Spotting Melanoma:

An Analysis of Melanoma Rates and Treatment Costs in the United States

Team #11806: Significant Errors

2022-2023 Modeling the Future Challenge Project Report

Executive Summary

Melanoma is the deadliest type of skin cancer with incidence rates rising in the United States over the past couple of decades. Furthermore, these rates have been rising at an alarming rate for the senior population, which includes individuals sixty-five and older. The cancer starts in the skin but develops and spreads out to other regions of the body. Later stages of melanoma start to affect the body's lymph nodes, which are a vital part of the immune system. Individuals become immunocompromised and more susceptible to illnesses and infections, especially older adults. Treatment for late-stage melanoma is expensive, costing tens of thousands of dollars. However, if caught early, melanoma can be removed fully during a biopsy.

We draw data about melanoma incidence rates in the United States from the National Cancer Institute's Surveillance, Epidemiology, and End Results Program (SEER). The data includes information about the aggregate melanoma rates by age and stage of diagnosis for the entire nation. We draw information about costs and screening accuracy from different American studies; we observed past trends in melanoma rates from 2000 to 2019 for three different age groups: under 50, 50 to 64, and 65 and over. We also analyze the time series to create a model to predict future rates for each of the three age groups and predicted the melanoma incidence rates with a 95% confidence level. We determine that rates are rising for people in the older two age groups, but they are rising the fastest for seniors.

We explore the accuracy and cost of annual skin cancer screenings for each age group. We calculate the accuracy of a screening performed by a dermatologist. By implementing the annual screenings for the modeled rates for 2023 to 2033 and comparing the melanoma rates before and after, we determine that the screenings were 97.60% accurate for the under 50 age group, 97.58% accurate for the 50 to 64 age group, and 97.56% accurate for the 65 and over age group. We then calculate the expected value of melanoma treatment per person before and after annual screenings. We compare the costs before and after annual screenings: $23.38 and $150.00, $34.09 and $150.01, and $111.66 and $150.02 for under 50, 50 to 64, and 65 and over, respectively. However, with melanoma cases on the rise, we estimate that the program will be more economically advantageous for health insurers by 2046 for seniors.

A potential risk is that health insurers will not cover annual screenings for seniors due to cost. Another risk is that program effectiveness may differ between regions due to the limitations surrounding regional melanoma data.

We discuss different risk mitigation strategies with a focus on prevention. We propose that an annual skin cancer screening program for seniors is implemented through insurers, starting with public insurers. The initial deployment of the program will provide us with concrete results. To complement the screening program, we recommended a regular application of sunscreen when exposed to the sun for long periods of time and a behavioral change of seeking safe tanning alternatives to indoor tanning beds.

Introduction and Background

Melanoma, the most invasive cancer, will affect approximately 10.3 million Americans in their lifetime. Allowing it to develop significantly increases the risk of long-term health detriments. If melanoma is not detected early, it spreads to the body's lymph nodes, small structures that are part of the immune system which filter substances and contain white blood cells. Damaging the lymph nodes damages the body's entire immune system. A literary review published in the US Department of Health and Human Services estimates the average cost of treatment for severe melanoma treatment to be over $20,000 per patient. The healthcare industry spends hundreds of millions annually on skin cancer treatments. However, for patients whose melanoma is detected early, the five-year survival rate is over 99%[19]. The melanoma can be removed during the initial skin cancer screening as part of a biopsy. The severity of these risks is wide-ranging as it can range from a small surgery not costing much to a defective immune system or death after thousands in treatment.

A strategy to prevent melanoma from developing is regularly scheduling a skin cancer screening. The average cost of a skin cancer screening is $150, and it is recommended to attend one annually. If a very early-stage melanoma is detected, it can be removed completely within the screening appointment. It also will not have long-term negative effects on the body. We will analyze the frequency and severity of melanoma for Americans with regard to different factors to determine more cost-effective methods to implement annual preventive screenings.

Biological Factors

A biological factor that increases the risk of melanoma is age. The skin ages in two ways: intrinsic and extrinsic[1]. Everybody will experience intrinsic aging where their skin will lose fat and water and become thinner, and the body's self-healing ability decreases. This causes the skin to be more susceptible to UV rays and increases the risk of melanoma. Extrinsic aging is caused by factors like UV rays and pollutants which play a part in melanoma risk. Once retired, many Americans spend a longer time in the sun than working adults, exposing themselves to UV rays for a longer period of time. Seniors also have been exposed to environmental pollutants and diseases for a longer time.

Research also shows that biological sex and race are a factor in melanoma incidence rates, but based on our initial modeling, we have determined that the rates are increasing despite these factors. Because of this increase regardless of race or biological sex, we will focus on modeling and analyzing the rates of melanoma in individuals by age.

Problem Statement

Melanoma poses long-term health detriments to those who are affected if not caught early. The cancer costs health insurers and patients $3.3 billion annually in the United States and

incidence rates are currently rising. We analyze data of melanoma incidence and treatment to identify past trends, model future rates, and calculate medical costs. In order to mitigate risks of melanoma, we recommend that health insurance companies provide an annual skin cancer screening for the group at the highest risk, American seniors.

Data Methodology

We will focus our report on two major points: frequency and severity. We will look at these two aspects in regards to melanoma rates and the economic rates of melanoma treatment and screenings for the American population. We will examine the rates of melanoma for Americans by age to determine the frequency of melanoma, and examine the rates of melanoma by stage to determine the expected value of cost for health insurance companies. The cost of melanoma treatment varies greatly by stage of diagnosis. We will look at the stage of diagnosis with regards to four different stages of cancer staging standardized by the National Institute of Cancer:

1. Localized: the melanoma is limited to where it started and has not spread to any other areas
2. Regional: the melanoma has spread to nearby tissues, organs, or lymph nodes
3. Distant: the melanoma has spread to distant tissues, organs, or lymph nodes
4. Unstaged: there is not enough knowledge about the melanoma to determine a stage.

We will assess the severity of the melanoma to determine expected total treatment costs. Analyzing the frequency and severity of melanoma rates and cases will help determine the target group for implementing the insurance program to conduct an annual melanoma screening.

Data Focus 1: Melanoma Rates

We will use data from SEER[32]. This data describes the incidence rates for melanoma in the American population. The data tells us the rate of incidence based on type of incidence rate, biological sex, race, and age for the years 2000 to 2019. The data also describes the stage of diagnosis of the melanoma for the years 2004 to 2019. The stages are categorized by four different severities: localized, regional, distant, and unstaged. However, with the SEER data, there are some limitations:

1. The data is only taken from SEER 22 areas which are San Francisco, Connecticut, Hawaii, Iowa, New Mexico, Seattle, Utah, Atlanta, San Jose-Monterey, Los Angeles, Alaska Native Registry, Rural Georgia, California excluding SF/SJM/LA, Kentucky, Louisiana, New Jersey, Georgia excluding ATL/RG, Idaho, New York, Massachusetts,

Illinois, and Texas. Due to the expansive range the SEER 22 areas cover in the United States, we will use the data to generalize our results for all Americans.

2. Furthermore, the data surrounding persons of the non-hispanic American Indian/Alaskan Native race category is limited due to it being obtained from areas where purchased or referred care by the Indian Health Service is available. This limits melanoma data for non-hispanic American Indians or Alaskan Natives because we only have information about melanoma cases that were reported in a purchased or referred care area (PRCDA).
3. We do not possess the rates of melanoma for each region and are using the aggregate data to model the rates. The rates and trends in each region are unknown to us due to the difficulty of obtaining specific medical data under the Health Insurance Portability and Accountability Act of 1996 (HIPAA).
4. We will also disregard the aggregate melanoma rates from the years 2000 to 2003 when modeling with stage of diagnosis due to lack of data about stage before 2004. This SEER database does not possess data for 2020 to 2022 as the data has not been made available to use, we will create models to predict rates for ten years from now, 2023 to 2033.

For these reasons, we will project trends and come to conclusions with regards to the population as the entire nation, focusing on the trends of melanoma rates with regards to age, stage of diagnosis, and cost of treatment from 2004 to 2019 and only use data from 2000 to 2019 to predict future aggregate melanoma rates without regards to stage.

Data Focus 2: Cost and Effectiveness of Treatment

We will draw the costs of melanoma treatments from a literary review published in 2012 by the US Department of Health and Human Services[11]. This review compares the cost of melanoma treatment from multiple different studies and breaks them down by stage. Using the data from US studies, we can find the average cost of treatment for localized, regional, and distant. We primarily draw costs from this review from a study done on cancer treatment cost in the United States[41]. We will use the details about the effectiveness of a skin cancer screening by a dermatologist from an evidence report comparing multiple studies. This report was published in 2016 by the US Preventive Services Task Force[16]. We will use the statistics outlined in the report to calculate the effectiveness of annual skin cancer screenings with regards to cost and incidence rates by age group.

Data Usage

We describe the details of the data and studies and include reasons for inclusion or exclusion in the report.

Data	Reasoning for inclusion/exclusion
SEER Melanoma Incidence - Age[32]	The age group data is categorical. The data is divided into multiple different groups, but we will focus on these three categories: under 50, 50-64, and 65 and over. We divide rates by age because skin aging plays a large factor in susceptibility to melanoma.
SEER Melanoma Incidence - Stage of Diagnosis[32]	The stage of diagnosis data is categorical. It is divided into different stages of diagnosis: localized, regional, distant, and unstaged. We focus on the stage of diagnosis because the severity of the cancer and treatment costs are affected.
SEER Melanoma Incidence - Race and Sex[32]	The race and biological sex data are both categorical. The data is divided by different races and sexes. We do not focus on these factors because melanoma rates are increasing despite these factors.
Melanoma Treatment Costs[11, 41]	The studies determine the cost in dollars of melanoma treatment by stage of diagnosis in the US. We focus on the costs to determine the impact of annual screenings.
Skin Cancer Screening Accuracy[16]	The report discusses the accuracy of a skin cancer screening test. We use results from the report to determine the accuracy of the screening.

Mathematics Methodology

We will use the data sources outlined in the data methodology to create models, predict future trends, and estimate the significance of implementing an annual skin cancer screening.

Assumptions

We define assumptions used throughout our project where relevant in addition to the following:

1. *There are many parameters that influence melanoma rates such as age, race, biological sex, climate change, and more.* There are many different factors that influence a person's

health and susceptibility to a cancer like mood, weight, or biological sex. From our initial modeling we have determined that melanoma rates follow the same general trend across many of these factors. For the purpose of the report, we will focus on melanoma rates and age.

2. *The effects of COVID-19 on melanoma rates can be neglected when modeling future rates.* An effect of COVID-19 on melanoma rates is the delay in diagnosis due to maximum hospital capacity being reached and priority given to treating COVID-19 patients. This may have impacted the rates and stage of diagnosis from 2020 to 2022. While some studies have established that contracting COVID-19 intensified the effects of the melanoma, there is not sufficient data or evidence to conclude that contacting the respiratory disease has a long-term impact on risk of melanoma. For the purpose of this report, we will model melanoma rates without considering COVID-19 as there is no data recent enough to conclude its effects.
3. *The trends observed and projected are made for the nation as a whole.* The SEER data surrounding melanoma rates provides melanoma rates for the entire United States, not regional rates.

Terminology and Variables

We define key terms, language,and variables used throughout our project where relevant in addition to the following:

1. Incidence: Incidence is a term used primarily in epidemiology that refers to the probability that the disease or disorder occurs in a population for a specific time period. We will be exploring melanoma incidence in regards to annual rates.
2. Rates: Melanoma rates refer to the number of cases calculated per 100,000 people in America.
3. Specificity: The specificity of a medical test, which is a skin cancer screening by a dermatologist in this case, refers to its ability to identify an individual who does not have melanoma as negative.
4. Sensitivity: The sensitivity of a medical test refers to its ability to identify an individual who has melanoma as positive.
5. Accuracy: The accuracy of a medical test refers to its ability to correctly identify an individual's melanoma status. The accuracy of a skin cancer screening by a dermatologist describes the percentage of correctly identified melanoma cases.
6. Prevalence: The yearly prevalence refers to the probability of melanoma in the population each year.

Modeling and Analysis

Age is a factor in risk of melanoma because of its effect on skin and health. For this reason, we will start by graphing melanoma incidence rates by age group and defining past trends. We have divided the ages into three categories: under 50, 50 to 64, and 65 and over. The data is graphed in Figure 1.

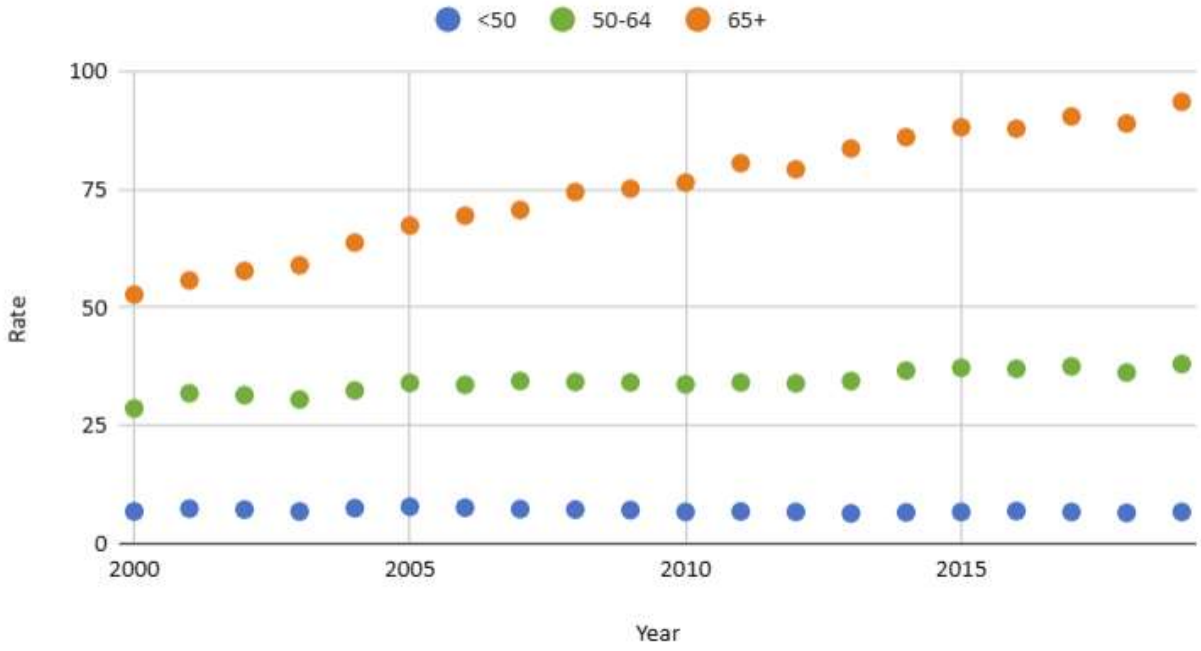

Figure 1: Melanoma Rates by Age from 2000-2019

In this graph, we see that melanoma incidence rates for members of the 65+ age group are increasing at a high rate. For people under the age of 50, the melanoma incidence rates have been constant over the 19 years and for people between 50 and 64, the rates seem to be slowly increasing. To analyze the melanoma incidence rates further, we will create a model to predict future rates. This model will be used to find the melanoma incidence rates for the next ten years after 2022. This process will be repeated for each of the three age groups to determine the past and future trends of melanoma rates.

The rates for the under 50 age group have varied greatly over the past 19 years which limits the accuracy of a model. We chose a linear model because it had the highest R^2 value compared to a logarithmic, exponential, or polynomial model. The linear model can be seen in Figure 2.

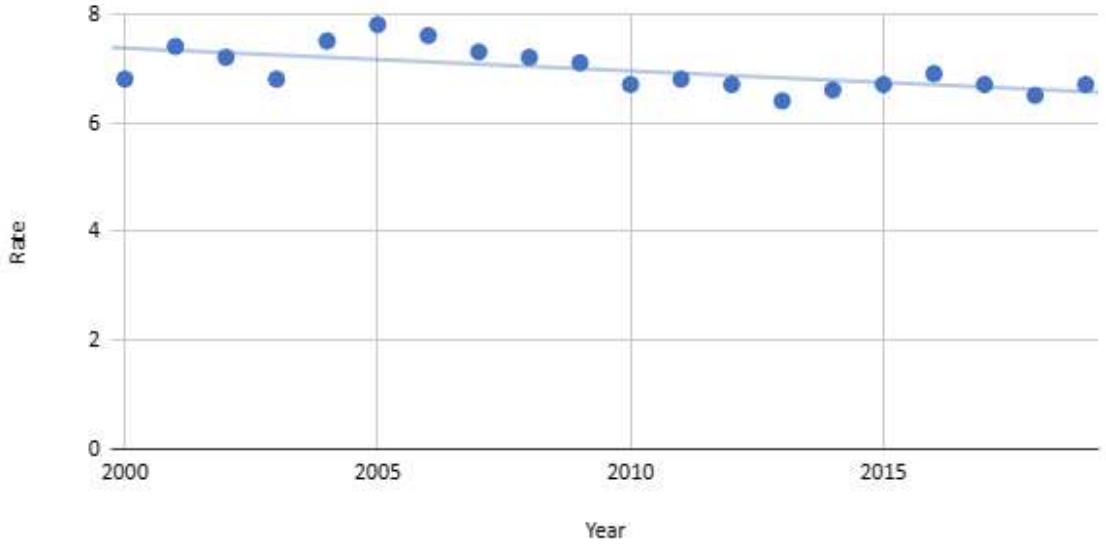

Figure 2: Melanoma Rates for People Aged <50 from 2000-2019

The line can be modeled using the equation, where x represents the year and y represents the rate,

$$y = -0.0421x + 91.5810,$$

with an R^2 value of 0.4035. The R^2 value is moderately low which means that the model is not very accurate. As this model predicts values in a time series and major changes in incidence rates for people under 50 are not expected, we will still use the model. The incidence rates for the next ten years have been calculated with the equation of the model and are displayed in Table 1. We have also calculated a 95% confidence interval (C.I.) for our model. Because the SEER melanoma incidence rates for each age group have been calculated with large sample sizes (greater than 30), we can classify rates to fall in a normal distribution. We add and subtract two standard deviations to obtain the 95% confidence interval.

Year	Modeled Rate	Lower 95% C.I.	Upper 95% C.I.
2023	6.4127	6.3513	6.5570
2024	6.3706	6.3144	6.5160
2025	6.3285	6.2775	6.4750
2026	6.2864	6.2406	6.4340
2027	6.2443	6.2037	6.3930

2028	6.2022	6.1668	6.3520
2029	6.1601	6.1299	6.3110
2030	6.1180	6.0930	6.2700
2031	6.0759	6.0561	6.2290
2032	6.0338	6.0192	6.1880
2033	5.9917	5.9823	6.1470

Table 1: Modeled Melanoma Rates for People Aged <50

The slope of the model describes that incidence rates have been generally decreasing from 2000 to 2019. Based on this model, the melanoma rates for people under 50 will decrease in the next ten years. We will now examine the melanoma rates for people between 50 and 64 (inclusive). From our initial graph, we see that the rates have been increasing. We decided a linear model would fit the general trend of data best because it had the highest R^2 value compared to a logarithmic, exponential, or polynomial model. This model can be seen in Figure 3.

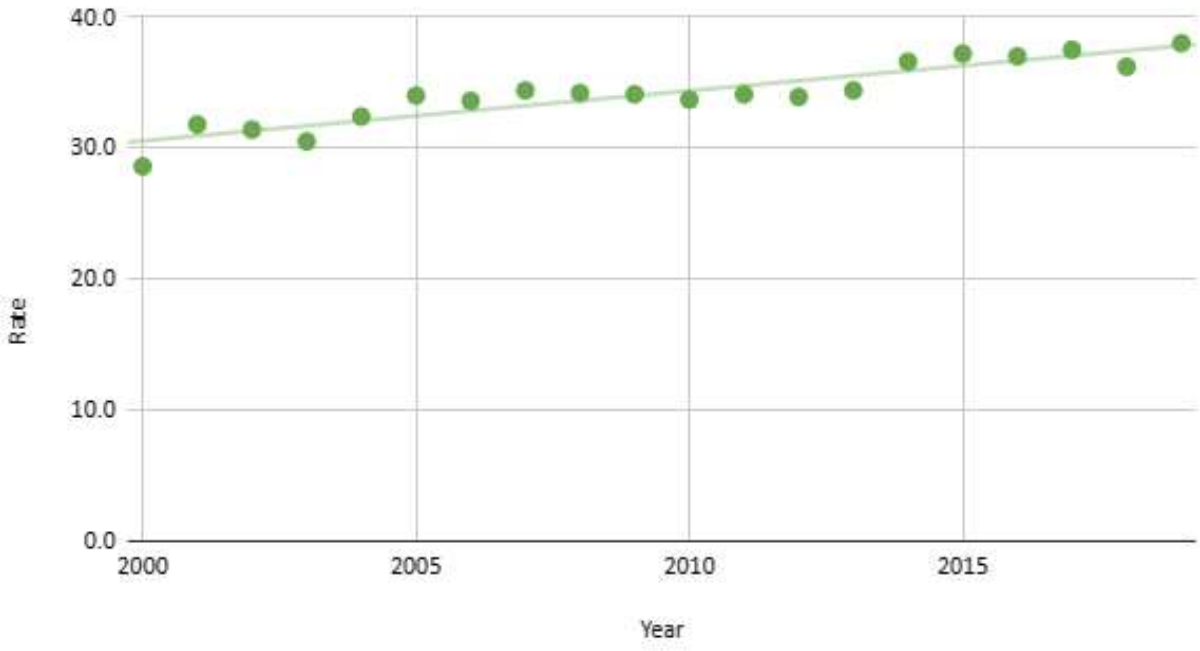

Figure 3: Melanoma Rates for People Aged 50-64 for 2000-2019

The linear model follows the equation, where x represents the year and y represents the rate,

$$y = 0.3820x - 733,$$

with an R^2 value of 0.8423. The R^2 value is moderately high which indicates that the model is a moderately reliable predictor of incidence rates. The incidence rates for the next ten years have been calculated with the equation of the model and are displayed in Table 2. We have also calculated a 95% confidence interval (C.I.) for our model. We are 95% confident that the future value will fall within the interval.

Year	Modeled Rate	Lower 95% C.I.	Upper 95% C.I.
2023	39.786	38.855	40.671
2024	40.168	39.240	41.048
2025	40.550	39.625	41.425
2026	40.932	40.010	41.802
2027	41.314	40.395	42.179
2028	41.696	40.780	42.556
2029	42.078	41.165	42.933
2030	42.460	41.550	43.310
2031	42.842	41.935	43.687
2032	43.224	42.320	44.064
2033	43.606	42.705	44.441

Table 2: Modeled Melanoma Rates for People Aged 50-64

Based on the modeled melanoma values for Americans of ages 50 to 64, the rates are slowly increasing. From the initial graph, we determined the rates for people 65+ (seniors) is increasing quickly. We decided a logarithmic model would fit the general trend of data best because it had the highest R^2 value compared to a linear, exponential, or polynomial model. This model can be seen below in Figure 4.

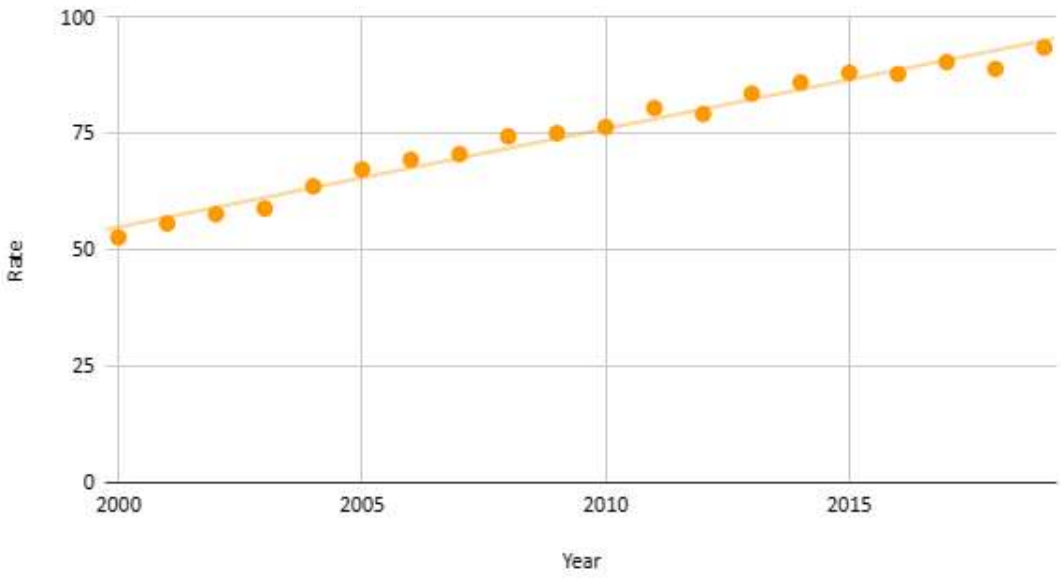

Figure 4: Melanoma Rates for People Aged 65+ for 2000-2019

The logarithmic model follows the equation, where x represents the year and y represents the rate,

$$y = -32157 + 4238\, ln\,(x)\,,$$

with an R^2 value of 0.9801. The R^2 value is very high which indicates that the model is a reliable predictor of incidence rates. The incidence rates for the next ten years have been calculated with the equation of the model and are displayed in Table 3. We have also calculated a 95% confidence interval (C.I.) for our model. We are 95% confident that the future value will fall within the interval.

Year	Modeled Rate	Lower 95% C.I.	Upper 95% C.I.
2023	104.084	101.542	107.982
2024	106.178	103.630	110.081
2025	108.271	105.718	112.178
2026	110.364	107.805	114.274
2027	112.455	109.890	116.369
2028	114.545	111.975	118.464
2029	116.634	114.058	120.557

2030	118.723	116.141	122.649
2031	120.810	118.222	124.740
2032	122.896	120.303	126.830
2033	124.981	122.382	128.919

Table 3: Modeled Melanoma Rates for People Aged 65+

From the modeled values for melanoma rates for seniors, we determine that the rates will increase quickly. We will model the impact of an annual skin cancer screening using statistics from a US Preventive Services Task Force Evidence Report on Visual Skin Cancer Screening in adults. The sensitivity of the screening performed by a dermatologist was 49.0% and the specificity was 97.6% on average. We will determine the average accuracy of the skin cancer screening using the following formula:

$$A = N * P + S * (1 - P)$$

where S is the specificity, N is the sensitivity, P is the prevalence, and A is the accuracy. The prevalence will be calculated using the average melanoma rate. We calculate the average accuracy over the 19 years to be 97.60% for people under 50, 97.58% for people between 50 and 64, and 97.56% for people 65 and over using the above formula.

Based on the accuracy of the screening for people under 50, we display the predicted results from the modeled rates in Table 4. We use the predicted incidence rates for the next ten years. We use the assumption that the accuracy of the screening reduces the rate because the melanomas identified will be treated immediately and not affect the patient in the long-term.

Year	**Modeled Rate Before Annual Screenings**	**Modeled Rate After Annual Screenings**	**Difference**
2023	6.413	0.154	6.259
2024	6.371	0.153	6.218
2025	6.329	0.152	6.177
2026	6.286	0.151	6.136
2027	6.244	0.150	6.094
2028	6.202	0.149	6.053
2029	6.160	0.148	6.012
2030	6.118	0.147	5.971

2031	6.076	0.146	5.930
2032	6.034	0.145	5.889
2033	5.992	0.144	5.848

Table 4: Modeled Melanoma Rates for People Aged <50 Before and After Annual Screenings

Based on the accuracy of the screenings for people between 50 and 64, we display the predicted results from the modeled rates in Table 5.

Year	Modeled Rate Before Annual Screenings	Modeled Rate After Annual Screenings	Difference
2023	39.786	0.963	38.823
2024	40.168	0.972	39.196
2025	40.550	0.981	39.569
2026	40.932	0.991	39.941
2027	41.314	1.000	40.314
2028	41.696	1.009	40.687
2029	42.078	1.018	41.060
2030	42.460	1.028	41.432
2031	42.842	1.037	41.805
2032	43.224	1.046	42.178
2033	43.606	1.055	42.551

Table 5: Modeled Melanoma Rates for People Aged 50-64 Before and After Annual Screenings

Based on the accuracy of the screenings for people over 65, we display the predicted results from the modeled rates in Table 6.

Year	Modeled Rate Before Annual Screenings	Modeled Rate After Annual Screenings	Difference
2023	104.084	2.540	101.544
2024	106.178	2.591	103.587
2025	108.271	2.642	105.629
2026	110.364	2.693	107.671

2027	112.455	2.744	109.711
2028	114.545	2.795	111.750
2029	116.634	2.846	113.788
2030	118.723	2.897	115.826
2031	120.810	2.948	117.862
2032	122.896	2.999	119.897
2033	124.981	3.050	121.931

Table 6: Modeled Melanoma Rates for People Aged 65+ Before and After Annual Screenings

From the data tables shown above, annual skin cancer screenings reduce the projected rate of melanoma for all three age groups. The reduction in the projected rate implies that a certain percentage of melanoma cases in the next ten years will be diagnosed before it reaches a more severe stage. The reduction in rates means that the melanoma can be removed during the skin cancer screening in the biopsy. To show the economic significance of the annual screenings, we will calculate the expected value of treatment costs related to melanoma for each age group before and after annual screenings. The expected value formula for multiple events is the following:

$$E(X) = \sum X * P(X),$$

where X represents a possible outcome and $P(X)$ represents the probability the outcome occurs. To calculate the expected value of treatment costs, we will define the four possible outcomes as the stages of melanoma that require treatment apart from the initial screening or biopsy. These four outcomes are localized, regional, distant, and unstaged. We define X to be the cost of the treatment for each stage and we define $P(X)$ to be the probability of the treatment. We will estimate the cost for unstaged melanoma treatment by taking a weighted average of the treatment costs for the other three stages. We will use the following formula:

$$X_U = X_L * P(X_L) + X_R * P(X_R) + X_D * P(X_D)$$

where X_L represents the cost of a localized treatment, X_R represents the cost of a regional treatment, X_L represents the cost of a distant treatment, and X_U represents the cost of an unstaged treatment. We display these costs in Table 7.

Stage	**Cost ($)**	**Percentage of Rates (%)**
Localized	25242	75.68%

Regional	32847	8.94%
Distant	57860	4.03%

Table 7: Costs of Melanoma Treatment by Stage

We calculate the cost of unstaged treatment to be $24856.78 using the formula above. We will now calculate the expected value of treatment cost per patient per age group before and after annual screenings. Currently, about 14.47% of people under 50, 15.73% of people from 50-64, and 55.47% of people over 65 visit a dermatologist and get checked for skin cancer annually. We use the assumption that 100% of people in each age group will attend the annual screening and the calculated screening accuracy values for the calculation of expected value after the screenings. The results are displayed in Table 8.

Age Group	**Expected Value of Treatment Cost Before Annual Screenings ($)**	**Expected Value of Treatment Cost After Annual Screenings ($)**
<50	26087.45	626.10
50-64	26380.32	638.40
65+	27342.46	667.16

Table 8: Cost of Expected Value Before and After Annual Screenings

We have found the expected value of treatment cost before and after the screenings. We will now calculate the expected value of total melanoma screening and treatment costs per American by age group using the following formula for E_C, the expected cost:

$$E_C = D * P * C + R * P * E(X),$$

where C represents the cost of a skin cancer screening, R represents the melanoma rate as a percentage, P represents population, and D represents the percentage of Americans who visit the dermatologist or get a skin cancer screening annually. The results for each age group for 2023 are displayed in Table 9.

Age Group	**Rate Before Annual Screenings (2023)**	**Expected Cost (2023) ($)**	**Rate After Annual Screenings (2023)**	**Expected Cost (2023) ($)**

<50	6.413	23.38	0.154	150.00
50-64	39.786	34.09	0.963	150.01
65+	104.084	111.66	2.540	150.02

Table 9: Rate and Cost Before and After Annual Screenings by Age Group in 2023

An observation of the expected costs before and after annual screenings leads to an economic argument. While healthcare companies will save more money by not covering annual screenings, the rates of melanoma after annual skin cancer screenings decrease drastically. The expected costs differ more for 50 and 50-64 age groups than they do for the over 65 age group. For this reason, we will model the expected costs for the next ten years for people over 65 in America. The costs are shown in Table 10.

Year	**Expected Cost Before Annual Screening ($)**	**Expected Cost After Annual Screening ($)**
2023	111.66	150.02
2024	112.24	150.02
2025	112.81	150.02
2026	113.38	150.02
2027	113.95	150.02
2028	114.52	150.02
2029	115.10	150.02
2030	115.67	150.02
2031	116.24	150.02
2032	116.81	150.02
2033	117.38	150.02

Table 10: Expected Cost Value Before and After Annual Screenings for Seniors

Observing the expected costs per person over 65 before and after annual screenings, we find that the expected cost of annual screenings is more than the current expected cost. However, we also find that there is a 97.56% reduction in melanoma rates for seniors. We also observe that expected costs before annual screenings are increasing while expected costs after annual screenings stay constant for the next ten years. From our modeling, we determine that seniors in America are at a high risk of getting melanoma.

Risk Analysis

Melanoma is a serious risk for seniors in America. With rates rising for people over 65, it is important that this cancer is treated. Melanoma treatment varies in cost by stage of diagnosis in the United States. Treatment costs health insurance companies thousands of dollars per patient, which can increase a customer's premium, the monthly rate for the insurance, significantly. Furthermore, annual limits set by healthcare companies can be exceeded with melanoma treatment, especially because seniors face other health problems, leading to a patient paying out of pocket. To mitigate these risks, we propose a program where annual skin cancer screenings are covered by insurance companies.

Program Implementation

Melanoma treatment and screening coverage vary greatly between different health insurance providers. Costs differ between different public and private insurers which limits access to melanoma preventive measures and treatments for different groups of people. This may influence melanoma rates for different groups in the future. If annual skin cancer screenings for seniors are covered by a certain insurer, people who are not covered by that insurer may not want to spend extra on annual screenings.

We group health insurance providers into two groups, private and public. Public health insurance plans, like Medicare and Medicaid, are provided by the government for groups that qualify for special subsidies, like seniors. Private health insurance plans are provided by private organizations. Public health insurance tends to be more affordable, but less flexible in choosing its medical service providers, than private health insurance. Statistics from a 2021 Centers for Disease Control and Prevention report outline the differences between groups of seniors. Factors like poverty level, marital status, education, race, and biological sex differ between different types of coverage. Seniors whose income is considered below the Federal Poverty Level are more likely to be covered by public health insurers with an estimate of 73.8% covered by public plans compared to the 13.8% covered by private insurance[25]. Private insurers are able to provide and cover more services than public insurers which may affect melanoma rates for different socioeconomic groups.

Healthcare companies may be hesitant to cover annual skin cancer screenings for seniors in America due to the cost. While melanoma costs are rising, insurers will be concerned with the extra costs. If an insurer decided to cover the cost of screenings, they could also increase the price of the premium, which places the economic burden on the patient. Insurers will require promising results of annual skin cancer screenings in action in order to cover them for seniors in America.

Regional Program Effectiveness

In our data methodology section, we highlighted the limitations of the SEER Data. The data details aggregate melanoma rates for the entire nation but does not break down the rates by region. A risk of implementing a program based on aggregate data is that the program will have different expected values of costs and incidence rate reduction based on region.

Recommendations

Melanoma rates have been rising rapidly over the past 19 years for American seniors. We offer three different categories of recommendations: insurance, modifying outcomes, and behavioral changes. We recommend that an annual skin cancer screening program is implemented by health insurance companies in order to identify melanoma as early as possible. To accompany the screening program, we recommend regular and proper use of sunscreen when exposed to sunlight for long periods of time. We also recommend using skin-safe alternatives to indoor tanning beds.

Insurance: Annual Skin Cancer Screening Program

From the modeling of melanoma incidence rates, we determine that seniors have a high risk of getting melanoma. Health insurance companies should implement a program for an annual skin cancer screening by a dermatologist for seniors. Based on the models for melanoma rates, we determined that the cost per person for screening and treatment without annual screenings is slowly increasing while the cost per person after the program stays constant. The implementation of the program will cost $150.02 per person compared to the $111.66 in 2023. With 99% of seniors in America insured[25], insurers will spend an extra 2 billion dollars in 2023 with the program. From our modeling we determined the significant decrease in melanoma rates with this program. And as melanoma rates are rising rapidly for seniors, the program will be the economically better choice in less than 30 years. Using the model to predict melanoma rates for seniors, we determine that in 2046, the cost of treatment without the program will be $151.99 per person.

This project focuses on the economic costs and incidence of melanoma specifically, however the implementation of an annual screening program would also help reduce rates of other types of skin cancer. A dermatologist would be able to identify other types of skin cancer as well as other skin conditions like eczema or certain symptoms of organ failure through the annual screenings.

In order for insurers to adopt the proposed program, the implementation must be tested and deliver promising results. The program must also be fairly implemented at different facilities in different locations across the country. Many private insurance companies also only offer plans to residents of certain locations which may skew skin cancer rates among different groups of

individuals. In order to ensure a fair implementation of the program, we could regulate the program throughout the nation through Medicare, where 50.2% of the American population is insured[25]. Medicare's total spendings was $829 billion[15] compared to its funding of $888 billion in 2021, with the screening program costing insurers $2 billion. Introducing regulations for the program with private insurers will take many years and until then there is no guarantee that every insurer will adopt the program. We propose that a stratified random sampling method with American cities as stratum be used to test the program before a full scale implementation. Testing the program by region will fill data gaps and improve our knowledge about the impact of the program.

Modifying Outcomes: Wearing Sunscreen

One of the most significant causes of melanoma is an increased exposure to ultraviolet (UV) rays; studies have found that over 85% of melanomas are caused by this carcinogen[34]. People are mostly exposed to large amounts of UV radiation from the sun.

Americans are encouraged to spend time in the sun to increase their vitamin D levels which leads to many health benefits like stronger bones or improved cognition. However, many Americans do not practice proper UV safety. In the 2020 United States National Health Interview Survey, only 13.6% of men and 27.7% of women aged 65 and over used sunscreen when they were outdoors for longer than an hour[30]. Sun damage is cumulative and more harmful to older skin. Furthermore, the accumulation of more than five sunburns increases a person's risk of melanoma by 100%[34]. Proper sun protection practices will reduce the number of melanomas and the cost of treatment per person. Modifying outcomes include applying sunscreen before going outside for longer periods of time and reapplying when necessary. The regular application of sunscreens with a sun protection factor (SPF) of at least 15 reduces the risk of melanoma by 50%[34]. Because sun damage is cumulative, practicing proper sunscreen habits early on will reduce the risk of melanoma throughout an individual's lifetime.

Behavioral Changes: Indoor Tanning

Apart from the sun, another source of large amounts of UV radiation are indoor tanning devices. Indoor tanning devices are classified as Class II (moderate to high risk) devices by the FDA[34]. Women are more likely to develop melanoma from this practice, with 70.2% of women and 39.9% of men having used indoor tanning beds. While younger adults between the ages of 18 and 29 use harmful tanning devices the most, at 20.4%, accumulated sun damage increases the risk of melanoma later on. Indoor tanning is practiced by 26.6% of white people[12]. Behavior changes including abstaining from the use of indoor tanning devices with UV radiation. However, many Americans use indoor tanning devices for a cosmetic purpose and may not change this behavior. Alternative options to indoor tanning devices that do not increase an individual's risk of melanoma include spray tans or self-tanning lotions[36].

Conclusion

Melanoma is the deadliest skin cancer which is responsible for the most severe health and economic detriments related to skin cancer in the United States. Rates are rising rapidly for Americans aged over 65. Our primary recommendation is the implementation of an annual skin cancer screening program for seniors through health insurance companies. An annual screening not only reduces rates of melanoma, but also helps identify early signs of non-melanoma skin cancers and external symptoms of organ failure. To complement the screenings and reduce melanoma risk, we also recommend a regular, proper use of sunscreen and seeking safe alternatives to indoor tanning. Melanoma has many negative effects on long-term health and it is imperative that more serious preventive measures are taken to combat the rising rates for seniors in America.

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