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## Increased Motor Vehicle Fatalities Tuesday Through Thursday During the US Thanksgiving Holiday (1980-2018)

Kendra Ratnapradipa

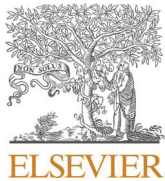
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## Short communication

# Increased motor vehicle fatalities Tuesday through Thursday during the US Thanksgiving holiday (1980–2018)

Kendra L. Ratnapradipa<sup>a</sup>, Motao Zhu<sup>b,c,d,\*</sup><sup>a</sup> Department of Epidemiology, University of Nebraska Medical Center, 984395 Nebraska Medical Center, MCPH 3025, Omaha, NB 68198-4395, USA<sup>b</sup> Center for Injury Research and Policy, Abigail Wexner Research Institute at Nationwide Children's Hospital, 700 Children's Drive, Columbus, OH 43205, USA<sup>c</sup> Department of Pediatrics, The Ohio State University, Columbus, OH, USA<sup>d</sup> Division of Epidemiology, The Ohio State University, Columbus, OH, USA

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## ABSTRACT

Traffic crashes remain a leading cause of death in the United States; holidays are known to have increased travel and traffic fatalities. Our purpose was to determine which days during Thanksgiving had the highest crash fatality risk compared to non-holiday periods. Using time series and binomial approximations, we analyzed Fatality Analysis Reporting System data (1980–2018) with a Monday-Sunday holiday and matching comparisons the weeks before and after. Fatalities included 31,263 during the holiday, 30,361 the previous week, and 29,399 the following week. Deadliest days during the holiday were Saturday (16.7% of fatalities) and Wednesday (16.0%), but odds of a traffic fatality (vs. non-holiday) were highest Wednesday [odds ratio (OR) 1.35, 95% confidence interval (CI) 1.29–1.40], Thanksgiving (OR 1.18, 95% CI 1.13–1.23), and Tuesday (OR 1.12, 95% CI 1.06–1.17). The 35 excess holiday fatalities per year may have limited practical significance considering increased holiday travel.

## 1. Introduction

Motor vehicle crashes remain a leading cause of death in the United States (US), encompassing 38,659 fatalities in 2017 (National Center for Injury Prevention and Control, 2017). Thanksgiving is one of six holidays in the US known to have increased traffic fatalities (Liu and Chen, 2004; Liu et al., 2005) and is considered one of the busiest travel times in the US, following the period between Christmas and New Year's (Cristiano, 2019). Thanksgiving is a US national, secular holiday occurring the fourth Thursday in November. The holiday dates to colonial times as a religious and cultural harvest celebration and became an official holiday following the American Civil War. Many employees allocate Friday as vacation time, creating a 4-day weekend. In 2018, an estimated 54 million Americans travelled at least 50 miles from home, primarily (89.3%) by motor vehicle (Hall, 2018). Increased holiday travel (e.g., volume, distance, number of passengers) and the associated exposure to risk are difficult to accurately measure, but with so many travellers, even a small increased risk can be significant.

We evaluated traffic fatalities during the Thanksgiving holiday to determine which day(s) and times during the holiday had the highest

motor vehicle fatality risk compared to non-holiday periods.

## 2. Material and methods

Because we used publicly available de-identified data, this study was exempt from Institutional Review Board oversight.

### 2.1. Data source

We obtained a national census of traffic fatalities (mortality within 30 days of the crash date) on public roadways in the US from the National Highway Traffic Safety Administration (NHTSA)'s Fatality Analysis Reporting System (FARS) from 1980 through 2018, which is the most recently-available year of data. FARS is a publicly available registry database with strict quality control measures to ensure validity. It contains yearly crash, vehicle, and person-level files. We included all crashes during the specified study period with valid year, month, day and hour of the crash and limited the analysis to those with a fatal injury. Additional variables were coded as follows: day of week (Monday-Sunday), 5-year groups (the final group had 4 years), age ( $\geq 65$  years,

\* Corresponding author at: Center for Injury Research and Policy, Abigail Wexner Research Institute at Nationwide Children's Hospital, 700 Children's Drive, Columbus, OH 43205, USA.

E-mail addresses: [Kendra.ratnapradipa@unmc.edu](mailto:Kendra.ratnapradipa@unmc.edu) (K.L. Ratnapradipa), [Motao.zhu@nationwidechildrens.org](mailto:Motao.zhu@nationwidechildrens.org) (M. Zhu).

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18–64 years, <18 years), sex (male, female), position (driver, passenger, pedestrian/other), Census region (Midwest, Northeast, South, West), and road location (rural, urban).

2.2. Participants

Cases were defined as a fatality occurring between midnight on the Monday before Thanksgiving through 11:59 pm on Sunday, or 168 h (7 days) of exposure time. Comparisons were fatalities occurring during the corresponding 168-hour periods exactly one week before and one week after the holiday. For example, Thanksgiving occurred on November 27, 1980 so the holiday period was November 24–30, 1980 and the corresponding comparison periods were November 17–23 and December 1–7, 1980. Comparison days were averaged to create equal exposure times.

2.3. Statistical analyses

This was a 1:2 matched design using time-referenced definitions for exposure status (holiday versus comparison periods). This design has been used previously to analyze FARS fatality data (Redelmeier and Steward, 2005; Redelmeier and Tibshirani, 2008, 2018; Redelmeier and Yarnell, 2012, 2013; Staples and Redelmeier, 2018; Tang et al., 2020). The design controls for day of the week, seasonality and year (Redelmeier and Steward, 2005). It also controls for potential confounders which are not subject to short-term variability in the driver (e.g., education, licensure), vehicle (e.g., make and model, technology, availability of airbags), roadway (e.g., road geometry, speed limits), economy (e.g., gasoline price trends, employment), healthcare (e.g., locations, access, insurance status), and population (e.g., demographics, genetics).

Descriptive analysis consisted of fatality counts and percentages stratified by exposure status compared using Chi-square analysis. Primary analysis consisted of a time series plot of fatality counts by day and hour of crash, stratified as before comparison, holiday, and after comparison period. Additional analysis was based on a binomial approximation comparing the differences between observed (holiday) and expected (averaged comparison) counts. One million non-eventful driving exposures were assumed per study day, which does not reflect differences in travel exposure (Redelmeier and Yarnell, 2013; Redelmeier and Tibshirani, 2018). This method essentially cancels out non-eventful driving exposures to compare holiday and non-holiday outcomes (Redelmeier and Yarnell, 2013). Individuals missing data on stratification variables were excluded casewise (sex,  $n = 40$ ; location,  $n = 654$ ). Results are reported as odds ratios (OR) with 95% confidence intervals (CI) to estimate the strength of association between exposure and outcome. We used stratified analysis to examine selected variables.

Analyses were conducted using SAS version 9.4 (SAS Institute, Cary, NC).

3. Results

Most fatalities for both holiday and control periods involved adults age 18–64 and males (Fig. 1). More than half the fatalities during each period occurred in rural locations. Fatality counts were highest in the South and lowest in the Northeast. For the holiday interval, Saturday was the deadliest day (16.7% of fatalities) followed by Wednesday (16.0%). In total, 31,263 fatalities occurred during the 7-day Thanksgiving holiday, or an average of 114.5 deaths per day. In contrast, 59,760 fatalities occurred during the fourteen corresponding control days each year, averaging 109.5 deaths per day. Of these control days, 30,361 fatalities (111.2 per day) occurred in the week before the holiday, and 29,399 fatalities (107.7 per day) occurred in the week following.

Based on the time series plot (Fig. 2), holiday travel fatalities began diverging from expected patterns Tuesday evening and extended through Saturday (solid vs. dashed lines). The week before (dash) and

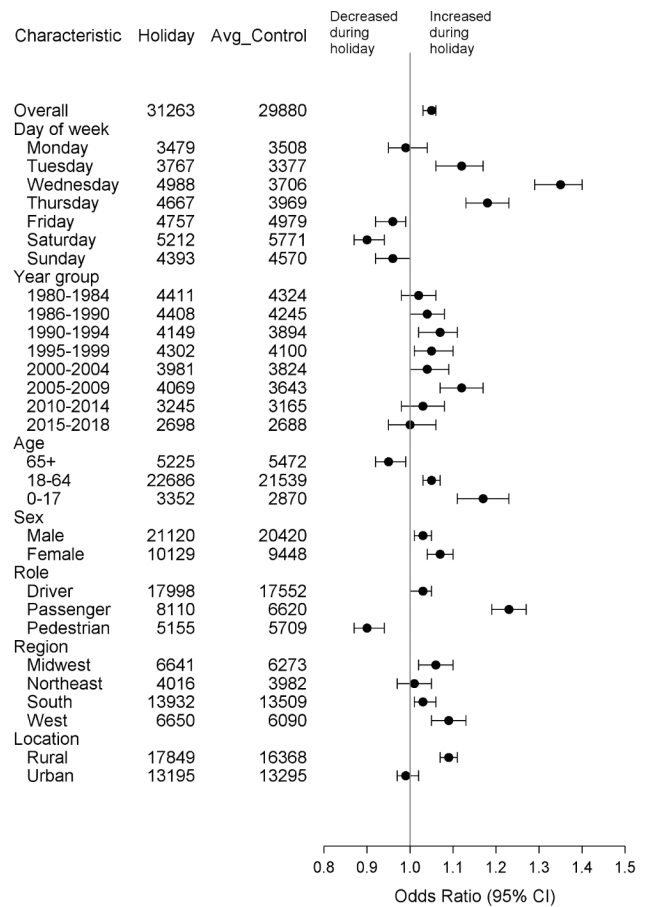


Fig. 1. Risk of a motor vehicle fatality during Thanksgiving, FARS (1980–2018).

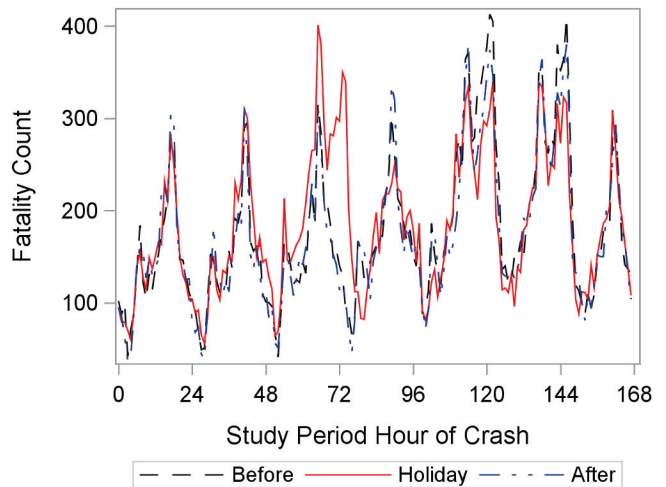


Fig. 2. Hourly fatality counts, Monday – Sunday, FARS (1980–2018).

after (dash dot) comparison periods had similar fatality patterns, with fatalities slightly higher Friday and Saturday nights the week before the holiday.

During the holiday period, the odds of fatality on Wednesday were 35% greater than during the averaged comparison period (OR 1.35, 95% CI 1.29–1.40), 18% greater on Thanksgiving (OR 1.18, 95% CI 1.13–1.23) and 12% greater on Tuesday (OR 1.12, 95% CI 1.06–1.17) (Fig. 1). However, those travelling on Friday (OR 0.96, 95% CI

0.92–0.99) and Saturday (OR 0.90, 95% CI 0.87–0.94) during the holiday were at 4% and 10% decreased odds compared to the comparison period, with no statistically significant difference between holiday and non-holiday fatalities on Monday and Sunday. The overall odds of a fatal motor vehicle crash occurring during the Thanksgiving holiday were 5% greater than during the comparison periods (OR 1.05, 95% CI 1.03–1.06), resulting in an absolute increase of 1,383 holiday traffic fatalities over 39 years (35.5 fatalities per year).

Analysis of 5-year categories revealed the periods of 1990–1994, 1995–1999, and 2005–2009 had higher odds of holiday fatalities. None of the other time periods were statistically significant.

Odds of traffic fatalities also differed by person. Older adults were 5% less likely to die in a motor vehicle crash during the holiday (OR 0.95, 95% CI 0.92–0.99). In contrast, adults aged 18–64 experienced a 5% increase (OR 1.05, 95% CI 1.03–1.07) and children younger than 18 were 17% more likely to be fatally injured during the holiday period (OR 1.17, 95% CI 1.11–1.23). Both sexes had increased odds of holiday vehicular fatalities, with females at 7% greater odds (OR 1.07, 95% CI 1.04–1.10) and males at 3% greater odds (OR 1.03, 95% CI 1.01–1.05). Passengers were 23% more likely to be fatally injured during the holidays (OR 1.23, 95% CI 1.19–1.27), and drivers were 3% more likely (OR 1.03, 95% CI 1.00–1.05). In contrast, other road users (pedestrians and bicyclists) were 10% less likely to be fatally injured during the holidays (OR 0.90, 95% CI 0.87–0.94).

Geographically, odds of holiday vs. control period fatalities were higher in the Midwest, South, and West, with no statistically significant difference in the Northeast. Regarding the crash location, the odds of traffic fatalities during the Thanksgiving holiday were higher for rural areas (OR 1.09, 95% CI 1.07–1.11).

#### 4. Discussion

Although Saturday and Wednesday had the highest number of traffic fatalities during the extended Thanksgiving holiday, holiday patterns of fatalities began diverging from the expected patterns during the evening hours on Tuesday and extending through Saturday, resulting in increased odds of a holiday fatality Tuesday through Thursday but decreased odds on Friday and Saturday. Overall, during the week-long study period, the odds of holiday traffic fatalities were 5% higher than expected. This is much less than would be expected based on Bureau of Transportation Statistics estimates from the 2001 National Household Travel Survey of a 54% increase in long-distance trips during Thanksgiving (Bureau of Transportation Statistics, 2017). Passengers, particularly children, were at increased risk, as were those traveling on rural roads. This may result from greater numbers of passengers (as families travel together) compared to typical work commute travel patterns. It may also reflect a decreased amount of local pedestrian travel. The attenuation for older adults may reflect travel patterns related to family gatherings.

NHTSA defines the Thanksgiving holiday as 18:00 Wednesday through 05:59 Monday (National Center for Statistics and Analysis, 2018), and NHTSA reports of increased Thanksgiving holiday fatalities aggregate across 4 days (Liu and Chen, 2004; Liu et al., 2005). A previous study found excess fatalities beginning at 16:20 on Wednesday (Harper and Palayew, 2019). In contrast, AAA defines the holiday as Wednesday through Sunday; AAA also predicts the worst travel days/times which include Monday and Tuesday afternoons (Hall, 2018). The Bureau of Transportation Statistics defined the holiday as Tuesday through Sunday; Tuesday had below-average long-distance trips and Thursday had the heaviest travel (Bureau of Transportation Statistics, 2017). Our study extends the analysis to include the entire week surrounding the holiday to capture those who may be travelling earlier in the week. Any definition of the holiday period is somewhat arbitrary as travel patterns continue to evolve and are influenced by general economic conditions. Marketing estimates predicting traffic congestion suggest that Thanksgiving holiday travel may begin as early as the

Monday and Tuesday evening commutes (Hall, 2018). We did not see any difference in weekend travel fatalities for the two comparison periods, suggesting that increased travel the weekend before Thanksgiving is likely not an issue. Thus, future studies should extend analysis to include the entire work week preceding Thanksgiving, with analysis beginning Monday. Accurately estimating actual holiday travel exposure would also advance this work.

#### 5. Strengths and limitations

One of the strengths of this study is including the weeks before and after the defined holiday period with a graphic display of hourly fatalities for all three time periods. While the binomial approximation method relies on assumed denominators that essentially cancel out the non-eventful driving exposures to compare holiday and non-holiday outcomes (Redelmeier and Yarnell, 2013), this does not capture the true increased risk due to increased travel. The time series plot tracks fatality counts and is therefore not bound by such assumptions. Both methods, as well as comparative statistical methods (National Center for Statistics and Analysis, 2018), are limited by a lack of detailed national data about actual travel, as previously noted. Additional study strengths include the use of a national census of all fatal crashes on public roadways, making results generalizable to the United States. The study used a well-established method of comparing a consistent case period with balanced comparison periods that account for a variety of observed and unobserved potential confounders and random chance (Redelmeier and Steward, 2005; Redelmeier and Tibshirani, 2008, 2018; Redelmeier and Yarnell, 2012, 2013; Staples and Redelmeier, 2018). By analyzing 39 years of data in 5-year groups, we were able to examine overall effect trend. Although we quantified the risk of motor vehicle fatality during the Thanksgiving holiday, we lacked data to explore the factors for the increased risk such as driving patterns (e.g., volume, distance, number of passengers). We did not study the risk of non-fatal injury.

#### 6. Conclusion

We found excess traffic fatalities as early as the Tuesday afternoon before Thanksgiving which were statistically significant but may have limited practical significance considering the aggregated 39 years of data (approximately 35 increased fatalities per year). While the general guidelines for public safety remain unchanged: wear seatbelts and use age-appropriate child restraint systems, children < 12 should sit in the back seat, and avoid intoxicated driving (Notice to readers, 2001), additional traffic patrols and enforcement beyond what is already implemented to address increased holiday travel may not be warranted. If used, they should be strategically leveraged at the start of the travel period (i.e. Tuesday afternoon and Wednesday). Public service announcements reminding holiday travellers to expect traffic delays, avoid speeding, and minimize distracted driving are possible policy implications.

#### 7. IRB/Human subjects

This study utilized public, de-identified data not subject to IRB oversight.

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## CRedit authorship contribution statement

**Kendra L. Ratnapradipa:** Conceptualization, Methodology, Formal analysis, Writing - original draft, Writing - review & editing. **Motao Zhu:** Conceptualization, Funding acquisition, Writing - review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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