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Article

Excess Cardiopulmonary Arrest and Mortality after COVID-19 Vaccination in King County, Washington

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Abstract: Background: Since the onset of widespread COVID-19 vaccination campaigns, there have been concerns about serious cardiovascular adverse events, including myocarditis, myocardial infarction, and venous thromboembolisms, all of which can lead to cardiopulmonary arrest. This study aimed to estimate excess cardiopulmonary arrest mortality in King County, WA, and investigate any association with COVID-19 vaccination rates. **Methods:** Data was obtained from the annual King County, WA, EMS reports, the U.S. Census Bureau, and The Tennessean COVID-19 Vaccine Tracker. An exploratory data analysis was performed. Excess deaths were calculated using the 2015-2020 cardiopulmonary arrest mortality trend line. The relationship between excess cardiopulmonary arrest mortality and vaccination rates was analyzed using polynomial regression analysis. A quadratic regression model was used to generate expected population growth trends. The excess mortality model for King County was used to calculate yearly estimates for excess cardiopulmonary arrest fatalities in the USA. **Results:** Approximately 98% of the King County population received at least one dose of a COVID-19 vaccine by 2023. Our analysis revealed a 25.7% increase in total cardiopulmonary arrests and a 25.4% increase in cardiopulmonary arrest mortality from 2020 to 2023 in King County, WA. Excess cardiopulmonary arrest deaths were estimated to have increased by 1,236% from 2020 to 2023, rising from 11 excess deaths (95% CI: -12, 34) in 2020 to 147 excess deaths (95% CI: 123, 170) in 2023. A quadratic increase in excess cardiopulmonary arrest mortality was observed with higher COVID-19 vaccination rates. The general population of King County sharply declined by 0.94% (21,300) in 2021, deviating from the expected population size. Applying our model from these data to the entire United States yielded 49,240 excess fatal cardiopulmonary arrests from 2021-2023. **Conclusions:** We identified a very strong ecological and temporal association between excess cardiopulmonary arrest mortality and the COVID-19 vaccination campaign, which resulted in high vaccination rates. The biological plausibility of death from acute cardiac and pulmonary causes after COVID-19 vaccination has been previously demonstrated and is concerning given these real-world observations. Urgent further research is needed to determine if similar trends are observed in other regions with attention to risk mitigation for incident events and improved survival with resuscitation.

Keywords: COVID-19 vaccines; excess death; cardiac arrest; thrombosis; pulmonary; adverse event; mRNA; Spike protein; mortality

Introduction

In the United States, COVID-19 vaccination campaigns began in December 2020 after the commencement of Operation Warp Speed. The primary vaccine platform utilized in the US is messenger RNA (mRNA) in lipid nanoparticles (LNPs) used by Pfizer/BioNTech (BNT162b1) and Moderna (mRNA-1273), followed by the viral vector platform used by Johnson & Johnson (Ad26.CoV2.S) [1]. COVID-19 vaccines have since been linked to several cardiovascular adverse events such as myocarditis [2–4], myocardial infarction [5–7], and venous thromboembolisms [8–10]. This has led to concerns of a possible relationship between vaccination rates and increased rates of cardiopulmonary incidents.

In the United States, the incidence of myocardial infarction notably increased in 2021, especially among younger adults aged 25 to 45 years. This age group, which is typically considered at lower risk for cardiac events, experienced a dramatic 29.95% rise in myocardial infarction compared to pre-pandemic predictions [11]. At the time of writing, cardiovascular related deaths continue to rise in the United States ever since the COVID-19 pandemic and the inception of COVID-19 vaccination campaigns [12].

King County, Washington (WA), provides a unique opportunity to study possible associations between COVID-19 vaccines and cardiopulmonary arrest mortality due to its comprehensive emergency medical services (EMS) data and significant vaccination efforts. This ecological study aims to analyze cardiopulmonary arrest data from King County EMS reports to estimate excess cardiopulmonary arrest mortality and explore any potential association with COVID-19 vaccination rates.

Methods

Data Sources and Study Period

Cardiopulmonary arrests and survival rates were obtained from the King County Emergency Medical Services (EMS) annual reports for the years 2016 to 2023 [13]. These reports provided EMS attendance data for the number of cardiopulmonary arrests and the survival rate to hospital discharge for the years 2015 to 2022. The total number of cardiopulmonary arrests includes those that occurred before the arrival of EMS as well as those that occurred after EMS arrived. The population of King County and the United States were obtained from the U.S. Census Bureau [14]. Vaccination rates were sourced from The Tennessean COVID-19 Vaccine Tracker, which collates data from the Centers for Disease Control and Prevention and state/local health departments. The data were extracted from the bar figure showing the percentage of the population that were partially and fully vaccinated [15]. For this analysis, vaccination rates for mid-year (June 30, 2021, and June 29, 2022) were utilized. For the 2023 vaccination rate, the final date with available data was used (December 7, 2022). The study focused on data from 2015 to 2023, with a particular emphasis on the period from 2021 to 2023 to capture the impact of the COVID-19 vaccination campaign.

Exploratory Data Analysis

An exploratory data analysis was performed to understand the trends and patterns in the cardiopulmonary arrest data before conducting the main analysis. This included examining the distribution of cardiopulmonary arrest cases and deaths over time, identifying any anomalies or outliers, and visualizing the data to detect potential correlations between variables. Various graphical representations were created to facilitate the identification of patterns, trends, and outliers, thereby guiding the subsequent analytical approach. Additionally, differences between pre-COVID-19 vaccination and post-COVID-19 vaccination periods were examined, focusing on any significant deviations from historical trends.

Statistical Analysis

Statistical analyses were performed using Microsoft Excel. Since data was not available for 2023, total cardiopulmonary arrests for 2023 were estimated using linear regression. The cardiopulmonary arrest mortality data for 2021 and 2022, which diverged significantly from the 2015-2020 trend line, were used to estimate cardiopulmonary arrest mortality for 2023 based on the difference between extrapolated data and reported deaths. Excess cardiopulmonary arrest deaths were calculated as the difference between reported cardiopulmonary arrest deaths (estimated deaths for 2023) and the 2015-2020 cardiopulmonary arrest mortality trend line. The upper and lower bounds for excess mortality were calculated based on a 95% confidence interval (CI 95%), using the Wilson Score Binomial Interval [16]. Polynomial regression analysis of degree two (quadratic) was used to examine the relationship between vaccination rates and excess cardiopulmonary arrest mortality, which was expressed as the estimated percentage of the population that died from excess cardiopulmonary

arrests. Quadratic regression was used to generate an expected population growth trend line for 2015-2023, based on population data from 2015-2020. Yearly estimates for excess cardiopulmonary arrest fatalities in the USA were calculated using the excess mortality model developed for King County, WA, in this study. The estimated percentage of the population that died from excess cardiopulmonary arrests was applied to the US population to obtain national estimates.

Results

Table 1 provides detailed data on cardiopulmonary arrests, survival rates, mortality (deaths), trend lines, excess deaths, and vaccination rates for King County, WA, from 2015 to 2023. Approximately 98% of the King County population received at least one dose of a COVID-19 vaccine by 2023. The number of cardiopulmonary arrests attended by the King County EMS showed an upward trend from 1,114 in 2015 to 1,350 in 2020, representing a 21.2% increase. However, in 2021 and 2022, there was a significant jump in cardiopulmonary arrests, reaching 1,499 and 1,598 cases respectively. Our model forecasts 1,697 cardiopulmonary arrests in 2023, representing a sharp 25.7% increase since in the inception of COVID-19 vaccination campaigns.

Table 1. King County, Washington, EMS Reports and Calculated Excess Deaths (2015-2023)
Cardiopulmonary arrests and mortality for 2023 are estimated. *Number of deaths from cardiopulmonary arrest. **Standard deviation for excess cardiopulmonary deaths from 2015-2019: ±7.8. ***The percentage of the population that died from excess cardiopulmonary arrests.

Year	Cardiopulmonary arrests	Survival rate	Mortality *	Trend line	Excess deaths* *	Population (mil)	Excess deaths of population (%)***	COVID-19 Vaccination rate
2015	1114	20%	891	884	7	2.127	0.0003%	-
2016	1228	24%	933	929	4	2.168	0.0002%	-
2017	1215	21%	960	974	-14	2.205	-0.0007%	-
2018	1298	22%	1012	1019	-7	2.228	-0.0003%	-
2019	1308	19%	1059	1064	-5	2.250	-0.0002%	-
2020	1350	17%	1121	1110	11 (95% CI: -12, 34)	2.274	0.0005%	-
2021	1499	18%	1229	1155	75 (95% CI: 51, 98)	2.252	0.0033%	66.59%
2022	1598	18%	1310	1200	111 (95% CI: 87, 134)	2.265	0.0049%	85.19%

2023	1697	18%	1392	1245	147	2.271	0.0065%	98.0%
3					(95% CI: 123, 170)			

Figure 1 displays cardiopulmonary arrest mortality from 2015 to 2023, incorporating the 2015-2020 trend line ($y = 45.077x - 89946$, $R^2=0.9871$). The high R^2 value indicates a strong fit of the trend line to the data, explaining approximately 98.71% of the variance in cardiopulmonary arrest mortality during this period. The trend line indicates a steady increase in mortality until 2020, followed by a sharp rise in 2021 and 2022. Specifically, the number of cardiopulmonary arrest deaths increased from 891 in 2015 to 1,110 in 2020, representing a 24.6% increase. In 2021, deaths jumped to 1,229 and continued to rise to 1,310 in 2022. The projection for 2023 suggests 1,392 cardiopulmonary arrest deaths in King County, WA, indicating a sharp 25.4% increase since the onset of COVID-19 vaccination campaigns. Excess cardiopulmonary arrest deaths were estimated to have increased by 1,236% from 2020 to 2023, rising from 11 excess deaths (95% CI: -12, 34) in 2020 to 75 excess deaths (95% CI: 51, 98) in 2021, 111 excess deaths (95% CI: 87, 134) in 2022, and 147 excess deaths (95% CI: 123, 170) in 2023 (Figure 2). The standard deviation for excess deaths from 2015-2019 is ± 7.8 .

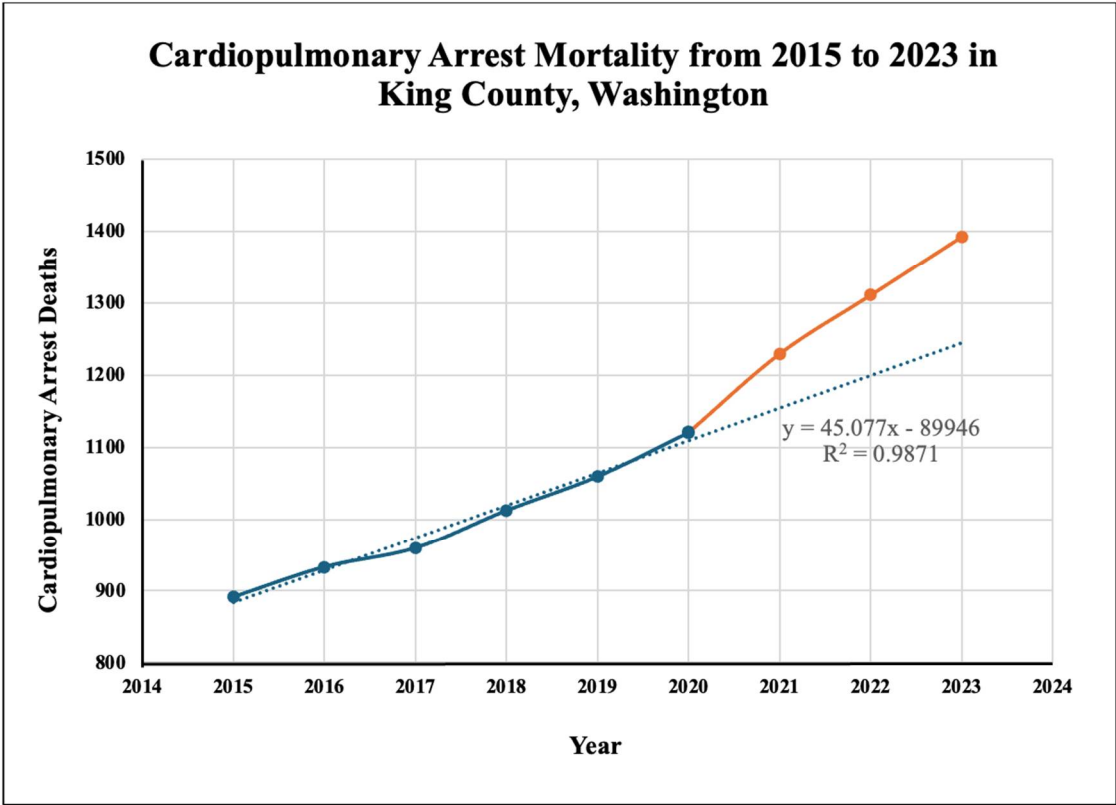


Figure 1. Cardiopulmonary Arrest Mortality from 2015 to 2023 in King County, Washington. The blue dotted line shows the expected cardiopulmonary arrest mortality trend line based on data from 2015 to 2020 (solid blue points). The orange dots represent cardiopulmonary arrest mortality deviating from the expected trend line. The data point for 2023 was estimated using linear regression.

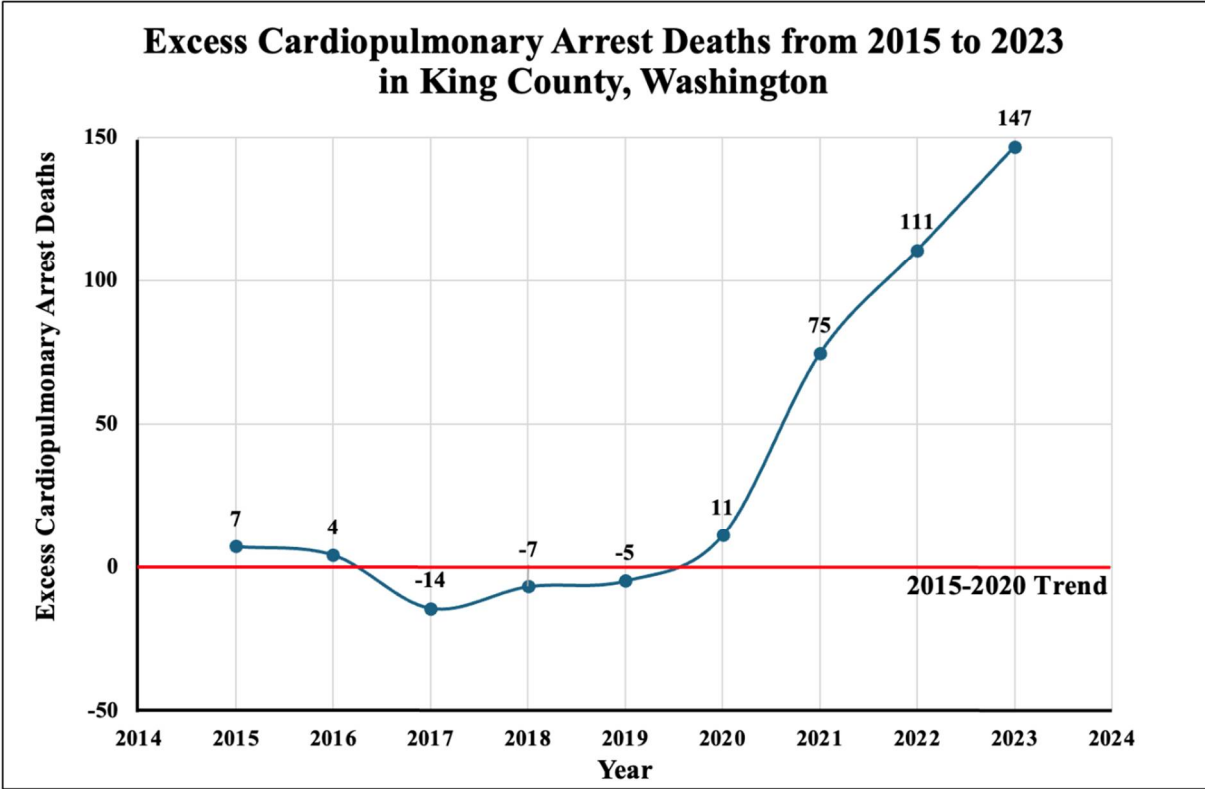


Figure 2. Excess Cardiopulmonary Arrest Deaths from 2015 to 2023 in King County, Washington. The 2015-2020 cardiopulmonary arrest mortality trend line was used to estimate excess cardiopulmonary arrest deaths.

Figure 3 plots excess cardiopulmonary arrest mortality versus COVID-19 vaccination rate. The model demonstrates a quadratic increase in excess mortality as vaccination rates rise, with the equation $y = 0.0053x^2 + 0.0014x + 4 \times 10^{-6}$. The high R^2 value of 0.9992 indicates an excellent fit of the model to the data, explaining approximately 99.92% of the variance in excess mortality. This suggests that the rate of increase in excess mortality accelerates with higher vaccination rates. The population of King County, WA, sharply decreased by 0.94% (21,300 people) in 2021, deviating from the expected population trend line ($y = -0.0026x^2 + 0.0468x + 2.0841$, $R^2=0.9987$) (Figure 4). The high R^2 value of 0.9987 indicates an excellent fit of the model to the data, explaining approximately 99.87% of the variance in population trends. From 2021 to 2023, the population size has slowly recovered but remains below the expected number. Table 2 provides yearly estimates for excess cardiopulmonary arrest fatalities in the USA, yielding 49,240 excess cardiopulmonary arrest deaths from 2021-2023.

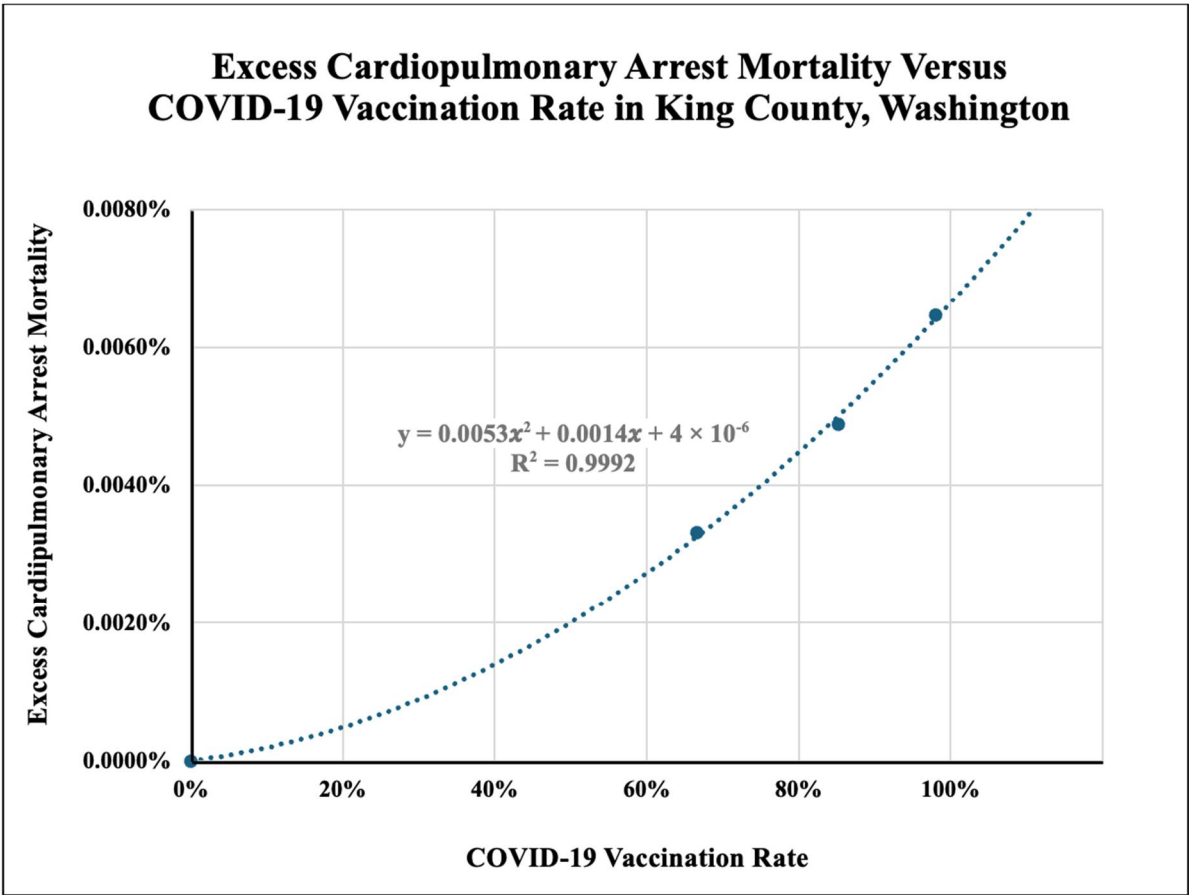


Figure 3. Excess Cardiopulmonary Arrest Mortality Versus COVID-19 Vaccination Rate in King County, Washington. The dotted line represents the quadratic model created using the COVID-19 vaccination rates and estimated excess cardiopulmonary arrest mortality (expressed the percentage of the population that died from excess cardiopulmonary arrests).

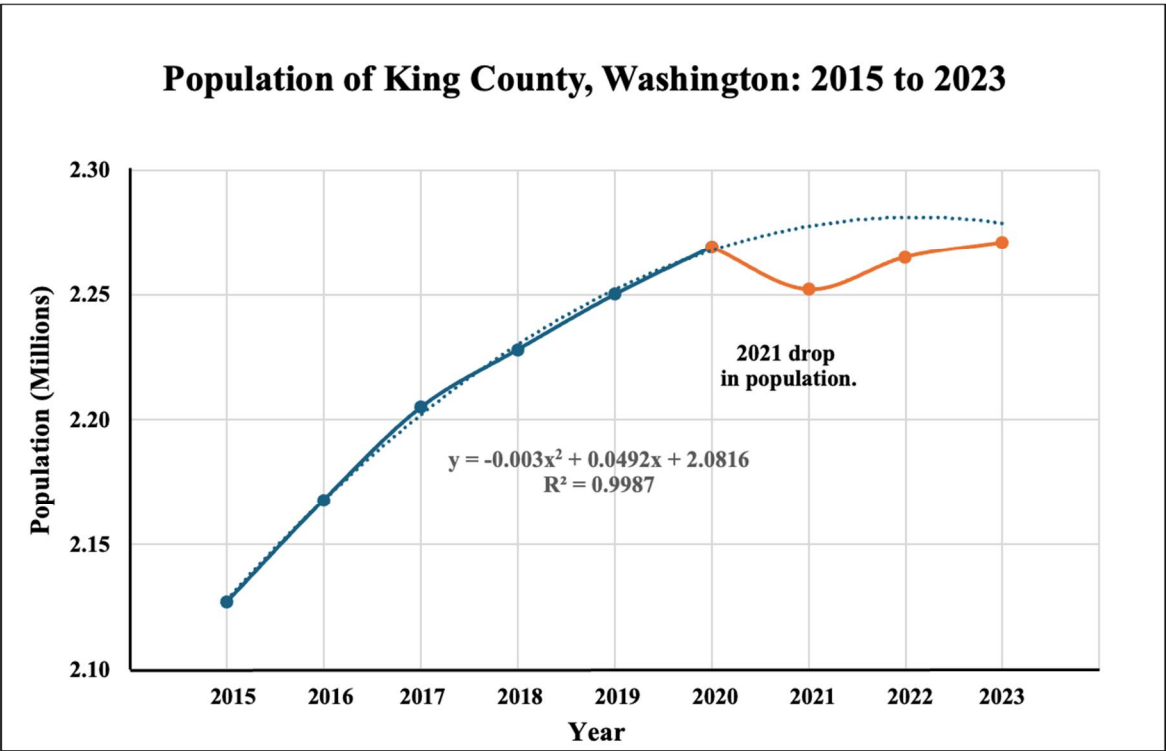


Figure 4. Population of King County, Washington, from 2015 to 2023. The dotted blue line represents the expected population size based on population data from 2015-2020. The solid orange line represents the drop in population in 2021 that deviated from the expected trend.

Table 2. United States Estimates for Excess Cardiopulmonary Arrest Fatalities. *The estimated number of excess cardiopulmonary arrest fatalities based on the model developed in this study.

Region	Year	Population (Mil)	Excess Deaths*
King County, WA	2021	2.252	75
	2022	2.265	111
	2023	2.271	147
USA	2021	332.0	10,990
	2022	333.3	16,280
	2023	340.0	21,970

Discussion

We found that both the total number of cardiopulmonary arrests and fatal events increased more than expected coinciding with the rollout of the COVID-19 mass vaccination program in King County, WA. Our study estimated a 1,236% rise in excess cardiopulmonary arrest deaths following the introduction of COVID-19 vaccines, which have regulatory warnings for myocarditis and thromboembolism [17,18]. Both of these conditions have been proven to likely be fatal in autopsy studies of death after COVID-19 vaccination [19,20]. A very strong correlation between higher vaccination rates and excess cardiopulmonary arrest mortality was observed in the quadratic model. Additionally, the population of King County decreased by 0.94% in 2021, which coincided with the sharp rise in cardiopulmonary arrest fatalities and onset of vaccination campaigns. Applying our model to the entire United States yielded 49,240 excess cardiopulmonary arrest deaths from 2021-2023.

These findings are consistent with existing literature that report an increase in cardiopulmonary arrests and cardiovascular-related deaths since 2020 and 2021 [11,12,21–23]. Sun et al found a 25% increase in the number of cardiac arrest and acute coronary syndrome EMS calls among the 16–39 age group during the COVID-19 vaccination campaign in Israel compared with the same time period in prior years, corroborating the 25.7% increase in cardiopulmonary arrests estimated in our study [22]. Moreover, they used Negative Binomial regression models and found the weekly emergency call counts were significantly associated with COVID-19 vaccination rates in the 16-39 age group, and not with COVID-19 infection rates [22]. The authors concluded that surveillance of COVID-19 vaccine adverse events should incorporate EMS data, as we did in our study. Woodruff et al found that from 2020 to 2022, 228,524 excess cardiovascular-related deaths occurred in the United States, which was 9% more deaths than expected based on trends from 2010 to 2019, supporting our national estimate of 49,240 excess cardiopulmonary deaths possibly due to COVID-19 vaccination [23]. The largest COVID-19 vaccine safety study, conducted by the Global Vaccine Data Network (GVDN) and included around 99 million vaccinated individuals across multiple countries, found that the risk of myocarditis was significantly elevated after mRNA COVID-19 vaccinations, with the risk being 510% and 186% higher than baseline rates following the second doses of the mRNA-1273 and BNT162b2 vaccines, respectively [24]. Moreover, the large study found that the risk of pulmonary embolism was 33% higher than baseline rates after the first dose of mRNA-1273 and 29% higher than baseline rates after the first dose of BNT162b2, respectively [24]. Rose et al analyzed the Vaccine Adverse Event Reporting System (VAERS) and found that myocarditis reports following COVID-19 vaccination in 2021 were 223 times higher than the average incidence for all vaccines combined over the past 30 years, with a 2.9% fatality rate. They concluded that COVID-19 vaccines are strongly associated with a significant adverse safety signal for myocarditis, leading to hospitalization and death [4]. Since 98% of the population in King County was vaccinated against COVID-19, it can be inferred that an excess number of individuals may have suffered from COVID-19 vaccine-induced myocarditis or thromboembolism. Our study adds to this body of literature by specifically correlating the increase

in cardiopulmonary arrest mortality to vaccination rates, a relationship that has not been extensively explored before.

The biological plausibility of COVID-19 vaccine-induced myocarditis and thromboembolism leading to sudden cardiac death has been previously demonstrated and is concerning given our findings using real-world data. Among all published autopsy reports with COVID-19 vaccines as a previous exposure, 35.9% of deaths were attributed to sudden cardiac death, myocardial infarction, and myocarditis, while 15.3% were linked to pulmonary embolism and vaccine-induced immune thrombotic thrombocytopenia (VITT) [19]. Hulscher et al found that COVID-19 vaccine-induced myocarditis can most likely result in sudden cardiac death using post-mortem analysis in 28 autopsy cases [20]. COVID-19 mRNA vaccines systemically distribute mRNA via LNPs that encodes for the Spike protein, which has been shown to incite deleterious effects in multiple organ systems and cause fibrinolysis-resistant blood clots [25,26]. Baumeier et al found Spike protein and no nucleocapsid in the myocardium of 15 individuals with COVID-19 vaccine-induced myocarditis [27]. Schreckenberget al found that in isolated cardiomyocytes, both mRNA-1273 and BNT162b2 induce cardiac dysfunctions that are seen in cardiomyopathies [28]. Krauson et al identified the presence of COVID-19 vaccine mRNA in the hearts of individuals who died within 30 days after vaccination, along with histologically confirmed myocardial injury [29]. De Michele et al found isolated Spike protein without SARS-CoV-2 RNA or nucleocapsid in the blood clots of patients with myocardial infarction and acute ischemic stroke [30]. Thus, the likely occurrence of excess cardiopulmonary deaths associated with COVID-19 vaccination among over 2 million vaccinated individuals living in King County, WA, is not surprising. Moreover, COVID-19 infection and pandemic-related emergency care disruptions may have also contributed to the increase in excess cardiopulmonary arrest deaths [11,32]. However, the sharp increase in excess cardiopulmonary arrest deaths began in 2021, which was one year after the COVID-19 pandemic began and coincides with the onset of COVID-19 vaccination campaigns.

Our study has several significant strengths. With approximately 98% of the King County population having received at least one dose of a COVID-19 vaccine, nearly the entire population was exposed to the variable in our model. This widespread exposure enabled us to detect a significant safety signal of excess cardiopulmonary arrest mortality among a large sample size of over 2 million vaccinated residents. Additionally, the use of comprehensive EMS data from King County ensures a high level of accuracy and reliability in the reported data. Our study spans a period both before and after the COVID-19 vaccination rollout, providing a clear temporal framework to observe and analyze changes in cardiopulmonary arrest rates. This temporal context allows for a clear examination of the relationship between vaccination rates and cardiopulmonary arrest mortality. Furthermore, the ecological validity of our study is enhanced by focusing on a large and diverse urban population, making the findings more generalizable to other metropolitan areas. The significant correlation between vaccination rates and cardiopulmonary arrest mortality has implications for public health. It highlights the need for careful monitoring of vaccine side effects and underscores the importance of considering potential adverse events in vaccination campaigns. Our models suggests that similar increases in excess mortality could occur in other regions with high vaccination rates, thus highlighting the importance of conducting further research to validate these trends.

Our study has all the limitations of ecological data where individual case level information is not available. There are multiple potential, unaccounted confounding variables, such as changes in healthcare access, variations in public health interventions, socioeconomic factors, drug use, and COVID-19 infection that could have influenced cardiopulmonary arrest outcomes. The sudden population drop in King County during the pandemic may have been influenced by migration or temporary relocations, which are not fully captured in the data. Our model relies on extrapolating pre-pandemic trends, assuming underlying conditions remained constant. The high R^2 values observed in our models, such as 0.9992 for the quadratic model relating vaccination rates to excess cardiopulmonary arrest mortality, suggest an excellent fit. However, our models may be unstable due to containing few data points. High R^2 values in small datasets can sometimes indicate overfitting, and these findings should be validated with larger, independent samples. As an

ecological study, our findings apply to population-level trends and may not necessarily reflect individual-level associations.

Conclusion

The data from King County, WA, suggests a very strong ecological and temporal association between excess cardiopulmonary arrest mortality and the COVID-19 vaccination campaign, which resulted in high vaccination rates. This correlation raises important questions about the potential adverse effects of widespread vaccination efforts during the pandemic. The biological plausibility of death from acute cardiac and pulmonary causes after COVID-19 vaccination has been previously demonstrated and is concerning given these real-world observations. The findings of this study underscore the importance of continuous monitoring and analysis of cardiopulmonary arrest data to inform public health interventions and policies, especially in the context of vaccination programs. Urgent further research is needed to determine if similar trends are observed in other regions with attention to risk mitigation for incident events and improved survival with resuscitation. Specifically, the U.S. Centers for Disease Control and Prevention COVID-19 vaccination administration data should be merged with all death cases so that the vaccine type, dose(s), and date of administration can be analyzed as possible determinants.

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Informed Consent Statement: Not applicable as we use publicly available data.

Data availability Statement: All data extracted and analyzed in this study are publicly available and referenced in the methods section.

Conflicts of Interest: Nothing to declare.

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