Relationships Between Weather and Roadway Safety

tech transfer summary

Understanding the relationships among winter weather, traffic safety, and winter maintenance operations can help decision makers better understand how winter maintenance impacts safety.

Objective

The objective of this research was to analyze the relationships between road weather conditions and crash occurrences in Iowa and to develop crash frequency and severity models considering weather-related factors. In particular, the researchers used snowplow automatic vehicle location (AVL) data to examine the effects of winter maintenance operations on roadway safety and mobility.

Background and Problem Statement

Inclement winter weather significantly impacts traffic safety. Between 2010 and 2014, Iowa saw more than 8,000 winter weather-related crashes, including 190 fatalities and serious injuries and 2,200 minor injuries. To mitigate the impacts of winter weather, the Iowa Department of Transportation (DOT) spent 34.6 million dollars on winter maintenance in 2018 and has averaged 29.44 million annually over the last five years.

Much research has attempted to determine the impacts of winter weather events on safety. As more knowledge has been gained, attention has turned to quantifying the impacts of winter maintenance operations on safety.

In recent years, the Iowa DOT has collected large amounts of detailed data pertaining to winter weather, traffic safety, and winter maintenance operations. Because of the amount of detail in the data, a thorough examination of the interactions between all three concerns has become possible.

Research Description

A crash frequency model and a crash severity model were developed to quantify and provide insight into the relationships among winter weather, traffic safety, and winter maintenance operations.

The models utilized data from various sources covering the winters of 2016–2017 and 2017–2018 and eight city centers in Iowa.

Weather data were obtained from automated weather observing system (AWOS) and road weather information system (RWIS) units. These data were fed into the Iowa Environmental Mesonet system, which provides highly granular data across Iowa.

Crash data were extracted from the Iowa DOT crash database.

AVL data from snowplows captured date and time, longitude and latitude, travel speed, plow position, and material spreading rate at approximately 10-second intervals.

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RESEARCH PROJECT TITLE
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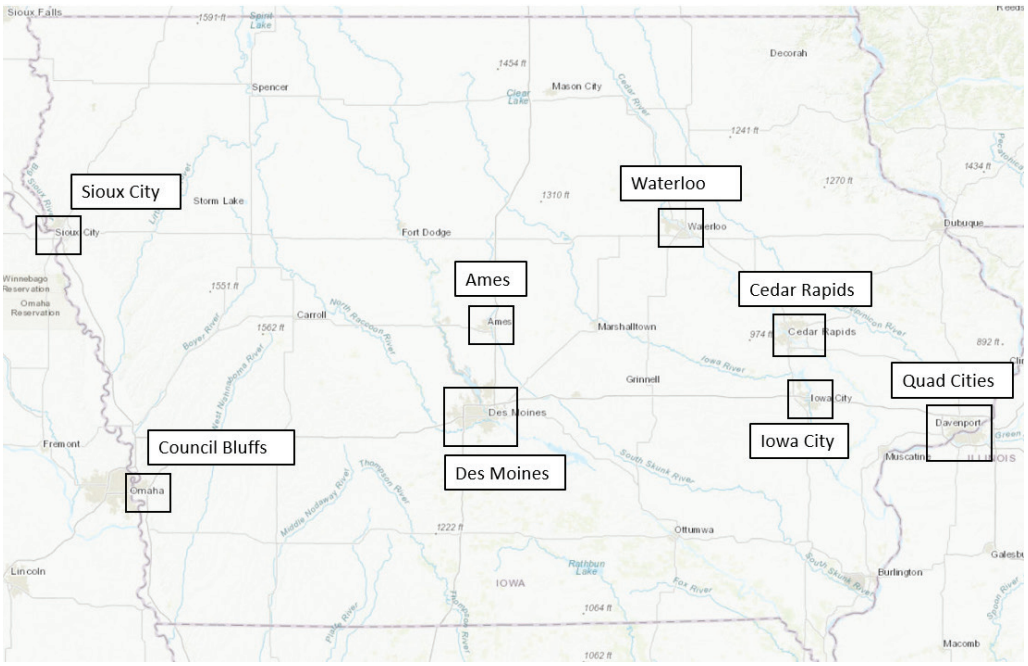
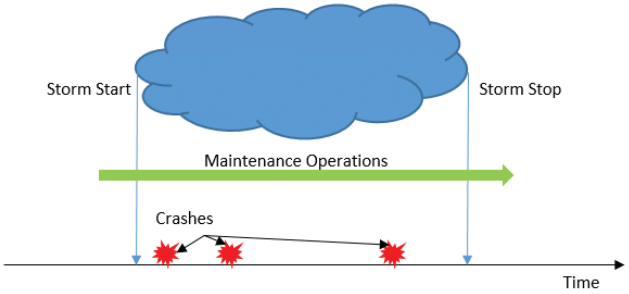


Eight city centers examined in this study



Data collected during a storm event for the crash frequency model

The crash frequency model was developed based on snowstorm events. Each winter storm was considered as a sample. The number of crashes associated with each event was analyzed in relation to traffic-, weather-, and snowplow operation-related variables.

The crash severity model was developed by linking each crash with weather- and snowplow operation-related variables. An ordered logit model was used to model crash severity based on the five-tier KABCO numerical categorization system.

Because of the depth of data available, a deeper analysis was conducted involving various ratios between different datasets to further explore the relationship between snowplow parameters and crash risk.

Key Findings

A roughly 50/50 split of winter weather-related crashes occurred during a winter storm (i.e., during precipitation) versus outside of a winter storm. The large proportion of crashes outside of a winter storm may be attributed to the persistence of adverse pavement conditions after the storm ends and possibly drivers' false sense of safety.

Crashes resulting from winter events were found to be less severe than comparable crashes during the same timeframe. Weather-related crashes were found to have a greater proportion of property damage only (PDO) crashes and a lower proportion of major injury and possible injury crashes.

Counterintuitively, higher crash counts and frequencies were correlated with a higher number of snowplow passes (i.e., greater snowplow activity). This is because the number of snowplow passes is directly correlated to storm duration, in that snowplows travel greater distances and spread more material during longer storms.

When controlling for weather variables, normalizing the total solid material that snowplows spread by the total snowfall revealed that the more solid material spread, the greater the safety benefit.

Many winter crashes were found to be temporally located near a snowplow pass either before or after the crash event. Many of these crashes occurred along Interstate routes. Because these routes have multiple lanes and are plowed frequently, Interstate crashes are likely to occur close to a snowplow pass.

Crashes on Iowa routes tended to occur when plow passes were temporally further away from the time of the crash. The crash severity model showed that these routes are less safe than Interstate routes and that both US and Iowa routes had a higher propensity for severe crashes than Interstate routes.

An analysis of expected versus observed crashes showed that almost one-third of all crashes occurred before a snowplow pass, which was significantly higher than the expected proportion. The proportion of observed crashes where several snowplow passes occurred before the crash was significantly lower than the expected proportion. These relationships suggest that the greater the number of snowplow passes early in the storm, the fewer the crashes.

Implementation Readiness and Benefits

The results of this research helped elucidate the key relationships among winter weather, snowplow operations, and traffic safety. These findings can help inform decision makers about how maintenance operations impact safety.

The scope of the study was limited by the number of RWIS sensors, difficulties in quantifying winter storms, and crash data quality. Additionally, non-precipitation-based winter weather events were not analyzed in the crash frequency model. For example, blowing snow can cause hazardous driving conditions across Iowa. Because of time and resource constraints, these events could not be incorporated into that part of the study.

The 50/50 ratio of crashes that occurred during versus outside of a storm event may indicate that crashes that occurred after a storm are underrepresented. Examining a longer period after the storm may present a clearer picture of the lasting effects of winter storms. Additionally, the impacts of individual snowplow passes on safety could be clarified by considering snowplow pass frequency in light of the number of lanes on the road.