Life-Threatening Alcohol-Related Traffic Crashes in Adverse Weather

Appendix

OVERVIEW

The purpose of this appendix is to provide methodological details for reviewers. The content addresses mathematical calculations and projections for public health implications of the study findings by extrapolating the findings to the United States population. The organization appears in four main sections: (§1) Estimating Absolute Deaths, (§2) Estimating Total Hospital Impact, (§3) Estimating Economic Costs, and (§4) Supporting References.

§1) Estimating Absolute Deaths from Drunk Driving in Rainy Weather

Throughout this section for simplicity we assume that adverse weather is well-represented by rainy weather (the most common form of prevailing adverse weather for crashes in the United States).

§1.1) Total Counts under All Conditions

We estimated the annual deaths from drunk driving in rainy weather for the United States by translating the observed relative risk of a life-threatening alcohol-related traffic crash associated with rainy weather into death counts. We used the most recent data from the National Highway Traffic Safety Administration (year = 2015) to define total annual traffic fatalities (n = 35,092), alcohol-impaired traffic fatalities (n = 10,265), and rainy weather traffic fatalities (n = 2,720) [1]. These values were aligned onto a 2x2 exposure-outcome table, and the counts of deaths in each of the four exposure categories were denoted by the variables *a*, *b*, *c* and *d* (Table 1).

Table 1: Traffic fatalities for the United States, 2015

	+ Alcohol	– Alcohol	Total
+ Rain	*a*	*b*	2,720
– Rain	*c*	*d*	32,372
Total	10,265	24,827	35,092

We next expressed the internal cell counts (*a*, *b*, *c*, *d*) using the following expressions based on the upper left cell (*a*). Specifically, *b* = 2,720 – *a*, *c* = 10,265 – *a*, and *d* = 22,107 + *a*. The results appear below (Table 2).

Table 2: Traffic fatalities as mathematical expressions			
	+ Alcohol	– Alcohol	Total
+ Rain	*a*	2,720 – *a*	2,720
– Rain	10,265 – *a*	22,107 + *a*	32,372
Total	10,265	24,827	35,092

We next calculated the total number of traffic fatalities involving both drunk drivers and rainy weather (equal to the variable *a* in Table 2) by imposing a further constraint implied by the oddsratio estimate observed in our study. Specifically, the odds-ratio for an alcohol-related traffic crash in adverse weather in our study (odds-ratio = 1.19) was assumed to follow the standard formula for an odds-ratio (odds-ratio = *a* x *d* / *b* x *c)*. The calculations were simplified further based on the expressions in Table 2; namely, 1.19 = (*a* x *d)* / (*b* x *c)* = [*a* x (22,107 + *a*)] / [(2,720 – *a*) x (10,265 – *a*)]. This yielded *a* = 889, indicating 889 traffic deaths in the United States involved both drunk driving and rainy weather. We then calculated the remaining values for the three variables (*b*, *c*, *d*), and completed the following 2x2 table (Table 3).

Table 3: Traffic fatalities derived from observed association (odds-ratio = 1.19)			
	+ Alcohol	– Alcohol	Total
+ Rain	889	1,831	2,720
– Rain	9,376	22,996	32,372
Total	10,265	24,827	35,092

§1.2) Excess Alcohol-Related Deaths in Rainy Weather

Next, we estimated the number of excess alcohol-related traffic deaths attributable to driving in rainy weather. For rigor, we developed two different estimates by using different approaches for evaluating the number of baseline alcohol-related deaths. This baseline value served as a reference point for assessing the excess deaths associated with drunk driving in rainy weather beyond the baseline risk.

Estimate 1: Based on Fully Null Hypothesis in Rainy Weather

For the first estimate of the excess traffic fatalities, we considered whether rainy weather might have no impact on the risk of an alcohol-related traffic crash. Under this null hypothesis, the odds of a life-threatening alcohol-related crash associated with rainy weather would be: oddsratio = 1.00. Using the same method employed earlier (Table 3) to calculate the total deaths, we developed another 2x2 table to determine the baseline traffic fatalities (Table 4). Specifically, we used the formula: odds-ratio = 1.00 = (*a* x *d)* / (*b* x *c)* = [*a* x (22,107 + *a*)] / [(2,720 – *a*) x (10,265 – *a*)]. This yielded *a* = 796, indicating 796 alcohol-related traffic deaths would occur if rainy weather had no impact on crash risk. We also calculated the values for the remaining three variables (*b*, *c*, *d*), and completed the 2x2 table (Table 4).

Table 4: Baseline alcohol-related traffic fatalities (odds-ratio = 1.00)

	+ Alcohol	– Alcohol	Total
+ Rain	796	1,924	2,720
– Rain	9,469	22,903	32,372
Total	10,265	24,827	35,092

Finally, we contrasted the upper left cell in Table 3 (n = 889 deaths) with the upper left cell in Table 4 (n = 796 deaths) to estimate the net excess deaths from drunk driving in rainy weather for the United States annually. This yielded 93 excess traffic deaths annually (889 – 796), equal to two additional deaths per week (93 / 52). This was our first estimate for the excess alcoholrelated fatalities due to rainy weather.

Estimate 2: Based on Partially Positive Hypothesis in Rainy Weather

For the second estimate of the excess traffic fatalities, we considered whether rainy weather might have no special impact on the risk of an alcohol-related traffic crash beyond the observed effect on sober drivers. Under this partially positive hypothesis, the odds of a life-threatening alcohol-related crash associated with rainy weather is assumed to be: odds-ratio = 1.10. Using the same method employed earlier (Table 4), we developed another 2x2 table to determine a second estimate of the baseline traffic fatalities (Table 5). Specifically, we used the formula: odds-ratio = 1.10 = (*a* x *d)* / (*b* x *c)* = [*a* x (22,107 + *a*)] / [(2,720 – *a*) x (10,265 – *a*)]. This yielded *a* = 846, indicating 846 alcohol-related traffic deaths would occur if rainy weather had no special impact crash risk beyond the observed effect on sober drivers. We also calculated the values for the remaining three variables (*b*, *c*, *d*), and completed the 2x2 table (Table 5).

Table 5: Baseline alcohol-related traffic fatalities (odds-ratio = 1.10)			
	+ Alcohol	– Alcohol	Total
+ Rain	846	1,874	2,720
– Rain	9,419	22,953	32,372
Total	10,265	24,827	35,092

Finally, we contrasted the upper left cell in Table 3 (n = 889 deaths) with the upper left cell in Table 5 (n = 846 deaths) to estimate the net excess deaths from drunk driving in rainy weather for the United States annually. This yielded 43 excess traffic deaths annually (889 – 846), equal to one additional death per week (43 / 52). This was our second estimate for the excess alcoholrelated fatalities due to rainy weather.

Summary

To conclude, these calculations provided two estimates for the absolute excess deaths attributable to drunk driving in rainy weather by combining the baseline data for the United States with the observed relative risk from our study. Overall, we determined that drunk driving in rainy weather might account for 1-2 extra deaths per week.

§2) Estimating Total Hospital Impact

§2.1) Population-Wide Odds-Ratio

We estimated the net effect of drunk driving in adverse weather on hospitalizations by first calculating the absolute increase in number of patient admissions by conceptualizing a population-wide odds-ratio. We began by determining the excess number of admissions from the direct data in our study. Specifically, adverse weather prevailed for 312 of the 2,088 alcoholrelated crashes, 282 of the 2,088 control days one week before the crash, and 255 of the 2,088 control days one week after the crash. This implied the baseline prevalence of adverse weather was 12.86% based on the controls ([282 + 255] / 2,088 / 2). We then transformed the observed relative risk of 1.1900 (for an alcohol-related crash during adverse weather) to a net populationwide relative risk of 1.0244 after accounting for the baseline frequency of adverse weather ([12.86% x 1.19] + [87.14% x 1.00]). Thus, adverse weather might explain 2.44% of alcoholrelated crashes in our entire study. This overall net increase was equal to 51 additional patients (2,088 x 2.44%).

§2.2) Excess Amount of Hospital Utilization

We next extrapolated this population-wide relative risk of 1.0244 to quantify the total hospital utilization from alcohol-related crashes in adverse weather. Specifically, we evaluated the excess patient-days, surgeries, critical care days, and deaths for 51 additional alcohol-positive patients injured in adverse weather. These four indicators allowed us to gauge the magnitude of additional acute hospital care potentially attributable to the odds-ratio observed in our study.

Patient-Days

In our study of 2,088 alcohol-positive patients, 312 were injured in prevailing adverse weather (resulting in 4,618 patient-days in hospital) whereas the remaining 1,776 were injured in other weather circumstances (resulting in 27,883 patient-days in hospital). The mean length of hospital stay was similar for patients regardless of prevailing weather conditions (14.8 vs 15.7 days, p = 0.552). This yielded a total of 32,501 hospital patient-days for all alcohol-related crashes (4,618 + 27,883). Therefore, the net impact of adverse weather on hospital stay was an additional 793 patient-days (32,501 x 2.44%).

Surgeries

In our study of 2,088 alcohol-positive patients, 312 were injured in adverse weather (resulting in 304 surgeries) whereas the remaining 1,776 were injured in other weather circumstances (resulting in 1,815 surgeries). This yielded a total of 2,119 surgeries for all alcohol-related crashes (304 + 1,815). Therefore, the net impact of adverse weather was an additional 52 surgeries (2,119 x 2.44%).

Critical Care Days

In our study of 2,088 alcohol-positive patients, 312 were injured in adverse weather (resulting in

1,799 critical care days) whereas the remaining 1,776 were injured in other weather circumstances (resulting in 8,633 critical care days). This yielded a total of 10,432 critical care days for all alcohol-related crashes (1,799 + 8,633). Therefore, the net impact of adverse weather was an additional 255 critical care days (2,119 x 2.44%).

Patient Mortality

In our study of 2,088 alcohol-positive patients, 312 were injured in adverse weather (resulting in 29 deaths), whereas the remaining 1,776 were injured in other weather circumstances (resulting in 145 deaths). This yielded a total of 174 deaths for all alcohol-related crashes (29 + 145). Therefore, the net impact of adverse weather on mortality was an additional 5 patient deaths (174 x 2.44%).

Summary

To conclude, these four indicators of acute hospital care and injury severity highlight selected consequences of drunk driving in adverse weather. We found that alcohol-related traffic crashes in adverse weather conditions might account for 793 additional patient-days in hospital, 52 additional surgeries, 255 additional critical care days, and 5 additional patient deaths in our study. These estimates reflect the additional crashes and the profile of average patients injured in different circumstances.

§3) Estimating Economic Costs

We estimated the financial costs related to drunk driving crashes in adverse weather by combining our data with previously published costs analyses for the United States [2]. These background cost estimates were comprehensive and included social, legal, property damage, workplace, and medical costs. The costs were tagged to calendar year 2010 (most recent data available) and not updated for inflation. For perspective, the background data suggested that the average motor vehicle crash was associated with an additional $17,838 in economic costs [2].

In Section §2.1 of this appendix (Population-Wide Odds-Ratio), we estimated that 51 additional alcohol-related crashes were attributable to adverse weather in our study. Thus, we calculated that these excess crashes would result in an additional $909,738 in economic losses ($17,838 x

51). This suggested that the added risk of a traffic crash for drunk drivers in adverse weather would translate to substantial costs to society for the patients observed in our study. More generally, extrapolating to the entire United States for one year, we estimate a total exceeding $15 million in economic losses (93 / 5 x $909,738).

§4) Supporting References

[1] National Highway Traffic Safety Administration. Traffic safety facts 2015: A compilation of motor vehicle crash data from the Fatality Analysis Reporting System and the General Estimates System [Internet]. U.S. Dept. of Transportation, National Highway Traffic Safety Administration; 2016 [cited 2017 July 4]. Available from: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812384

[2] Blincoe L, Miller TR, Zaloshnja E, Lawrence BA. The economic and societal impact of motor vehicle crashes, 2010 (Revised) [Internet]. U.S. Dept. of Transportation, National Highway Traffic Safety Administration; 2010 [cited 2017 June 20]. Available from: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013