The Effects of Medical Expenditures and Smoking on the Incidence of Myocardial Infarction

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Repositories:

Repositories: **Original Cohort Data Repository** and **Final Project Repository with Data, Analysis, README, and Quarto Report Files**.

Introduction

Cardiovascular disease is a major contributor to global morbidity and mortality. It is estimated that the number of cardiovascular disease cases has doubled over the last thirty years with 271 million cases reported in 1990 and 523 million reported in 2019. Roth et al. (2020) In the United States alone, it was estimated that cardiovascular disease contributed to 168.2 per 100,000 deaths in 2020 and $320 billion in healthcare spending. "Mortality in the United States, 2020" (2021); Birger et al. (2021) Myocardial infarction, one of the leading killers among cardiovascular disease patients, is estimated to increase in its prevalence by 30.1% by 2060, emphasizing the need to better understand causes, associated risk factors, and potential points of intervention. Mohebi et al. (2022) Hence, this analysis explores the relationships between myocardial infarction, smoking, and annual out-of-pocket healthcare expenditure.

Furthermore, this report also demonstrates the various skills learned in EPI 203 Methods for Reproducible Population Health and Clinical Research. Throughout this project, I aimed to demonstrate file folder organization, version control with Github, principles of effective coding, and the generation of a reproducible and dynamic Quarto document. Peer-to-peer code review would also be an important and anticipated step outside of the context of a written assignment.

Methods

Packages

The following packages were used for this report: **table1() and methods**, **arsenal()**, **tidyverse()**, **dplyr()** and **rmeta()**.

Study Design and Dataset

This is a retrospective cohort study with four assumptions (see section below, *Assumptions*).

This study assesses the relationship between annual out-of-pocket costs of medical care, smoking history and myocardial infarction, as defined by variables, `cost` and `cardiac,` in the **cohort data set**. This data set includes 5,000 observations (adults aged 18-65 years) and 5 variables, including `smoke`, `female`, `age`, `cardiac` and `cost`.

File Read in and Initial Exploration

The variables `smoke`, `female`, and `cardiac` are binary. A value of 1 represents an observation who identified as female (`sex`), previously smoked (`smoke`) or had an incident myocardial infarction (`cardiac`). A value of 0 represents a non-female participant (coded as male for the purposes of this analysis), no smoking history, or no incident myocardial infarction. The variables `age` (measured in years) and `cost` (measured in US dollars) are continuous variables.

Statistical Analyses

Assumptions

We assumed the `cost` variable represents annual cost of out-of-pocket medical care measured in US dollars and `cardiac` represents the presence of incident myocardial infarction. Furthermore, we assumed time ordering was upheld between exposures and outcome, such that annual cost of out-of-pocket medical care and smoking were measured prior to the myocardial infarction outcome. Finally, we recognize several confounding factors were not accounted for in this analysis.

Data Cleaning Procedures

Data cleaning began with an initial exploration of the data. The mean, median, and range of all continuous variables were calculated to detect extreme values (or values that were not biologically plausible, such as age=200 years). Furthermore, histograms of continuous variable were produced to assess distributional characteristics (e.g. normality). Similarly, crude counts and proportions of binary variables were calculated.

Data processing included the transformation of categorical variables into factors and renaming for data visualization. For instance, the variable `cardiac` was re-labelled as `CardiacEvent` with categories of 'No Myocardial Infarction' for `cardiac=0` or 'Myocardial Infarction' for `cardiac=1`. The variable `female` was converted into a factor and renamed so that `female=0` indicated a male observation and `female=1` indicated a female observation. The variable `smoke` was re-labelled `Smoking` with `smoke=0` indicating a non-smoker and `smoke=1` indicated a smoker. Finally, the variable `age` was renamed `Age` for presentation.

Analytic Plan

Because we are using a binary outcome variable, myocardial infarction, logistic regression (e.g. $log(odds_{MI}) = \alpha + \beta_{smoking} \times x_{smoking}$) was used to evaluate its relationship with both annual out-of-pocket medical care costs and smoking. Cost of care was transformed from a continuous to a categorical variable due to practical considerations for policy development and organization. Categories were defined as $\leq$ \$9800, \$9801-\$9950, and >\$9950 to minimize data sparsity and optimize equal distribution of observations across categories.

Table 1 Overview

A table 1 was created using the **table1() package**. The absolute count and percentage of each exposure category was presented for annual out-of-pocket medical care cost categories, ($\leq$ \$9800, \$9801-\$9950, and >\$9950), smoking history (non-smoker and smoker), and sex (male and female). The mean (with standard deviation) and median (with minimum and maximum) were reported for age. Each metric was presented for the overall cohort (n=5000) and stratified by myocardial infarction status.

Regression Models

Crude and adjusted odds ratios with 95% confidence intervals were generated using logistic regression (`glm()`). Adjusted models included age and sex. The outcome of interest was incident myocardial infarction and the exposure for the first model was annual out-of-pocket cost of medical care (USD) category (reference group: $\leq$ \$9800) and the second model was smoking history (history present/absent).

Data Visualization

Forest plots were generated using `ggplot()` and methods outlined by **Dayimu A. (2024)**. Crude and adjusted odds ratios and 95% confidence intervals were stored in a new dataset and visualized using `ggplot()`.

Results

Cohort Description and Demographics

This dataset included 5,000 observations, 4810 of which did not have a myocardial infarction reported. Approximately, 66% of individuals who had a myocardial infarction reported annual out-of-pocket care costs of >\$9950, compared to 21.4% of individuals without a cardiac event documented. The majority of individuals with a myocardial infarction event did not have a history of smoking (59.5%); a finding that was shared with the non-myocardial infarction group (91.0%). There were more male participants in the myocardial infarction group than females (90.0%). Finally, the mean age across both myocardial infarction and non-myocardial infarction groups was approximately 40 years.

Table 1: Demographic and clinical characteristics of cohort, overall and stratified by myocardial infarction status

	No Myocardial Infarction	Myocardial Infarction	Overall
	(N=4810)	(N=190)	(N=5000)
CostCategories			
<\$9800	3161 (65.7%)	42 (22.1%)	3203 (64.1%)
>\$9950	1031 (21.4%)	125 (65.8%)	1156 (23.1%)
\$9801-\$9950	618 (12.8%)	23 (12.1%)	641 (12.8%)
Sex			
Male	2394 (49.8%)	171 (90.0%)	2565 (51.3%)
Female	2416 (50.2%)	19 (10.0%)	2435 (48.7%)
Smoking			
Non-Smoker	4379 (91.0%)	113 (59.5%)	4492 (89.8%)
Smoker	431 (9.0%)	77 (40.5%)	508 (10.2%)
Age			
Mean (SD)	41.5 (13.5)	39.5 (13.7)	41.5 (13.5)
Median [Min, Max]	41.0 [18.0, 65.0]	39.0 [18.0, 64.0]	41.0 [18.0, 65.0]

Association Between Cost of Care and Myocardial Infarction

The results of this investigation revealed that increased annual out-of-pocket costs of care (as defined by categories of the `cost` variable) were associated with an increased odds of having a myocardial infarction (as defined by the variable `cardiac`).

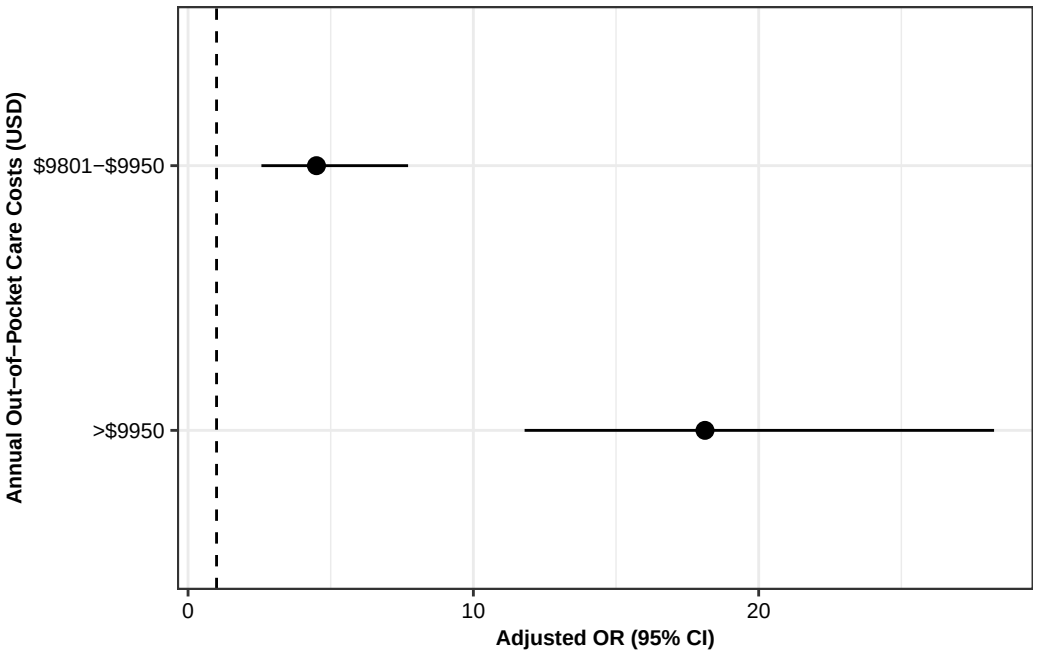
Crude Model

The results of the crude model indicated that having annual out-of-pocket care costs between $9800 and $9950 was associated with an increased odds of myocardial infarction of 2.80 [95% CI 1.65, 4.65] when compared to the reference cost of $\leq$ $9800. Furthermore, participants with care costs greater than $9950 had an increased odds of myocardial infarction of 9.12 [95% CI 6.45,13.17] relative to the reference group (Table 2a).

Adjusted Model

After adjustment for sex and age, having annual out-of-pocket care costs between $9800 and $9950 was associated with an increased odds of myocardial infarction of 4.50 [95% CI 2.57, 7.71] when compared to the reference cost of $\leq$ $9800. Furthermore, participants with care costs greater than $9950 had an increased odds of myocardial infarction of 18.12 [95% CI 11.80, 28.25] relative to the reference group (Figure 1, Table 2a).

Figure 1: Adjusted Odd Ratios for Relationship Between Myocardial Infarction and Annual Cost of Care (USD)



Association Between Smoking History and Myocardial Infarction

The relationship between smoking history (as defined by the variable `smoke`) and myocardial infarction (as defined by the variable `cardiac`) was also explored.

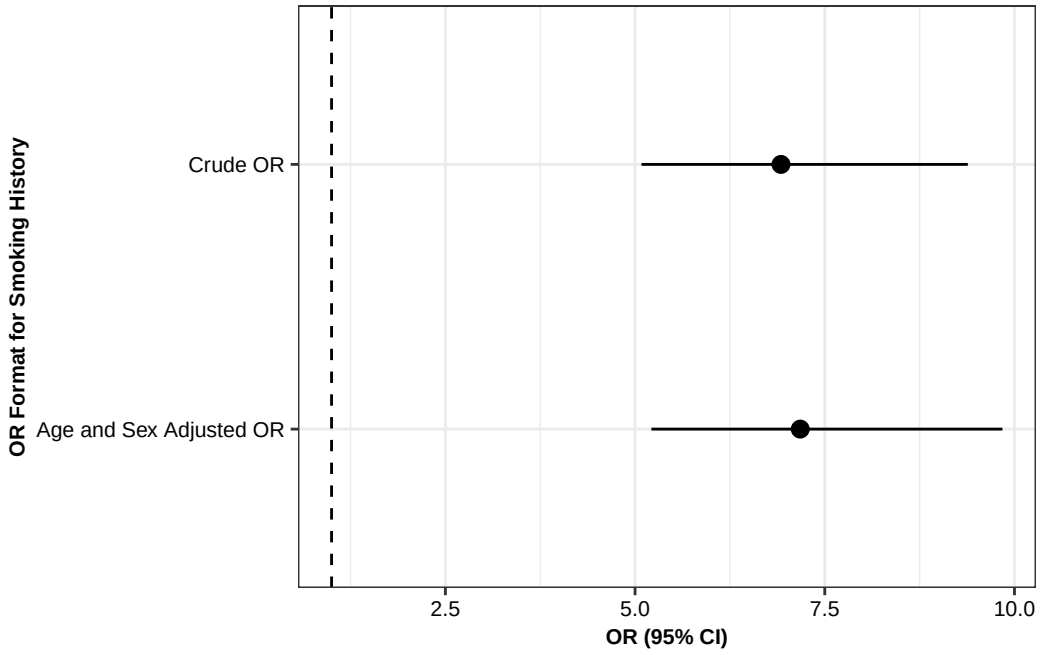
Crude Model

The results of the crude model indicated that having a smoking history is associated with an increased odds of myocardial infarction of 6.92 [95% CI 5.08, 9.39] when compared to non-smokers (Figure 2, Table 2b).

Adjusted Model

After adjusting for sex and age, the results continued to demonstrate that having a smoking history is associated with an odds of myocardial infarction of 7.18 [95% CI 5.21, 9.84] when compared to non-smokers (Figure 2, Table 2b).

Figure 2: Odds Ratios for Relationship Between Myocardial Infarction and Smoking



Data Summary and Conclusion

This analysis demonstrated evidence of increased odds of myocardial infarction among adults with higher annual out-of-pocket costs of care (relative to annual costs of $\leq$ \$9800) and among smokers (compared to non-smokers). This finding was consistent across crude and age- and sex-adjusted models (Tables 2a and 2b).

Table 2a: Summary Odds Ratios For Relationship Between Annual Out-of-Pocket Care (USD) and Myocardial Infarction

Measure	Parameter	Odds Ratio	95% Confidence Interval
Crude Model: Intercept	Intercept	0.01	0.01, 0.02
Crude OR	Expenditure: \$9801-\$9950	2.80	1.65, 4.65
Crude OR	Expenditure: >\$9950	9.12	6.44, 13.17
Adjusted Model: Intercept	Intercept	0.18	0.12,0.30
Adjusted OR	Expenditure: \$9801-\$9950	4.50	2.57, 7.71
Adjusted OR	Expenditure: >\$9950	18.12	11.80, 28.25
Adjusted OR	Age	0.94	0.93, 0.95
Adjusted OR	Sex (Ref: Male)	0.22	0.13, 0.36

Table 2b: Summary Odds Ratios For Relationship Between Smoking and Myocardial Infarction

Measure	Parameter	Odds Ratio	95% Confidence Interval
Crude Model: Intercept	Crude Intercept	0.03	0.02, 0.03
Crude OR	Smoking	6.92	5.08, 9.39
Adjusted Model: Intercept	Adjusted Intercept	0.07	0.04, 0.11
Adjusted OR	Smoking	7.18	5.21, 9.84
Adjusted OR	Age	0.99	0.98, 1.00
Adjusted OR	Sex (Ref: Male)	0.11	0.06, 0.17

Given that both smoking and increased annual out-of-pocket costs of medical care are associated with an increased odds of myocardial infarction, this analysis presents a potential avenue for future intervention aimed towards reducing the overall burden of cardiovascular disease.

References

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