The impact of the Affordable Health Care Act (ACA) on Cardiovascular Death (CVD) rates in King County, Washington.

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Abstract

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Objectives

The study's primary objective was to assess the association between the ACA and the age-adjusted cardiovascular disease (CVD) death rates in King County, Washington, among working-aged Adults (18-64) from 2009 to 2019. I hypothesized that during the post-ACA period (2014-2019), there would be a decrease in the age-race-sex-adjusted CVD death rates compared with the pre-ACA period (2009-2013).

Methods

A quarterly age-race-sex adjusted King County CVD death rates using King County death data from January 1, 2009, through December 31, 2019, was modeled to compare CVD death rates before the implementation of the ACA (2009-2013) (pre-exposure) to the rates of CVD deaths after the implementation of the ACA (2014-2019) (post-exposure) across King County. The exposure of interest was the implementation of the ACA on January 1st 2014 in King County. The primary outcome of interest was death due to cardiovascular disease (CVD).

The study population included King County residents, who were working-aged adults (18- 64) from 2009 to 2019. Quarterly counts by sex, age and race/ethnicity, that were matched within both the denominator and numerator, in this analysis. These death records were collected from the Washington State Department of Health Center for Health Statistics (CHS). The Office of Financial Management of the State of Washington (OFM) provided population estimates that were used in the denominator. Death records were collected from the CHS and were used as the numerator. CVD deaths were identified using underlying cause of death ICD-10 codes (see Appendix Table 2). All individuals who experienced a CVD death between 2009 and 2019 were included in the study.

Deaths were characterized as a CVD death after a physician, coroner, or medical examiner certified the cause of death on a death certificate. ICD-10 encoding was performed by the National Center for Health Statistics. Demographic data were recorded by funeral directors or individuals in similar positions in consultation with the next of kin.

Results

The regression model (without an ACA-time interaction term) shows that after the ACA, there was an increased risk among working-aged adults experiencing a CVD death by 58%, given an incidence rate ratio (IRR) of 1.58 (95% confidence interval (CI): 1.41 – 1.76). For every one-quarter increase in time, there is a 2% decreased risk of working-aged adults in King experiencing a CVD death, given an IRR of 0.98 (95% CI: 0.97 – 0.98). The interaction of ACA and time in quarters does not have a statistically insignificant association with CVD deaths among working-age adults. Given a Wald test p-value of 0.14 and an IRR of 1.01, the primary model that will be discussed is the regression model with no interaction term.

Conclusions

This study showed that after the implementation of the ACA, King County working aged adults experienced an increased risk of experiencing a CVD death. Although the interaction between the ACA and time (quarters) was not statistically significant, after the ACA, working aged adults had an increased risk of experiencing a CVD death. Hence, future research employing more robust study designs and accounting for additional potential confounding factors is warranted to better understand the complex determinants of CVD mortality.

Introduction

Cardiovascular disease (CVD) stands as the leading cause of death and disability worldwide (Mensah et al., 2007). Compounded by factors such as an aging population, obesity, and suboptimal control of risk factors, the burden of CVD has intensified in the United States (U.S.), accounting for 928,741 deaths annually (Mensah et al., 2007; Tsao et al., 2023). CVD currently affects 1 in 3 adults in the U.S. (Hoyert D. L et al., 2005; Hoyert D. L et al., 2006), and over 40% of Americans are expected to have CVD by 2030 (Barghi et al., 2019). Historically, there has been a broad agreement within the scientific and medical communities that advancing age significantly contributes to the emergence of CVD among individuals. However, recent studies have found that in the U.S., as high as 62% of adults living with CVD are below the age of 65 (Mensah et al., 2007).

According to studies conducted by the Division for Heart Disease and Stroke Prevention at the Centers for Disease Control and Prevention (CDC), social and economic factors have the strongest association with avoidable death rates from CVD (Greer, S et al., 2016). Hence, interventions that address social and economic barriers to access to care are crucial in preventing avoidable CVD deaths. One such intervention is the Affordable Care Act (ACA). Implemented in 2014 and widely regarded as the most comprehensive reform of the U.S. medical system within the last 40 years (Gruber, 2011).

The ACA consisted of multiple changes to the U.S. tax code to increase health insurance coverage, reduce healthcare costs, and finance healthcare reform (Cleven, 2020). Through the ACA, states were free to expand Medicaid to cover everyone near the poverty line and subsidize private insurance for people who are not poor but do not have workplace coverage (Hall & Lord, 2014). ACA coverage has been shown to increase healthcare-seeking behaviors (HCSB) (Wherry et al., 2016); ACA and Medicaid expansion states have experienced 4.3 fewer deaths per 100,000 residents per year from CVD (Khatana et al., 2019).

In King County, the average percentage of uninsured working-aged adults between 2009 and 2013 was 16.30% (Appendix Table 1). However, after the implementation of the ACA in 2014, the average percentage of uninsured working-age adults decreased to 7.30% between 2015 and 2019 (see Appendix Table 1). Given that increased ACA coverage has empirically shown to increase preventative healthcare-seeking behavior (Simon et al., 2016; Brown-Podgroski et al., 2022) and subsequently improve early-case detection of CVD (Serakos et al., 2016), it is reasonable to expect a decrease in CVD death rates in King County. However, the direct causal relationship between the implementation of the ACA and CVD death rates among working-aged adults in King County has not been investigated. Pre-existing ACA policies targeted individuals who were aged 18-64 (Long, et al., 2017).

The study's primary objective was to assess the association between the ACA and the age-adjusted cardiovascular disease (CVD) death rates in King County, Washington, among working-aged Adults (18-64) from 2009 to 2019. I hypothesized that during the post-ACA period (2014-

2019), there would be a decrease in the age-race-sex-adjusted CVD death rates compared with the pre-ACA period (2009-2013).

Methods

Study Design

I modeled quarterly age-race-sex adjusted King County CVD death rates using King County death data from January 1, 2009, through December 31, 2019, to compare CVD death rates before the implementation of the ACA (2009-2013) (pre-exposure) to the rates of CVD deaths after the implementation of the ACA (2014-2019) (post-exposure) across King County. The exposure of interest was the implementation of the ACA on January 1st 2014 in King County. Thus, King County residents aged 18 to 64 were considered unexposed between January 1, 2009, and December 31, 2013. King County residents aged 18 to 64 years were considered exposed between January 1, 2014, and December 31, 2019. The primary outcome of interest was death due to cardiovascular disease (CVD).

The study population included King County residents, who were working-aged adults (18-64) from 2009 to 2019. I used quarterly counts by sex, age and race/ethnicity, that were matched within both the denominator and numerator, in this analysis. These death records were collected from the Washington State Department of Health Center for Health Statistics (CHS). The Office of Financial Management of the State of Washington (OFM) provided population estimates that were used in the denominator. Death records were collected from the CHS and were used as the numerator.

CVD deaths were identified using underlying cause of death ICD-10 codes (see Appendix Table 2). We had individual-level data on deaths, which included sex (male or female), race/ethnicity (American Indian/Alaska Native (AIAN), Asian, Black, Hispanic, Multiple, Native Hawaiian/Pacific Islander (NHPI), and White), geographic region within King County (East, North, Seattle, and South), and age (as a continuous variable) variables (Table 1). Working -aged adults (18-64) who lived in King County were included in the analysis.

Outcome Definition

All individuals who experienced a CVD death (see Appendix Table 2) between 2009 and 2019 were included in the study. Deaths were characterized as a CVD death after a physician, coroner, or medical examiner certified the cause of death on a death certificate. ICD-10 encoding was performed by the National Center for Health Statistics. Demographic data were recorded by funeral directors or individuals in similar positions in consultation with the next of kin.

Data Analysis

Descriptive Analyses

Descriptive analyses were conducted to characterize the study population. Available sociodemographic variables included sex, race, geographic region within King County, and age group (18-24, 25-34, 35-44, 45-54, 55-64). Categorical variables were summarized by reporting their proportions. Age-race-sex adjusted rates were calculated using the 2014 population from the Office of Financial Management of the state of Washington (OFM) (1,340,061) as the standard population.

Statistical analyses

The primary confounders of interest are sex, age, and race/ethnicity as these factors are strongly linked to CVD risk and their distribution before and after the ACA may have changed. The primary analysis adjusts for these variables by using multivariate regression (i.e. they were included as variables in the Poisson regression). The model was informed by deaths, the corresponding population, and demographic characteristics (age, race, and sex). Adjusted mortality rates were estimated by the model. Robust standard errors were calculated in the analysis.

I constructed a regression model to compare the age-race-sex adjusted cardiovascular disease (CVD) death rates among working-aged adults (18-64 years) before (pre-ACA) and after (post-ACA) the implementation of the ACA. Since the analysis involved count data (number of CVD deaths), Poisson regression models were employed to analyze the influence of the implementation of the ACA on CVD death rates.

The model specification took the following form:

$$E[CVDdeaths|ACA] = \beta 0 + \beta 1(ACA) + \beta 2(T) + \beta 3(ACA*T) + \beta 4(Age) + \beta 5(Sex) + \beta 6(Race) + offset(log(population))$$

Where:

ACA: A dichotomous variable coded as 0 for pre-ACA and 1 for post-ACA.

T: Represented time in quarters, providing a temporal dimension to the analysis

ACA*T: Interaction term capturing the effect of time within the context of the ACA's implementation. This interaction term captured how the trend post-ACA implementation differed from the trend before the implementation, adjusted per quarter.

Age: A continuous precision variable included for age-adjustment.

Sex: Sex was a dichotomous variable coded as 0 for females and 1 for males, included for sex-adjustment.

Race: Race was a variable consisting of Asian, AIAN, Black, Hispanic, NHPI, White, and Multiple race. This variable was included for race-adjustment.

Note* Asian race was used as the reference group for the analysis as they are a group with decent size population that would provide a stable estimate for statistical comparison.

offset(log(population): The offset(log(population)) is another predictor in the model that is restricted to have a parameter estimate equal to 1.

All analysis was conducted using the Rigr R statistical Software.

Human subject approval

This research was not considered human subject research since I do not have access to any information which can be linked to identifiable data.

Results

Descriptive Analyses

The total number of deaths during the pre-ACA period was 59,944, while during the post-ACA period it was 78,253. The total number of CVD deaths pre-ACA was 2,129 while during the post-ACA it was 2,631. Table 1 presents descriptive statistics for the full sample between the years 2009 and 2019. As seen in Table 1, there were modest changes in demographic measures before and after the ACA.

Table 1: Characteristics of working aged adults in King County between the years of 2009 – 2019

	pre-ACA (2009-2013) Population (%)	post-ACA (2014-2019) Population (%)
Sex		
Female	49.45%	49.00%
Male	50.55%	51.00%
Race		
AIAN	0.69%	0.60%
Asian	15.30%	18.03%
Black	5.92%	6.22%
Hispanic	8.49%	9.73%
NHPI	0.72%	0.81%

Multiple	3.31%	4.85%
White	65.57%	59.76%
Age		
18-24	13.34%	13.01%
25-34	25.92%	28.31%
35-44	22.67%	22.07%
45-54	22.26%	20.56%
55-64	18.00%	18.20%
AIAN: American Indian and Alaska Native NHPI: Native Hawaiian and Pacific Islander ACA: Affordable Care Act Pre-ACA: Before the implementation of the ACA (2009-2013) Post-ACA: After the implementation of the ACA (2014-2019)		

Table 2 highlights the crude and age-sex-race/ethnicity-adjusted CVD death rates per 100,000 of the population. The average age-race-sex standardization CVD death rate during the pre-ACA period was 31.68 deaths per 100,000 of the population. The average age-sex-race adjusted CVD death rate during the post-ACA period increased by 0.94 deaths per 100,000 to 32.62 deaths per 100,000.

Table 2: Annual age-sex-race-adjusted CVD death rates among working-aged adults in King County - using direct standardization				
Year	Count	Population	Crude Rate per 100,000	Adjusted rate per 100,000
2009	436	1,299,867	33.54	32.44
2010	413	1,308,261	31.57	30.73
2011	431	1,310,489	32.89	32.07
2012	434	1,315,126	33.00	32.29
2013	415	1,330,032	31.20	30.88
2014	452	1,351,061	33.46	33.63
2015	450	1,380,827	32.59	33.48
2016	427	1,421,727	30.03	31.77
2017	404	1,451,703	27.83	30.06
2018	458	1,474,925	31.05	34.08
2019	440	1,497,491	29.38	32.74
CVD: Cardiovascular death				

Regression Analyses

As seen in Table 3, the regression model (without an ACA-time interaction term) shows that after the ACA, there was an increased risk among working-aged adults experiencing a CVD death by 58%, given an incidence rate ratio (IRR) of 1.58 (95% confidence interval (CI): 1.41 – 1.76). For every one-quarter increase in time, there is a 2% decreased risk of working-aged adults in King experiencing a CVD death, given an IRR of 0.98 (95% CI: 0.97 – 0.98).

Table 3: CVD deaths rates among working aged in King County (2009 – 2019) with no interaction between the ACA and Time

Variable	Incidence Rate Ratio (IRR)	95% CI	p-value
ACA	1.58	1.41 - 1.76	p < 0.001
Time in quarters	0.98	0.97 - 0.98	p < 0.001
Age (years)	1.12	1.12 - 1.13	p < 0.001
Sex (Male)	3.00	2.78 - 3.17	p < 0.001
Race			
Asian	Referent		
AIAN	0.54	0.41 - 0.70	p < 0.001
Black	4.48	3.91 - 5.12	p < 0.001
Hispanic	1.59	1.32 - 1.90	p < 0.001
Multiple	0.04	0.03 - 0.06	p < 0.001
NHPI	0.32	0.26 - 0.4	p < 0.001
White	2.13	1.91 - 2.39	p < 0.001

AIAN: American Indian and Alaska Native
NHPI: Native Hawaiian and Pacific Islander
ACA: Affordable Care Act
Pre-ACA: Before the implementation of the ACA (2009-2013)
Post-ACA: After the implementation of the ACA (2014-2019)

As seen in Table 4, the interaction of ACA and time in quarters does not have a statistically insignificant association with CVD deaths among working-age adults. Given a Wald test p-value of 0.14 and an IRR of 1.01, the primary model that will be discussed is the regression model with no interaction term (Table 3).

Table 4: CVD deaths rates among working aged in King County (2009 – 2019)

Variable	Incidence Rate Ratio (IRR)	95% CI	p-value
ACA	1.30	0.96 - 1.80	0.14
Time in quarters	0.97	0.96 - 0.98	p < 0.001
Interaction between CVD quarterly deaths and the ACA	1.01	0.99 - 1.03	0.14

Age (years)	1.13	1.12 - 1.13	$p < 0.001$
Sex (Male)	3.00	2.71 - 3.25	$p < 0.001$
Race			
Asian	Referent		
AIAN	0.54	0.41 - 0.70	$p < 0.001$
Black	4.50	3.90 - 5.20	$p < 0.001$
Hispanic	1.59	1.32 - 1.91	$p < 0.001$
Multiple	0.04	0.03 - 0.06	$p < 0.001$
NHPI	0.32	0.26 - 0.41	$p < 0.001$
White	2.13	1.88 - 2.42	$p < 0.001$

AIAN: American Indian and Alaska Native
NHPI: Native Hawaiian and Pacific Islander
ACA: Affordable Care Act
Pre-ACA: Before the implementation of the ACA (2009-2013)
Post-ACA: After the implementation of the ACA (2014-2019)

Discussion

Summary of the results

The underlying hypothesis of this study was that the implementation of the ACA in King County would reduce the CVD death rates among working-aged adults. The study did not find a reduction in death rates after ACA implementation. Instead, we found a statistically significant increase in CVD death rates among working-aged adults in King County during the post-ACA implementation period. The ACA increased the risk of working-aged adults by 1.58 times. Given its statistical significance, I reject the null hypothesis.

Limitations

Some recognized limitations of the study included the aggregation of data at the population level, which might have masked heterogeneity within the population. First, given the nature of CVD, the post-ACA observation period may not have been sufficient to observe significant changes in CVD death rates. Thus, the ACA may not have had enough time to make a meaningful impact on CVD deaths. Further, given the lack of all possible confounders available to me, the associations observed at the population level did not necessarily hold true at the individual level. Furthermore, time and age were modeled in quarters as a linear continuous variable, but they could have been modeled in a more flexible way (i.e., spline).

Further, race/ethnicity was reported by the next of kin—when possible. Consequently, this may not align well with the self-reported data that is the basis for the population data.

Furthermore, the model was unable to account for events or policies that took place simultaneously because they were not included. For example, perhaps more employers began offering health insurance as an incentive to attract workers in a tight labor market, or perhaps more employers dropped health insurance as a benefit because it became too expensive. We lacked this data.

Strengths

My study had its strengths. First, by using a regression analysis and age-sex-race adjusted rates, I was able to control for these confounding variables. Second, the models allowed you to easily test differences in slopes before and after ACA. A further significant strength is that I have a complete death record of all King County residents and not just a sample data set.

Integration of the results with what is known in the literature

An increase in CVD death rates associated with the onset of the ACA was contrary to the hypothesis. Additionally, King County's baseline uninsurance rates were already relatively low before the ACA. Thus, to observe a drastic decrease in the number of CVD deaths, given increased coverage, would have been unlikely. Further, it is much more likely that CVD deaths were already increasing before and after the implementation of the ACA in 2014. As seen in one study, from 2010 to 2016, CVD deaths increased from 10.50% to 11.50%, respectively (MusongeEffoe, et al., 2020).

Moreover, my findings are inconsistent with CDC findings of CVD mortality after the implementation of the ACA. According to a compressed mortality file, after the implementation of the ACA, there was a 6% decrease in CVD-related deaths (McClellan, 2017). Further, a nationwide study of 48 states from 2010-2016 looking at individuals aged between 45-64 found that after the ACA, there were 4.3 per 100,000 fewer CVD deaths (95% CI: 1.8-6.9) (Khatana, et al., 2019).

Although assumptions can be made based on historical studies of health outcome changes since the implementation of the ACA (Act, 2017), generalizing national findings to the King County population fails to consider differences in population demographics and characteristics. Findings from previous studies cannot be generically applied to King County as it differs from other geographies in three key domains. Compared with the national average, King County is wealthier, has a healthier population, and its residents have better access to healthcare than most counties or states in the U.S. (Healthiest Communities, 2022). With regards to wealth, King County bears half of the state of Washington's gross domestic product (GDP) (Nystrom & Zaidi, 2013) and has a median household income of $116,000, that is $41,420 higher than the national median ($74,580) (United States Census Bureau, 2022; United et al. Bureau, 2023). Regarding health, studies concluded that King County has a population health score of 88 out of 100 and a life expectancy of 82.4 years, which is 4.9 years higher than the national median (77.5 years) (Healthiest Communities, 2022). Further, King County spends significantly more, per capita, on health and emergency services ($868) compared with the national median of $358 (Healthiest Communities, 2022). Finally, regarding healthcare access, King County has 2.14 primary care doctors per 1,000 residents – 1.07 more than the rest of the U.S. (Healthiest Communities, 2022).

Nevertheless, my findings are consistent with similar studies in the literature. One study found that the odds ratio (OR) for CVD deaths increased during the post-ACA period to 1.81 (95% CI: 1.76–1.86). Compared to the pre-ACA period, there was an increase in the risk by 0.3 times of individuals experiencing a CVD death (Musonge-Effoe, et al., 2020). Furthermore, my results showed that for every year increase in age, the risk of experiencing a CVD death increased by 1.12 times. This finding was inconsistent with a similar study in literature, whereby, there was no association between the ACA and CVD death rates. This study looked at middle-aged adults (45-64) and found that after the implementation of the ACA, there was no significant change in CVD mortality rates between the pre-ACA and post-ACA periods 146.50 (95% CI: 132.40-160.70) and to 146.40 (95% CI: 131.90-161.00) deaths per 100,000, respectively (Khatana, et al., 2019). Therefore, although all my findings were statistically significant, this does not mean that they are universally generalizable to all contexts, as there appears to be general disagreements on the impact of the ACA on CVD death rates.

Conclusion

In summary, this study showed that after the implementation of the ACA, King County working aged adults experienced an increased risk of experiencing a CVD death. Although the interaction between the ACA and time (quarters) was not statistically significant, after the ACA, working aged adults had an increased risk of experiencing a CVD death. Hence, future research employing more robust study designs and accounting for additional potential confounding factors is warranted to better understand the complex determinants of CVD mortality.

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Appendix

<table>
<tr><td colspan="6">Appendix Table 1: Uninsured working aged adults (18-64) in King County, WA 2009-2019</td></tr>
<tr><td>Year</td><td>Total population</td><td>Number of uninsured</td><td>Percentage uninsured (%)</td><td>Average percent of uninsured people from 2009 -2013 and 2015 - 2019</td><td>The difference in the average uninsured percentage between 2015-2019 and 2009 - 2013</td></tr>
<tr><td>2009</td><td>1,296,900</td><td>198,257</td><td>15.30%</td><td rowspan="5">16.30%</td><td rowspan="11">9.00%</td></tr>
<tr><td>2010</td><td>1,303,685</td><td>219,905</td><td>16.90%</td></tr>
<tr><td>2011</td><td>1,324,599</td><td>217,274</td><td>16.40%</td></tr>
<tr><td>2012</td><td>1,343,485</td><td>220,555</td><td>16.41%</td></tr>
<tr><td>2013</td><td>1,361,688</td><td>223,207</td><td>16.40%</td></tr>
<tr><td>2014</td><td>1,382,934</td><td>139,163</td><td>10.10%</td><td></td></tr>
<tr><td>2015</td><td>1,407,784</td><td>108,110</td><td>7.68%</td><td rowspan="5">7.30%</td></tr>
<tr><td>2016</td><td>1,427,099</td><td>94,928</td><td>6.65%</td></tr>
<tr><td>2017</td><td>1,425,433</td><td>107,752</td><td>7.55%</td></tr>
<tr><td>2018</td><td>1,453,312</td><td>107,400</td><td>7.39%</td></tr>
<tr><td>2019</td><td>1,466,008</td><td>106,166</td><td>7.24%</td></tr>
<tr><td colspan="6">Note* The year 2014 is the point of exposure for the ACA. Pre-exposure uninsured percent averages were calculated from 2009 -2013. Post-exposures uninsured percent averages were calculated from 2015-2019.</td></tr>
</table>

Appendix Table 2: CVD attributable causes of death	
ICD 10 code	Cause of death (COD)
I00-I09	Acute rheumatic fever and chronic rheumatic heart diseases.
I11	Hypertensive heart disease.
I13	Hypertensive heart and renal disease.
I20-I51	Acute myocardial infarction, Other acute ischemic heart diseases Atherosclerotic cardiovascular disease, so described. All other forms of chronic ischemic heart disease Acute and subacute endocarditis Diseases of pericardium and acute myocarditis. Heart failure. All other forms of heart disease.