

# Morbidity and Mortality of Texas Tornado Outbreaks

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## Introduction

Tornadoes are a significant cause of disaster-related morbidity and mortality in the United States, especially in Texas. An increasing proportion of tornadoes now occur during what are known as tornado 'outbreaks', which were responsible for almost 80% of tornado-related fatalities in the U.S. between 1972 and 2010.

**Outbreaks** can be defined as a group of six or more tornadoes originating from the same general weather system and occurring within the same 24-hour period.

While the relationships between tornado severity, economic damage, and mortality/morbidity are generally well understood, less is known about the relationships when single tornadoes are compared with those that are part of a tornado outbreak.

We attempt to identify the drivers of morbidity and mortality from tornado hazards between 1980-2009, particularly of outbreak events via statistical and spatial analysis of the number of tornadoes (i.e. outbreaks) and tornado severity.

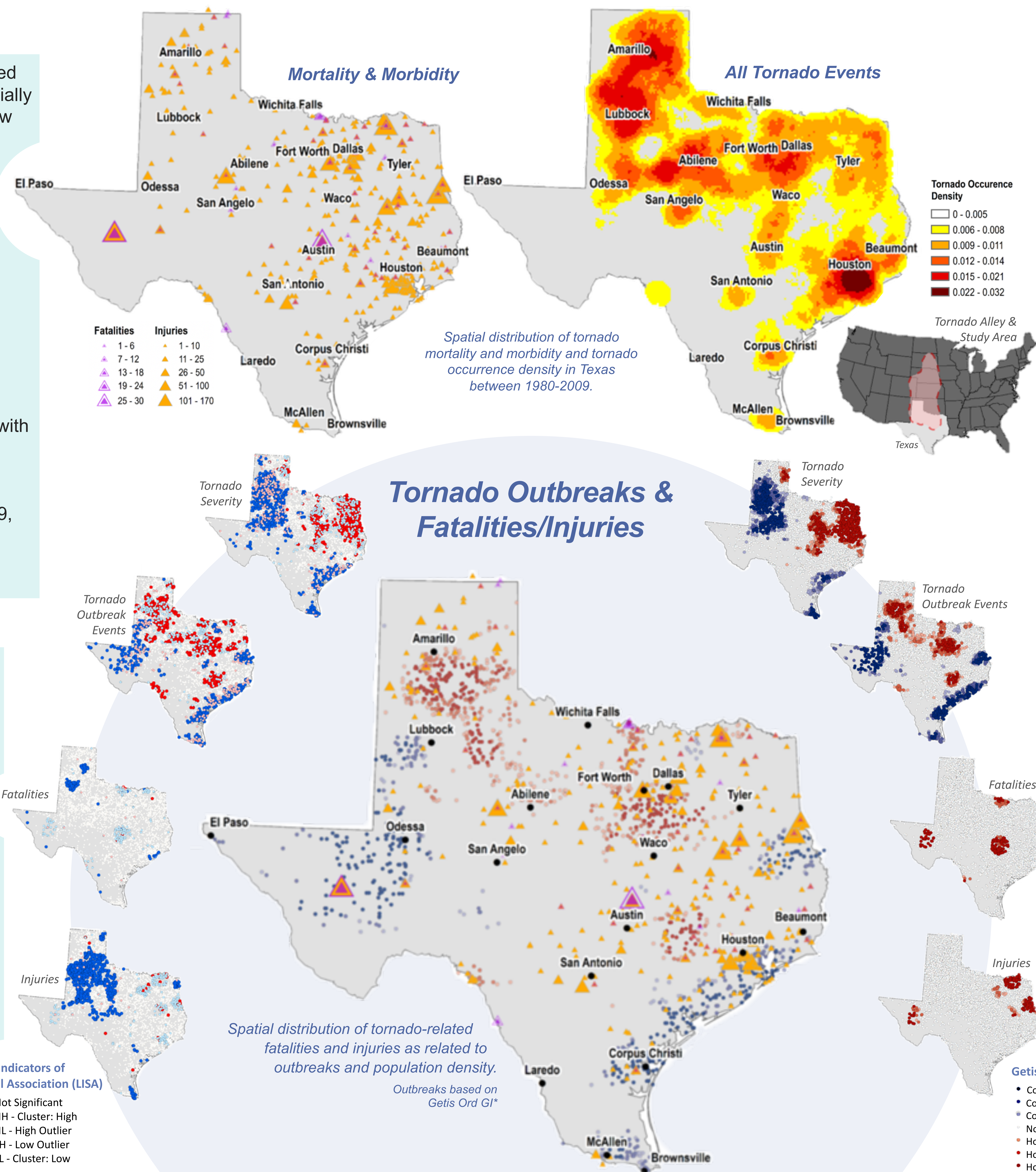
## Methods

Utilizing historical data on tornadoes in Texas between 1980 and 2009, we analyzed and compared four grouped classifications using two sample unequal variable **t-tests**: minor tornadoes (F0-F2), major tornadoes (F3-F5), outbreak events, and non-outbreak events.

Geographic Information Software (GIS) is used to spatially analyze the geographic distribution of individual tornado events. Two types of spatial statistics analyze the following four variables: severity, outbreaks, fatalities, and injuries.

A **Local Indicator of Spatial Association (LISA)** statistic was calculated to identify clusters of high and low values determined using neighboring values.

A **Getis Ord Gi\*** statistic was calculated to determine hot spots of tornado severity, outbreak events, and casualties, which were compared to population density.



## Results

Within the ~4600 tornado events analyzed (178 fatalities, 2553 injuries), the highest cause of morbidity and mortality were outbreaks. T-test results suggest that outbreaks and severity have different impacts on morbidity and mortality. The overall trend from the point density heat map shows higher frequencies in the panhandle, north-central Texas and the south east coast.

The **Getis Ord Gi\*** and **LISA** results show similar geographic patterns: both suggest geographically similar hotspots of injuries and fatalities as well as cold spots for severity and injuries. While the Getis results are more clearly defined, both GIS analyses show tornado events composed of high and low severity incidents with no obvious clustering. Increased casualties also occur around outbreak hotspots in areas of high population density; however, there are small clusters of high population where cold spots of outbreaks have occurred, in the panhandle and along the coast.

## Discussion

While major tornadoes are expected to contribute a large proportion of tornado-related casualties, the presence of outbreaks is also an important contributor having a disproportionate impact on morbidity and mortality, regardless of tornado severity.

Spatial statistics confirm that areas of Texas have concentrations of tornado severity, outbreaks, and casualties, but there are important outliers, potentially demonstrating the importance of outbreaks on increased mortality and morbidity in these areas.

The exploratory, statistical and spatial analyses results indicate that there is a considerable difference in the number of fatalities and injuries within outbreaks rather than non-outbreaks. With this knowledge, emergency management and other governmental authorities may consider focusing on the development and implementation of advanced early warning systems to recognize outbreak potential/occurrence to alert the public of the higher threat to their safety.