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Impact of tornadoes on hospital admissions for acute cardiovascular events

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ABSTRACT

Background: There is a paucity of data describing cardiovascular events after tornado outbreaks. We proposed to study the effects of tornadoes on the incidence of cardiovascular events at a tertiary care institution.
Population and methods: Hospital admission records from a single center situated in a tornado-prone area three months before and after a 2013 tornado outbreak were abstracted. To control for seasonal variation, we also abstracted data from the same period of the prior year (control). Hospital admissions for cardiovascular events (CVEs) including acute myocardial infarction, stroke and venous thromboembolism (VTE) were summated by zip codes, and compared by time period.
Results: There were 22,607 admissions analyzed, of which 6,705 (30%), 7,980 (35%), and 7,922 (35%) were during the pre-tornado, post-tornado, and control time frames, respectively. There were 344 CVE in the controls, 317 CVE in pre-tornado and 364 CVEs in post tornado periods. There was no difference in the prevalence of CVE during the post-tornado season compared with the control (PPR = 1.05 95% CI: 0.91 to 1.21, p = 0.50) or the pre-tornado season (PPR = 0.96, 95% CI: 0.83 to 1.21, p = 0.63).
Conclusion: In conclusion, tornado outbreaks did not increase the prevalence of cardiovascular events. In contrast to the effect of hurricanes, implementation of a healthcare policy change directed toward the early treatment and prevention of cardiovascular events after tornadoes does not seem warranted.

1. Background

Inevitable and often unpredictable natural disasters can have preventable health effects in impacted communities. For instance, after the 2011 EF5 tornado in Joplin, Missouri, there was an increase in cases of mucormycosis [1]. Tornado strength is measured using the Enhanced Fujita (EF) scale, which measures 28 types of structural damage and estimates speeds. An EF 4 tornado is consistent with winds of 166–200 mph (267–322 km/h) and severe structural damage. An EF 5 tornado is consistent with winds of more than 200 mph (>322 km/h) and devastating structural damage [2].

Health effects of other natural disasters have been studied. Hurricane Katrina was one of the most devastating natural disasters in the history of the United States. It produced catastrophic damage with an estimated cost of 75 billion dollars in the New Orleans area and along the Mississippi coast in 2005 with a death toll of 1833 [3]. Other natural events might not be as violent but can be deadlier, the heat wave of 2003 in Europe caused 70,000 deaths [4].

An observational study of 1795 adults that lived in this area 6 months before and 6–16 months after the hurricane showed an increase in glycosylated hemoglobin levels [5]. Similarly, there was a 3 fold increase in admissions for myocardial infarction incidence after the hurricane, an effect that persisted even 6 years after the event, thought to be related to various factors including population shifts, alterations in the health care system, and the effects of chronic stress and associated behaviors [6]. Reports of rates of post-traumatic stress disorder following tornadoes vary from 2% to 59% [7].

Tornado outbreaks are among some of the most destructive weather phenomena. Based on data from 1996–2007, tornadoes in the United States cause annual property damages exceeding $1 billion, annual fatalities of 63.3 persons and annual injuries of 999 persons [8]. Almost 100,000 applications for federal disaster assistance have been submitted as a result of tornados between 1970–1980 [7]. In the United States, May tends to be the peak month for tornado occurrence in the Southern plains states, while the upper Midwest and Great Lakes region suffer

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the highest frequency in the summer months. The Moore, Oklahoma tornado was part of a tornado outbreak that occurred during the afternoon and evening hours of May 20, 2013, and was the last day of a three-day stretch of significant severe weather from May 18–20, 2013. This event also produced the most deadly and devastating tornado of the year for Oklahoma and the United States. With an approximately 14 miles long path, the tornado touched down in Newcastle and dissipated east of Moore. Peak width of damage path was approximately 1.1 mile. Peak damage rating: EF-5. [9]. On May 31st, 2013 there were two tornadoes; one sampled by mobile radar and also the widest known tornado on record. This tornado was known as the "El Reno Tornado" produced extensive crop and property damage and a total of 8 motorists were killed by the tornado as it overtook them along U.S. Interstate Highway 40 [10]. Several tornados touched down in the El Reno/South OKC area during the late afternoon of 31 May 2013. An EF3 tornado touched down approximately 8.3 miles west-southwest of El Reno and traveled south of El Reno before turning northeast and crossing I-40. The tornado traveled approximately 16.2 miles before dissipating 4 mi east-southeast of El Reno. The tornado grew to become the widest on record (2.6 mile wide) and had winds exceeding 296 mph. The surprisingly low EF rating for this tornado (it was originally rated EF5 but was eventually downgraded by the National Weather Service to EF3) was because the tornado traveled over open terrain during much of its lifespan and did not affect many structures (EF ratings are based on structural damage, not wind speed).

There is paucity of data describing cardiovascular events after tornado outbreaks. We proposed to study the effects of tornadoes on the incidence of cardiovascular events (CVE) during the Oklahoma tornado outbreaks of 2013.

2. Population and methods

2.1. Institution

The University of Oklahoma Medical Center is the only level one trauma center in the state [11] and the biggest hospital in the tornado areas by bed count and admissions [12]. The hospital in the city of Moore was destroyed by one of the tornadoes, and patients were diverted to our center [13]. Oklahoma is one of the top 17 states in US that has the highest average tornadoes per 10,000 mile^2 over 20 years [3] and is at the center of the so called "tornado alley" because is an area of disproportionate high incidence of tornadoes [14].

Medical records for all hospital admissions during the three months before and after the tornado outbreak of 2013 (pre-tornado 2/20/2013–5/19/2013), (post-tornado 5/20/2013–8/31/2013) were abstracted. To control for seasonal variation, we also abstracted data from the same period of the prior year (control, 5/20/2012–8/31/2012). There were no high magnitude tornadoes in 2012 in the corresponding geographic areas.

Hospital admissions for coronary artery disease, stroke and VTE were identified through a hospital wide ICD-9 code using a previously described and validated method [15]. Specific codes are available in Appendix A. The admissions were analyzed by zip codes affected by the tornado, identified with data from the National Weather Service with the assistance of the School of Meteorology of the University of Oklahoma. Age, gender, readmission rate were retrospectively abstracted for all the included patients.

To evaluate the possibility of a rather immediate effect of the Tornado on CVEs, specially CAD, rather than over 3 months, the same analysis was conducted with only 1 month after tornado.

3. Statistics

A univariate generalized linear model, using a log link to estimate the prevalence proportion ratio (PPR), was fit to compare the prevalence proportion of a CVE event among the three tornado time frames (post-tornado vs control, post- vs pre-tornado). Multivariate regression models were used to test the interaction between time period and gender or zip code group on the prevalence proportion of CVE. To explore the potential short-term impact of the tornado events, a one-month window relative to the tornado time period was also considered. A two-sided 0.05 alpha level was used to define statistical significance.

4. Results

There were 22,607 admissions analyzed, of which 6,705 (30%), 7,980 (35%), and 7,922 (35%) were during the pre-tornado, post-tornado, and control time frames, respectively. There were 344 (4.3%) CVE in the controls, 317 (4.7%) CVE in pre-tornado and 364 (4.6%) CVEs in post-tornado periods. The prevalence of CVEs subtypes among all the patients was: 1.3%–1.5% for VTE, 1%–1.2% for CAD, and 2%–2.2% for stroke (Table 1).

There was no difference in the prevalence of CVE during the post-tornado season compared with the control (PPR = 1.05 95% CI: 0.91 to 1.21, $p = 0.50$) or the pre-tornado season (PPR = 0.96, 95% CI: 0.83 to 1.21, $p = 0.63$).

When adjusted for gender, there was no significant association between the prevalence of a CVE diagnosis and time period (overall 2° of freedom test: $p = 0.55$).

The prevalence of CVEs was lower among those living in El Reno/South OKC compared to the other zip code areas; this difference was seen consistently across the three time periods. Within each zip code stratum, the prevalence of CVE was similarly distributed among the three time periods (Table 2). Due to the non-significant interaction term between time period and zip code ($p = 0.89$) we only tested the main effects. There was no significant association between the prevalence of a CVE diagnosis and time period (overall test, $p = 0.54$). Zip code was significantly associated with the odds of CVE diagnosis ($p < 0.0001$). Patients in El Reno/South OKC area had a 41% lower prevalence of a CVE diagnosis than in the other areas (PPR = 0.59, 95% CI: 0.47 to 0.75) and a 42% lower odds of a CVE diagnosis than patients in the Newcastle/Moore area (PPR = 0.58, 95% CI: 0.41 to 0.84), while there was no significant difference between patients in the Newcastle/Moore area versus other areas ($p = 0.91$).

During the follow up, 10% of the patients had recurrent visits for any indication. The percentage of patients with recurrent hospital stays and a diagnosis code of CVE was consistent among the time points (Table 3).

To evaluate the possibility of an immediate effect of the Tornado on CVEs, specially CAD, rather than over 3 months, the same analysis was conducted using a one-month time frame relative to the tornado events. The prevalence of CVE subtypes was not different among the three time periods: 0.9%-1.6% for VTE, 0.9%-1.5% for CAD, and 2.1%-2.3% for stroke. CAD in particular there were 19 events in controls (1.3% of all admits in time period), 19 events in pre tornado (0.9% of all admits in time period) and 36 events in post tornado (1.5% of all admits in time period). There was no difference in the prevalence of CVE during the post-tornado season compared with the control (PPR = 0.96, 95% CI: 0.74 to 1.24, $p = 0.77$) or the pre-tornado season (PPR = 1.12, 95% CI: 0.85 to 1.47, $p = 0.43$) when using one-month time windows.

5. Discussion

There was no difference in cardiovascular event admissions secondary to tornadic activity. This included CAD, VTE and stroke admissions. These findings remained despite controlling for zip code, gender and readmissions. The need to intensify preventive health care efforts specific to CVE does not seem necessary when anticipating this type of natural disaster.

Others have found an effect of natural disasters on the occurrence of CVE. These effects may persist for at least 6 years following a particular event and may be related to various factors including population shifts,