Winter Precipitation Impacts on Automobile Accidents in the United States

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Introduction & Background

Winter precipitation such as snow, sleet, and freezing rain is a hazard that can have a disruptive effect on human lives. One of the greatest impacts of winter precipitation is on travel. Poor road conditions and reduced visibility during winter precipitation can lead to automobile accidents, property damage, injuries, and fatalities.

Figure 1. Overhead view of a massive accident involving an estimated 50-100 vehicles on 14 February 2014. The accident resulted in 24 injuries and closed the Pennsylvania Turnpike for several hours.

Previous studies of Canadian cities by Andrey (2010) and Andrey et al. (2003) found that snowfall increased automobile crash risk anywhere between 66% and 117% as compared to dry periods. In the United States, Eisenberg and Warner (2005) analyzed the impact of snowfall on crash rates for the 1975-2000 period and found that snowfall days had fewer fatal crashes but more non-fatal injury and property damage crashes. This study seeks to determine if the presence of winter precipitation makes drivers more vulnerable to accidents, injuries, or fatalities as compared to dry roads and how that vulnerability changes spatially by determining the relative risk of driving during winter precipitation for 13 cities across the U.S.

Methodology

Several criteria were used to determine the cities used for the study:

- The city must have hourly weather data available in the form of Meteorological Terminal Aviation Routine Weather Report (METAR).
  - METAR data has both high temporal resolution and reports the type of precipitation (if any) occurring at each observation.
- The city must be within a state that participates in the National Highway Traffic Safety Administration's (NHTSA) State Data System (SDS). The SDS consists of computer files coded directly from traffic accident reports and contains information on fatality, injury, and property damage only crashes.
- An effort was made to select cities based on the climatology of sleet (Changnon, 2008), freezing rain (Changnon 2003; Changnon and Karl 2003), and snowfall (Changnon and Changnon 2006; Changnon, Changnon and Karl 2006) such that at least one location would be in a region that frequently receives each type of winter precipitation.

Once identified, METAR data for the principal weather station in the area was obtained. Crash data for the county containing the weather station was also gathered. In some cases crash data was obtained for other nearby counties, due to the proximity of the weather station to county lines and/or in order to obtain crash statistics for the majority of the urban area in question.

A matched pair design is adopted for the study (Andrey 2010, Andrey et al. 2003). Each hour with winter precipitation is paired with a control hour where inclement weather was absent.

- Each hour of winter precipitation was determined using the "present weather" field within the METAR data.
- Winter precipitation events and controls were defined as being exactly one week apart in order to control for season, day of the week, and time of day. If analysis of the meteorological data did not produce a match, the precipitation event was excluded from further analysis.
- Automobile accidents occurring during the event and control period for each matched pair were then tabulated.
- Once the accident data is tabulated for event and control periods, the relative risk of collision was calculated by taking the number of the collisions that occurred during winter precipitation periods and dividing by the number of collisions during the control periods.

Results

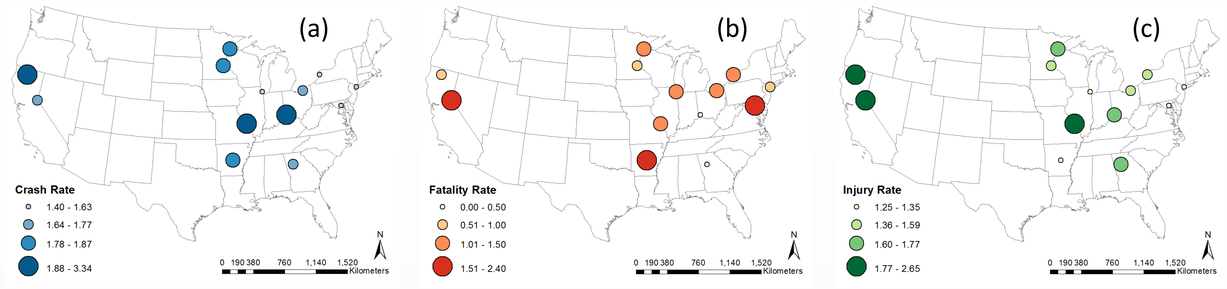

Figure 2. Relative risk of a) vehicle accident b) fatality and c) injury due to winter precipitation for 13 U.S. cities.

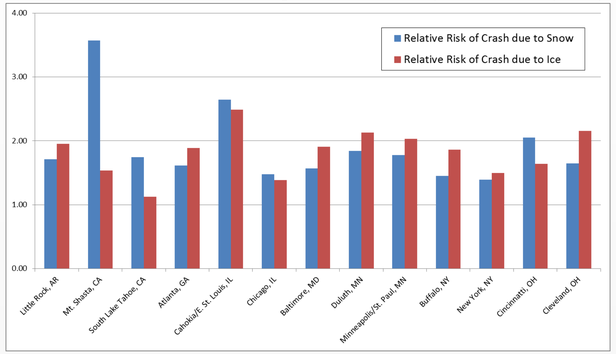

Figure 3. Relative risk of crash due to snowfall (blue bars) and freezing rain or sleet (red bars) for 13 U.S. cities.

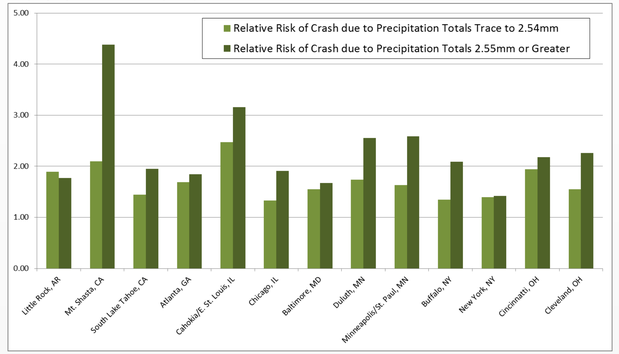

Figure 4. Relative risk of crash due to precipitation totals of a trace to 2.54mm (light green bars) and 2.55mm or greater (dark green bars) for 13 U.S. cities.

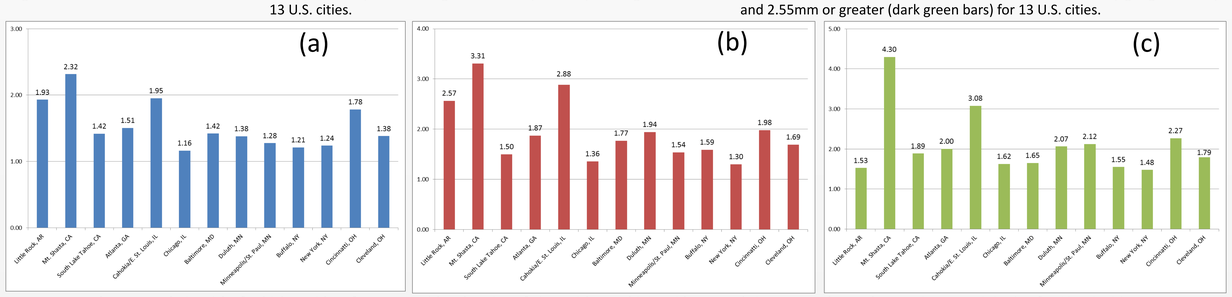

Figure 5. Relative risk of vehicle accident for events with a duration of a) 1 to 3 hours, b) 4 to 6 hours and c) 7 or more hours due to winter precipitation for 13 U.S. cities.

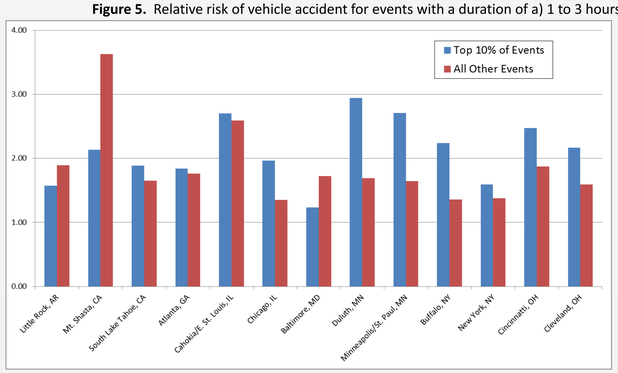

Figure 6. Relative risk of crash during the top 10% of winter precipitation events in terms of intensity (blue bars) and all other events (red bars) for 13 U.S. cities.

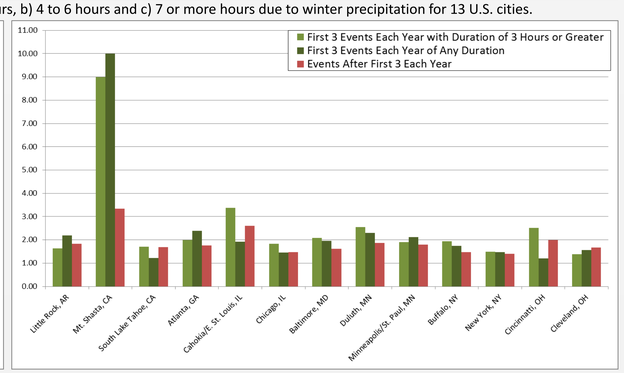

Figure 7. Relative risk of crash as a result of the first three winter precipitation events of the year after June 30th with duration 3 hours or greater (dark green bars) and of any duration (light green bars) compared to events after the first three (red bars) for 13 U.S. cities.

Results

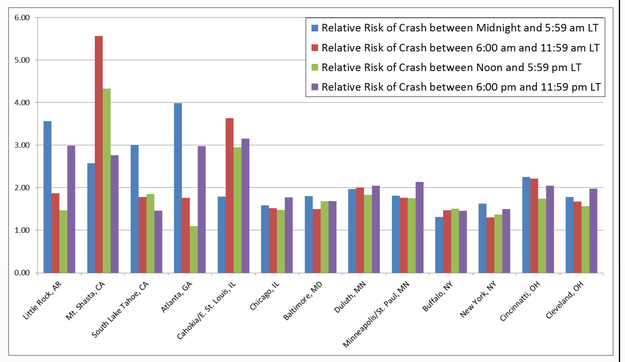

Figure 8. Relative risk of crash by 6 hour period (local time) for 13 U.S. cities.

Conclusions

- Winter precipitation results in an increase in both crashes and injuries for each of the 13 cities as compared to dry conditions. Most cities had a modest increase in automobile fatalities during winter precipitation (Figure 2).
- Most cities saw a greater increase in risk during ice precipitations types (freezing rain and sleet) as compared to snowfall (Figure 3). Cities with a greatest risk during snowfall and cities with a greatest risk during ice saw approximately the same percentage of hours with ice precipitation. This suggests that factors beyond the presence of ice precipitation may have a greater impact on crash rates.
- In general, relative risk of crash increased as precipitation totals increased (Figure 4).
- Most cities experience a greater risk of crash when the duration of precipitation increases (Figure 5).
- Most cities have a greater risk of crash when precipitation is more intense (greater hourly totals during an event; Figure 6).
- Every city experiences an increase in risk of crash during the first three winter precipitation events of the year as compared to both dry days and precipitation events beyond the first three (Figure 7), a finding consistent with Andrey et al. (2003).
- Most cities had a modest difference in relative risk of crash during 6 hourly periods. However, some cities (*e.g.* Little Rock, AR and Atlanta, GA) had a much greater relative risk in the "overnight" (6:00 pm to 5:59 am) period (Figure 8).

Future Work

- Assessment of the factors (societal response to winter precipitation, road engineering, road treatment during winter precipitation) which led to the relative risk rates found by preliminary work.
- Examination of annual trends to determine how the relative risk has changed over the period of record for each city.

References

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