1. INTRODUCTION

Motor vehicle collisions exact a significant toll on Canadians each year—2,917 deaths and 227,500 injuries in 2000 alone (Transport Canada 2001). This translates into approximately one injury for every 137 citizens each year. Motor vehicle collisions account for 16 percent of all injury admissions to acute care hospitals in Canada (Health Canada et al. 1999), and CCMTA (2000) reports that the cost of casualty collisions to the Canadian health care system exceeds $10 billion per year.

Weather is one of many risk factors that influence collision occurrence and severity. This paper reviews findings from empirical analyses of weather-related collision and injury risk including recent research by the authors for several Canadian cities. Estimated risks are discussed within the context of other atmospheric hazards, including heat stress, air pollution and severe weather events. Research issues and examples of interventions used to reduce risks for each hazard are also noted.

2. COLLISION AND INJURY RISK

Weather influences collision rates primarily by reducing visibility and road surface friction. Andrey et al. (2002) assessed the risks of motor vehicle collisions and injuries associated with various types of precipitation relative to normal, dry weather conditions for several Canadian cities. Risk ratios provided in Table 1 were determined by dividing collision (injury) counts for selected precipitation events by collision (injury) counts for corresponding controls. Events were matched with dry weather and road condition controls for the same day of the week and time period either one week before or following a selected event. The matched-pair method enables the researcher to control for time-sensitive factors, such as traffic volume, for which data are unavailable.

Findings from Andrey et al. (2002) and similar investigations support the following observations about weather-related collision risk:

- There is ample evidence to conclude that precipitation is associated with a substantial increase in road collisions and injuries. The situation is less clear for fatalities but it appears that fatality rates are lower during inclement weather—especially for snowfall—probably due to driver adjustments.

- The magnitude of the safety impact varies considerably from one weather event to another, and also in aggregate across both time and space. Some of the variations are due to differences in storm characteristics, but outcomes also appear to be sensitive to research methodology and to situational risk factors, such as roadway geometrics and time of day. Place differences are evident but are not well understood, making it difficult to generalize results.

- Researchers tend to report the influence of weather on safety in one of two ways: either by noting statistical significance in model development, or by reporting relative risk ratios, as shown in Table 1. Translation into absolute incidence rates, morbidity or dollars is seldom done, despite the advantages of these for evaluating and justifying interventions. However, first estimates for Canada indicate that approximately seven percent of traffic injuries and 12 percent of property-damage collisions are directly attributable to inclement weather; this translates into approximately 15,000 injured persons and $1 billion dollars in health and other costs per year (Andrey et al. 2001).

### TABLE 1 Relative Motor Vehicle Collision and Injury Risk for Several Canadian Cities (1995-1998)

<table>
<thead>
<tr>
<th>City</th>
<th>Relative Risk of Collision Rainfall</th>
<th>Winter Precip.*</th>
<th>Relative Risk of Injury Rainfall</th>
<th>Winter Precip.*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Halifax</td>
<td>1.31</td>
<td>1.68</td>
<td>1.16</td>
<td>1.23</td>
</tr>
<tr>
<td>Ottawa</td>
<td>1.79</td>
<td>1.83</td>
<td>1.58</td>
<td>1.41</td>
</tr>
<tr>
<td>Québec</td>
<td>1.39</td>
<td>1.20</td>
<td>1.19</td>
<td>0.94</td>
</tr>
<tr>
<td>Hamilton</td>
<td>1.71</td>
<td>1.86</td>
<td>1.67</td>
<td>1.67</td>
</tr>
<tr>
<td>Waterloo</td>
<td>1.89</td>
<td>2.57</td>
<td>1.47</td>
<td>1.96</td>
</tr>
<tr>
<td>Regina</td>
<td>1.29</td>
<td>2.56</td>
<td>0.88</td>
<td>2.45</td>
</tr>
<tr>
<td>Overall</td>
<td>1.59</td>
<td>1.73</td>
<td>1.41</td>
<td>1.47</td>
</tr>
</tbody>
</table>

*snow, freezing rain, ice pellets, and mixed precipitation Source: Andrey et al. (2002)
4. COMMON ISSUES AND INTERVENTIONS

4.1 Research Issues

Although the frequency and consequences of the hazards discussed previously are somewhat different, a number of similar issues emerge.

4.2 Interventions

The health effects of specific weather or pollution events, whether defined using hourly or daily data, show great variability. Temporal effects show up in results—such as heightened road collision risk during first snowfalls of the season or elevated mortality and morbidity for early season heat waves and air pollution episodes. These observations provide possible evidence of driver adjustment and pre-shifted mortality, respectively.

Studies also provide evidence of spatial and socio-demographic variability in risk. For instance, cities appear to have different heat stress ‘thresholds’ and varying sensitivities to road weather conditions; and dwelling type affects survival rates during tornadoes. As well, different segments of the population (e.g., elderly, infants, children, ill) may be disproportionately at risk during heat waves and air pollution episodes. Similarly, driving experience and age may have effects on collision risk.

Common issues are also apparent in the estimation and evaluation of health risks for each of these hazards with the most significant relating to:

- reliability of health and hazard indicator data;
- confounding or covariation among time- and location-sensitive variables;
- inference of causal relationships from population data to the individual level (ecological fallacy); and
- evaluation of estimated risks (e.g., the appropriateness and comparability of various indicators).

While the latter might be viewed as more of a policy than research issue, it has direct relevance to the selection and treatment of variables in risk analyses and to the evaluation and financing of interventions.
Occasionally such interventions have unintended and undesirable consequences (e.g., road salt effects on the environment and infrastructure, exacerbation of air pollution in meeting electricity demands for air conditioning during heat waves).

When these adjustments or responses fail, insurance and government assistance programs are available to facilitate recovery—a modest consolation for lost lives however.

These interventions have been relatively effective at reducing casualty risk for many forms of severe weather hazards (tornadoes and hurricanes). However, the risks associated with atmospheric hazards dominated by human influences, like air pollution and road collisions, remain high despite these programs. Substantive risk reduction in these areas demands more than the simple treatment of symptoms—greater attention must be given to the design of urban environments, and land use and transportation planning.

5. CONCLUSION

Weather-related injury collision risk is a serious health issue—and likely more important than ‘higher profile’ atmospheric hazards such as tornadoes, lightning, and hurricanes. Many of the research issues and challenges to reduce road collision and injury risk are similar to those affecting other atmospheric hazards, especially heat stress and air pollution. This initial insight suggests that more thorough comparisons among these hazards and more cooperation across the disparate research communities would be beneficial—both for research and in guiding policy.

REFERENCES


