test. This is clinically advantageous as multiple studies of cancer survivors indicate lung cancer screening is beneficial for these patients (O'Dwyer et al., 2021). Therefore, a patient's cancer history should not deter healthcare providers from recommending lung cancer screening when appropriate as this recommendation can appreciably promote patient health. It is important to note that survey responses in this dataset did not distinguish between types of cancer. History of certain types of cancer may influence health professionals to be concerned for lung cancer more so than others.

Rurality

The odds that an individual who had been recommended a lung cancer test lived in an urban environment was 1.939 (CI: 1.009 – 3.724) times the odds that the individual lived in a non-urban environment. As previously noted, urban residents may be less aware of lung cancer screening compared to non-urban residents but are more likely to have completed such screenings (Carter-Harris et al., 2018). These results indicate that one reason urban residents may be more likely to have completed a lung cancer screening is that they are recommended them at higher rates. In urban environments, emphasis should be placed on raising awareness of lung cancer screenings. On the other hand, non-urban environments may benefit more from efforts aimed towards health professionals and departments to recommend lung cancer screenings when appropriate. Importantly, rurality was only considered a significant predictor when education was excluded in the regression model. Conclusions regarding this variable should be drawn with caution. Still, these results should encourage future studies to consider how lung cancer recommendations may differ between urban and non-urban areas.

Non-Significant Predictors

The non-significance of certain predictors should also be discussed, as they represent interesting findings in terms of health equity. While it would be tempting to conclude that healthcare disparities in lung cancer screening do not exist in the spheres of age, race, and socioeconomic status, that is unfortunately not the case. These results provide insight into how these disparities may manifest in our healthcare system.

Although groups such as African Americans experience a disproportionately high rate of lung cancer mortality (Borondy Kitts, 2019), these results reveal such differences may not predominate at the step of lung cancer screening recommendations. The mechanism advancing these disparities may lie further in the pathway of disease progression. Indeed, these results should be analyzed in the context of existing literature which has demonstrated that the rate of lung cancer screening is lower among African Americans (Steiling et al., 2020) but does not examine lung cancer screening recommendation rates. Rather than these health inequities arising at the screening recommendation step, it seems they become significant at the actual screening step or even later steps such as diagnosis, treatment, or recovery. Investigating the specific barriers of undergoing a lung cancer screening after being recommended one can help address this inequity. Moreover, identifying the steps in disease progression that are affected most deeply by racial biases could help elucidate additional reasons explaining these health disparities.

Lower income levels, as well as Medicare/Medicaid/State Program or Other insurance, were not significant predictors of

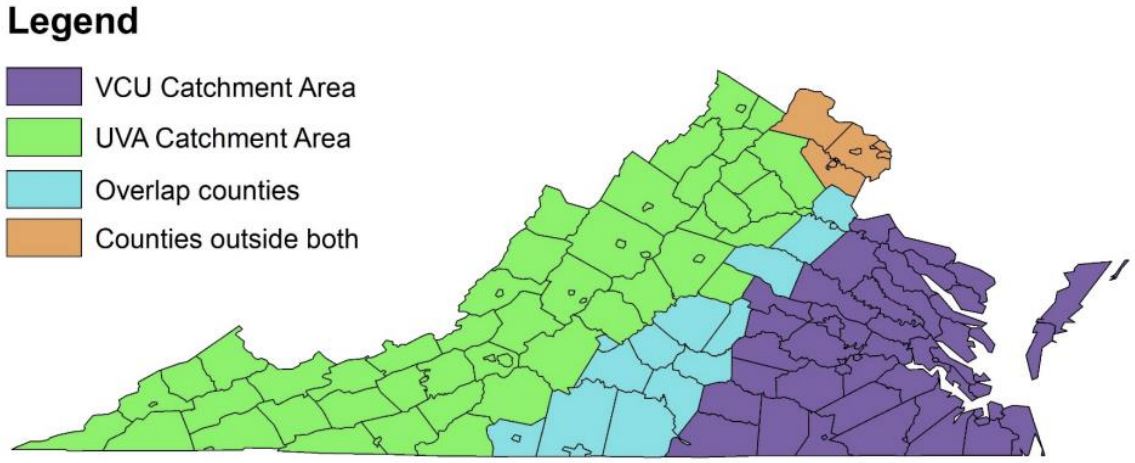
lung cancer screening recommendations, even though these populations tend to be associated with lower lung cancer screening rates (Carter-Harris et al., 2018; Sosa et al., 2021). As with the aforementioned racial disparities, an explanation is that lung cancer screening recommendations do not always translate to the patient undergoing the screening. Socioeconomically disadvantaged individuals face a myriad of healthcare barriers, such as lack of transportation, funds, or social support, that can prevent them from completing lung cancer screening even if recommended at rates comparable to the rest of the population (Sosa et al., 2021).

Additional limitations of this study include uneven distribution of participants with regard to income level, education status, and insurance status. The majority of participants had a household combined annual income of more than $20,000 and a college degree or higher. Thus, this study may not accurately capture the situations of those living in lower socioeconomic strata. Many study participants chose not to answer all survey questions, such as current smoking status. Incorporating medical record data for smoking status could mitigate this non-response bias while concurrently acknowledging that health professionals base much of their clinical decision-making regarding smoking history on patients' medical records (Volk et al., 2020). Lastly, another avenue for expanding on this research is assessing other strong risk factors of lung cancer, such as radon exposure and family history of lung cancer (CDC, 2022b).

Conclusion

This study identified that being an active smoker, having a personal cancer history, and living in an urban environment are associated with higher odds of being recommended a lung cancer screening by a health professional in Virginia. The non-significance of racial and socioeconomic predictors suggests that key mechanisms underlying lung cancer outcome disparities for these populations may lie beyond the level of screening recommendations. Future studies should investigate where healthcare disparities predominantly arise along the continuum of disease progression, such as during treatment or recovery. Such information could guide public health officials in designing targeted interventions to improve health equity.

Appendix A: Catchment Areas by University



Appendix B. Correlation Matrix

	Age	Sex	Race	Smoking Status	Cancer History	Education	Income	Insurance	Rurality
Age		-0.06039	-0.07591	0.15913	0.20492	-0.02124	-0.15947	0.27841	0.02545
Sex	0.06039		0.06178	0.00214	-0.02797	-0.05512	-0.23882	-0.01834	0.08955
Race	-0.07591	0.06178		-0.15088	-0.04558	-0.14091		0.02146	-0.13442
Smoking Status	0.15913	0.00214	-0.15088		-0.05332	0.20124	0.22685	-0.05866	0.12630
Cancer History	0.20492	-0.02797	-0.04558	-0.05332		0.00514	-0.00916	0.04224	0.04214
Education	-0.02124	-0.05512	-0.14091	0.20124	0.00514		0.51395	-0.17482	0.05304
Income	-0.15947	-0.23882	-0.20883	0.22685	-0.00916	0.51395		-0.30633	0.02344
Insurance	0.27841	-0.01834	0.02146	-0.05866	0.04224	-0.17482	-0.30633		0.03158
Rurality	0.02545	0.08955	-0.13442	0.12630	0.04214	0.05304	0.02344	0.03158	

References

Alves, J., Perelman, J., Ramos, E., & Kunst, A. E. (2022). Intergenerational transmission of parental smoking: When are offspring most vulnerable? *European Journal of Public Health*, *32*(5), 741–746. https://doi.org/10.1093/eurpub/ckac065

American Cancer Society. (2023, January 12). *Key Statistics for Lung Cancer*. https://www.cancer.org/cancer/types/lung-cancer/about/key-statistics.html

Borondy Kitts, A. K. (2019). The Patient Perspective on Lung Cancer Screening and Health Disparities. *Journal of the American College of Radiology*, *16*(4), 601–606. https://doi.org/10.1016/j.jacr.2018.12.028

Boston University School of Public Health. (2017, October 27). *Confidence Interval for One Sample, Dichotomous Outcome*. https://sphweb.bumc.bu.edu/otlt/MPH-Modules/BS/BS704_Confidence_Intervals/BS704_Confidence_Intervals4.html#headingtaglink_3

Carter-Harris, L., Ceppa, D. P., Hanna, N., & Rawl, S. M. (2015). Lung cancer screening: What do long-term smokers know and believe? *Health Expectations*, *20*(1), 59–68. https://doi.org/10.1111/hex.12433

Carter-Harris, L., Slaven, J. E., Monahan, P. O., Shedd-Steele, R., Hanna, N., & Rawl, S. M. (2018). Understanding lung cancer screening behavior: Racial, gender, and geographic differences among Indiana long-term smokers. *Preventive Medicine Reports*, *10*, 49–54. https://doi.org/10.1016/j.pmedr.2018.01.018

Centers for Disease Control and Prevention. (2022a, June 6). *Lung Cancer Statistics*. https://www.cdc.gov/cancer/lung/statistics/index.htm

Centers for Disease Control and Prevention. (2022b, October 25). *What Are the Risk Factors for Lung Cancer?* https://www.cdc.gov/cancer/lung/basic_info/risk_factors.htm

Centers for Disease Control and Prevention. (2022c, October 25). *How Is Lung Cancer Diagnosed and Treated?* https://www.cdc.gov/cancer/lung/basic_info/diagnosis_treatment.htm

Efird, J. T., Landrine, H., Shiue, K. Y., O'Neal, W. T., Podder, T., Rosenman, J. G., & Biswas, T. (2014). Race, insurance type, and stage of presentation among lung cancer patients. *SpringerPlus*, *3*(1), 710. https://doi.org/10.1186/2193-1801-3-710

Hall, D. L., Lennes, I. T., Carr, A., Eusebio, J. R., Yeh, G. Y., & Park, E. R. (2018). Lung Cancer Screening Uncertainty among Patients Undergoing LDCT. *American Journal of Health Behavior*, *42*(1), 69–76. https://doi.org/10.5993/AJHB.42.1.7

Jamal, A., Phillips, E., Gentzke, A. S., Homa, D. M., Babb, S. D., King, B. A., & Neff, L. J. (2018). Current Cigarette Smoking Among Adults—United States, 2016. *MMWR: Morbidity and Mortality Weekly Report*, *67*(2), 53–59. https://doi.org/10.15585/mmwr.mm6702a1

Kim, J. H. (2019). Multicollinearity and misleading statistical results. *Korean Journal of Anesthesiology*, *72*(6), 558–569. https://doi.org/10.4097/kja.19087

O'Dwyer, E., Halpenny, D. F., & Ginsberg, M. S. (2021). Lung cancer screening in patients with previous malignancy: Is this cohort at increased risk for malignancy? *European Radiology*, *31*(1), 458–467. https://doi.org/10.1007/s00330-020-07026-x

Office of the Assistant Secretary for Planning and Evaluation. (2021). *2021 Poverty Guidelines*. https://aspe.hhs.gov/2021-poverty-guidelines

PDQ Screening and Prevention Editorial Board. (2021). Lung Cancer Screening (PDQ®). In *PDQ Cancer Information Summaries [Internet]*. National Cancer Institute (US). https://www.ncbi.nlm.nih.gov/books/NBK65991/

Portet, S. (2020). A primer on model selection using the Akaike Information Criterion. *Infectious Disease Modelling*, *5*, 111–128. https://doi.org/10.1016/j.idm.2019.12.010

Ramos–Morcillo, Moreno–Martínez, Susarte, Hueso–Montoro, & Ruzafa–Martínez. (2019). Social Determinants of Health, the Family, and Children's Personal Hygiene: A Comparative Study. *International Journal of Environmental Research and Public Health*, *16*(23), 4713. https://doi.org/10.3390/ijerph16234713

Schwartz, A. G., & Cote, M. L. (2015). Epidemiology of Lung Cancer. In A. Ahmad & S. Gadgeel (Eds.), *Lung Cancer and Personalized Medicine* (Vol. 893, pp. 21–41). Springer International Publishing. https://doi.org/10.1007/978-3-319-24223-1_2

Sosa, E., D'Souza, G., Akhtar, A., Sur, M., Love, K., Duffels, J., Raz, D. J., Kim, J. Y., Sun, V., & Erhunmwunsee, L. (2021). Racial and socioeconomic disparities in lung cancer screening in the United States: A systematic review. *CA: A Cancer Journal for Clinicians*, *71*(4), 299–314. https://doi.org/10.3322/caac.21671

Steiling, K., Loui, T., Asokan, S., Nims, S., Moreira, P., Rebello, A., Litle, V. R., & Suzuki, K. (2020). Age, Race, and Income Are Associated With Lower Screening Rates at a Safety Net Hospital. *The Annals of Thoracic Surgery*, *109*(5), 1544–1550. https://doi.org/10.1016/j.athoracsur.2019.11.052

United States Census Bureau. (2022). *QuickFacts: Virginia*. https://www.census.gov/quickfacts/fact/table/VA/PST045222

United States Environmental Protection Agency. (2023, May 5). *Radon in Homes, Schools and Buildings*. https://www.epa.gov/radtown/radon-homes-schools-and-buildings

United States Preventive Services Task Force. (2021, March 9). *Lung Cancer: Screening*. https://www.uspreventiveservicestaskforce.org/uspstf/recommendation/lung-cancer-screening

University of Virginia Cancer Center. (n.d.). *Community Health Assessment Survey*. University of Virginia Health System.

Volk, R. J., Mendoza, T. R., Hoover, D. S., Nishi, S. P. E., Choi, N. J., & Bevers, T. B. (2020). Reliability of self-reported smoking history and its implications for lung cancer screening. *Preventive Medicine Reports*, *17*, 101037. https://doi.org/10.1016/j.pmedr.2019.101037

Williamson, T. J., Kwon, D. M., Riley, K. E., Shen, M. J., Hamann, H. A., & Ostroff, J. S. (2020). Lung Cancer Stigma: Does Smoking History Matter? *Annals of Behavioral Medicine*, *54*(7), 535–540. https://doi.org/10.1093/abm/kaz063