Citation & Culpability Technical Report

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The primary goal of traffic-related law enforcement is to limit unsafe driving, thereby preventing injury and death due to traffic collisions. Yet traffic collisions remain common, and prior research suggested there are likely ‘more safe’ and ‘less safe’ driver profiles, such that less safe drivers contribute disproportionately to collisions. Identifying such drivers and intervening on their behavior before they cause more crashes could improve traffic safety. We hypothesized that within two-car crashes, drivers with a criminal citation history would bear more responsibility for crashes.

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Abstract

The primary goal of traffic-related law enforcement is to limit unsafe driving, thereby preventing injury and death due to traffic collisions. Yet traffic collisions remain common, and prior research suggested there are likely ‘more safe’ and ‘less safe’ driver profiles, such that less safe drivers contribute disproportionately to collisions. Identifying such drivers and intervening on their behavior before they cause more crashes could improve traffic safety. We hypothesized that within two-car crashes, drivers with a criminal citation history would bear more responsibility for crashes.

To assess this hypothesis, we used Washington State’s Traffic Records Integration Program (TRIP), which includes a linkage of collision data to criminal traffic citation history for drivers involved in crashes. We adapted a previously validated culpability assessment tool to assign responsibility levels to drivers involved in crashes to work with TRIP crash reports, then assessed the association between criminal traffic citation history and crash responsibility in two-car collisions in Washington between 2009 and 2019 for which the culpability tool indicated that one driver was culpable and the other was not.

In 281,748 crashes that fit these inclusion criteria, drivers culpable for their two-car collision had higher odds of history of behavioral criminal traffic citation in 6 months (OR: 2.9, 95% CI: 2.6, 3.2), 1 year (OR: 2.7, 95% CI: 2.4, 2.9), 3 years (OR: 2.2, 95% CI: 2.1, 2.4), and 5 years (OR: 2.0, 95% CI: 1.9, 2.1) prior to the collision as compared with their not culpable counterparts.

Our results suggest that criminal traffic citation history is associated with crash culpability, consistent with the hypothesis that some drivers are consistently safer drivers and other consistently riskier. Target Zero 2030 and other traffic safety programs may use these results to better target driver safety programs.

Introduction

The primary goal of traffic-related law enforcement is to limit unsafe driving, thereby preventing injury and death due to traffic collisions. Yet traffic collisions remain common, and prior work in Washington State has shown that behaviors such as dangerous, distracted, or substance-impaired driving, which contribute to many collisions, contribute disproportionately to collisions involving drivers who themselves have previously been involved in collisions – that is, there are likely 'more safe' and 'less safe' driver profiles, and less safe drivers contribute disproportionately to collisions. Identifying such drivers and intervening on their behavior before they cause more crashes could improve traffic safety.

Traffic law enforcement records offer one opportunity for identifying riskier drivers, under the assumption that drivers who are repeatedly cited for riskier driving behaviors may indeed be driving more riskily. However, repeat offenses might simply represent more time spent driving – more time at risk for citation – in which case driving restrictions or other interventions in response to repeat offenses are unjust – removing transportation options from those who need to drive the most.

Driver records from crash reports are another resource for identifying driver risk patterns – that is, by exploring who was involved in crashes, researchers can describe the population of drivers who crashed and how often selected drivers crashed. However, as crash records contain only drivers who did crash, they cannot be used to describe the population at risk of crashing – the denominator of the risk fraction – they are only suitable for case-only analyses.

While case-only analyses have well-documented limitations for inferential analyses,[1] they can provide strong evidence through study designs that assess responsibility ('culpability') for crashes rather than crash incidence.[2,3] In a culpability design, drivers are categorized according to their responsibility for the collision, and then drivers who bear more of the responsibility are compared to those who bear less responsibility. This approach controls by design for different amounts of time spent driving and location-based risk of collision because (by definition) both drivers in a two-car crash were present on the road in the same place.

Washington State's recent linkage of Administrative Office of the Courts (AOC) data with collision records in the Traffic Records Improvement Program (TRIP) database offers a unique opportunity to explore the relationship between citation and crash culpability. We explored whether drivers with a history of criminal traffic citation are at higher risk for being responsible for a collision as compared with drivers who have not been cited previously. The findings, summarized in this report, may inform future penalties for repeat offenses.

Data

Overview of TRIP and data linkage

We used data from TRIP, a linked dataset managed by Washington State's Office of Financial Management (OFM). This index dataset is statewide vehicle collision data maintained by Washington State Department of Transportation (WSDOT). OFM has linked this dataset to other state records, including AOC records of criminal citations for drivers involved in crashes, DUI-related toxicology reports maintained by Washington State Patrol and other state-level datasets.[4] TRIP's linkage index is crash records; that is, no criminal data are available for people who were not involved in crashes. TRIP was developed with funding provided by the Washington Traffic Safety Commission and the National Highway Transportation Safety Administration (NHTSA) as part of an ongoing effort to combine public health and traffic safety data resources to further the goals of the Target Zero 2030.

Collision Data

TRIP's index dataset is statewide vehicle collision data. Included in this are all vehicle collisions in Washington State occurring between January 1, 2009 – December 31, 2019 that were reported to law enforcement. The collision reports include information related to the collision (date, time, objects struck, road/weather/lighting conditions), vehicle (type, actions), and driver (age, gender, impairment, citation, contributing actions/circumstances). In addition to driver and vehicle information, there is information about other individuals involved in the collision (passengers, pedestrians, cyclists).

Administrative Office of the Courts Records

The collision data were linked by individual identifiers to traffic charge records from the Administrative Office of the Courts (AOC) using Informatica Multi-Domain Master Data Management (MDM). Specifically, the OFM analyst first created Primary Keys (PKeys), which identify individuals. A PKey is the minimum necessary combination of variables needed to uniquely identify a person in a specific dataset. For example, a complete PKey might have someone's first name, middle name, last name, and date of birth. Next, an ID is bound to all records with matching PKeys, which provides a central repository of identifiers (e.g., full name, date of birth, and when available, SSN) over time for each individual source. This 'match' on the PKey includes probabilistic elements that leverage all available OFM data.

These records include all traffic related charges that were included in a traffic stop in which criminal traffic charges were filed. These records do not include traffic stops in which only civil charges were filed (i.e., most speeding charges). The AOC data captures all stops during the period from January 1, 2009 – March 30, 2020 for any person involved in a vehicle collision, including driver, passengers, pedestrians, and cyclists. Information about traffic stops and charges include a description of the charges filed, the date of the stop, the disposition of the charges (i.e., convicted, dismissed, amended, etc.), and limited demographic information about the driver.

Analyses

Analysis Overview

Our analysis comprised two phases: an exploratory phase and an inferential phase. In the exploratory phase, we developed a categorization of citation data and adapted a culpability scoring tool for crash reports. In the inferential phase, we explored the association between a history of prior citation and driver culpability in two-car collisions.

Categorizing Citation Data

Our preliminary analysis of citations indicated that many criminal traffic citations arise from administrative rather than driving behaviors. For example, the most common criminal citation (n=430,327, 37.9%) was for class 3 driving with a suspended license (DWLS3). DWLS3 arises when a driver has had their license suspended for a period of time and the suspension has expired, but the driver has not yet completed the paperwork required to reinstate their license. We reasoned that DWLS3 (and other charges related to licensing) were less likely indicative of driving behavior and more likely indicative of ability to navigate bureaucracy. Accordingly, we classified citations as behavioral or non-behavioral as detailed in Appendix A1. To align with our hypothesis that citation history may identify risky driving, our primary analysis focused on behavioral citations.

Exploring Crash Data

Our preliminary analysis of crash data assessed characteristics of drivers and crashes, including timing of crash incidence, counts of vehicles involved in crashes, and driver demographics. In this phase, we particularly focused on ensuring the data were complete enough to be used for a culpability analysis as detailed below.

Assessing Culpability

To assess culpability, we adapted an instrument developed by Brubacher, et al. for a prior responsibility study.[5] The Brubacher et al. tool was itself adapted from an earlier instrument developed by Robertson and Drummer,[6] with a focus on allowing rule-based, automated scoring of driver culpability based on administrative collision reports completed by crash site first-responders.

Briefly, Brubacher's culpability tool assessed 7 factors in these reports: 1) Road Type (i.e. one-way vs two-way traffic), 2) Driving Conditions, 3) Vehicle Condition, 4) Unsafe Driving Actions, 5) Contributions from other Parties, 6) Type of Collision, and 7) Task Involved. Each of these factors was given a score from 1-5, where lower scores indicate higher crash responsibility for the driver. For example, for the Road Type item, a crash that occurred on a one-way, non-ramp road is scored as 1, whereas as crash in which the police report mentions poor road design as a contributory factor is scored as 5. Not all scores are available for all factors; for example, for factor 4 (Unsafe Driving Actions), any unsafe action is coded as 1 and no evidence of unsafe action is 5, with no way to score 2, 3 or 4. Factors typically represent independent aspects of

the collision; however, all drivers scoring 1 on factor 4 (i.e. who were driving unsafely) also score 1 on factors 6 (type of collision) and 7 (driving task). Per the initial development, this reflects experts' concerns that evidence of reckless behavior should generally be considered a source of culpability regardless of other circumstances.

The final culpability score sums all 7 indicator scores; thus, final scores range from 5 to 35. Following Brubacher's work, drivers whose scores were 13 or lower were considered responsible for their collision, those whose scores are 16 or greater were considered not responsible, and those whose scores were 14 or 15 were considered indeterminate.

Nearly all factors incorporated in the Brubacher tool were included in Washington State's crash reports, though not all crash reports included all data for each factor. We made several decisions to adapt the tool to Washington State data:

1) In Washington State's database, the road type (i.e. one-way or two-way) is coded as a feature of the vehicle rather than of the crash. Initial investigation suggested 93% of two-car crashes either included the same value for each vehicle or included a value for one vehicle and missing data for the other. Washington's Office of Financial Management staff (Ian Kinder-Pyle, personal communication, 8/13/24) confirmed that treating road type present for one vehicle and missing for the other as occurring on the recorded road type was appropriate.
2) Washington State's crash reporting form allows for the recording of up to three contributing circumstances. Some of these (e.g. Failing to Signal) indicate unsafe driving, whereas others (e.g. Driver Not Distracted, Failure to use Xwalk) do not. We selected 29 contributing circumstances that we felt reflected unsafe driving behavior (Appendix Table A2) and considered the lack of any unsafe behavior recorded as a contributing circumstance to constitute No Evidence of Unsafe Action.
3) Some scores for Factor 6 (type of collision) incorporate pedestrian involvement in the crash. We assumed that no record of pedestrian crash indicated no pedestrians were involved in the crash.
4) We used Washington's set of vehicle action codes and contributing circumstance codes to assess Factor 7 (task involved). When more than one code suggested different actions (e.g. if a driver was merging but also avoiding an object in the road), we assigned the value indicating least responsibility.

This approach allowed us to assess culpability for nearly all drivers in nearly all crashes, as detailed in results below.

Inferential Study

Study design

We used a quasi-induced exposure (QIE) design to assess the association between prior citation history and culpability for a collision among two-driver crashes in Washington State. In a quasi-induced exposure design, a two-car collision is the unit of analysis. Exposures for the driver deemed culpable for the crash are compared to exposures for the driver deemed not culpable for that crash. In this design, non-culpable drivers can be thought of as a random sample of all drivers on the road at the collision time and location, eliminating many sources of exogenous variation predictive of crash involvement. It follows that Odds Ratios (OR) from a

QIE study can be interpreted as estimating the Risk Ratio (RR) that would be identified by a (typically infeasible) cohort study that followed all drivers in a population over time.[2,7]

Crash Selection

To develop our dataset, we first identified records in which exactly two vehicles were involved in a crash. From this set of reports, we eliminated records for which driver information was unavailable (e.g. due to one or more drivers leaving the scene before the responding officer arrived). We further limited our analysis to crashes in which one driver's culpability score exceeded the threshold for culpability and the other driver's score was below that same threshold.

Prior Traffic Citations

Our exposure of interest was history of prior criminal traffic citation as recorded by AOC. To avoid artifacts in which more citation history data would be available for crashes later in the period of interest, we limited citation history to a sliding window prior to the index crash. Because there is no set timeframe in which prior history might change present behavior or provide an indicator of driving behavior, we explored four windows of potential prior citation timing: 6 months, 1 year, 3 years, and 5 years. We selected 3 years as our primary analysis *a priori* as a balance between a more complete history and the risk of artifacts arising from differential history of driving in the state.

AOC's criminal traffic citation records include not only the criminal charge, but also the case's disposition (i.e. whether the driver was convicted of the charge). Approximately half the citations resulted in a conviction.

Statistical Analysis

Our analysis focused on two-car crashes in which one driver's culpability score was classified as "culpable" and the other driver's was "not-culpable". We considered the "culpable" scored driver to be responsible for the collision. We then assessed the odds ratio relating any history of criminal traffic citation to odds of crash responsibility.

Our primary analysis considered any behavioral citation within the previous 3-years to constitute a history of citation; secondary analyses considered 6 months, 1 year, and 5-year windows. We also considered a secondary analysis considering any criminal traffic citation (not just behavioral citations) in relation to crash responsibility. Finally, we conducted a sensitivity analysis using conviction rather than citation issuance as an exposure.

All analyses were conducted in R version 4.3.3 (R Foundation for Statistical Computing, Vienna Austria). The Washington State Institutional Review Board and the University of Washington Institutional Review Board determined this research was exempt from human subjects review.

Descriptive Results

Collisions

There were a total of 1,339,265 collisions involving 2,140,514 drivers reported to law enforcement in Washington State from 2009-2019. Accounting for those with multiple collisions, there were 1,678,907 unique drivers involved in collisions during this time frame. Collisions per year ranged from a low of 106,563 in 2011 to a high of 140,244 in 2016 (**Figure 1**). Collisions showed temporal patterns, both for time of year and time of day (**Appendix Figure S1**). Collisions were more common during October - December and more common during the afternoon hours; 3 pm – 5 pm were the hours when more collisions occurred.

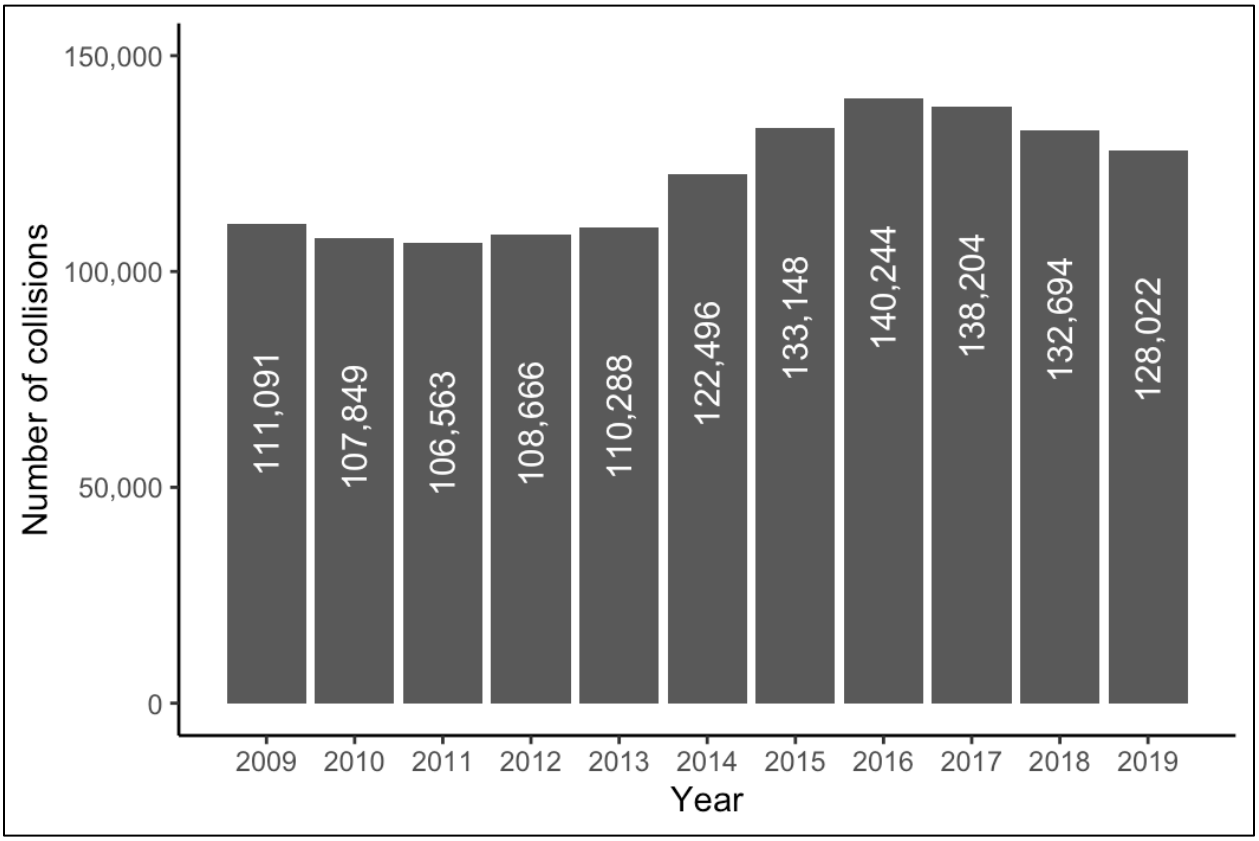

Figure 1. Number of collisions reported to law enforcement per year in Washington state from 2009 – 2019.

Collision descriptive characteristics are shown in **Table 1**. Most collisions did not result in injuries, although 21,444 (1.6%) collisions resulted in a serious injury and 5,231 (0.4%) collisions resulted in at least one fatality. The majority of collisions (66.4%) involved two cars, while approximately one quarter (24.8%) were single car collisions. Collisions involving pedestrians and cyclists comprised just 2.0% and 1.2% of all collisions respectively. Alcohol was reported to be involved in 5.6% of all collisions.

Table 1. Collision and driver characteristics for collisions reported to law enforcement in Washington from 2009 – 2019. There were a total of 1,339,265 collisions involving 1,678,907 unique drivers (some drivers were involved in multiple collisions). For driver characteristics, sex and age at collision are reported for every collision (some drivers are included multiple times). [1]Missing urban/rural classification for 48% of collisions. Missing <3% of all other characteristics.

Characteristic	N (%)
Collision characteristics	
Urban areas[1]	486,165 (69.7%)
Fire indicator	4,606 (0.34%)
Stolen vehicle indicator	5,658 (0.42%)
Hit and run indicator	237,128 (17.1%)
Collisions involving injuries	
Collisions involving minor injuries	97,198 (7.3%)
Collisions involving serious injuries	21,444 (1.6%)
Collisions involving fatalities	5,231 (0.39%)
Collisions involving cyclists	15,850 (1.2%)
Collisions involving pedestrians	26,750 (2.0%)
Number of vehicles involved	
Single car collision	332,458 (24.8%)
Two car collision	889,104 (66.4%)
Three or more car collision	117,062 (8.7%)
Alcohol involved	74,883 (5.6%)
Drug involved	6,957 (0.52%)
Citation for collision	219,612 (16.4%)
Driver characteristics	
Sex (# and % male)	1,226,932 (57.9%)
Age at collision (mean (sd))	39.83 (16.98)
Total number of collisions	1.29 (0.66)
Total number of criminal traffic stops	0.24 (0.99)
Total number of citations	0.37 (1.57)
Total number of convictions	0.19 (0.85)

Drivers

Driver characteristics, including number of collisions and stops are included in **Table 1**. Most drivers (1,401,655; 78.8%) were involved in a single collision during the study period. 282,260 (15.9%) drivers were involved in two collisions, while 94,262 (5.3%) were involved in three or more collisions. There were 138 drivers with 10 or more collisions and the maximum number of collisions for a single driver was 21. Drivers in collisions were more likely to be young and male; male drivers comprised 57.9% of drivers in collisions. The group with the largest number of collisions were males aged 18-24 (**Figure 2**). Age trends were consistent across sex with

younger drivers being involved in more collisions compared to older drivers; younger women were also involved in more collisions compared to older women.

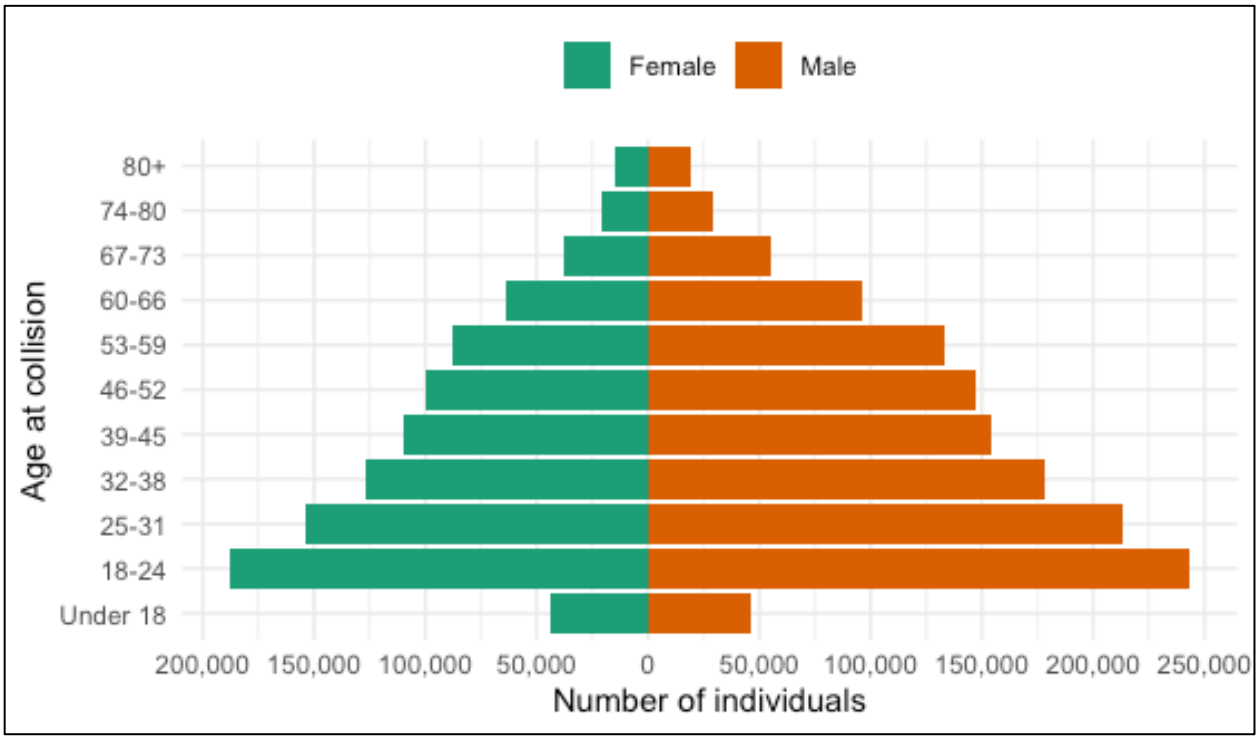

Figure 2. Age and sex of drivers in collisions. Data includes all collisions during time period (2009 – 2019). Individuals may be included multiple times if they are in multiple collisions.

Citation

In total, 319,129 individuals with 1,136,561 charges were included in the AOC data from January 1, 2009 – March 31, 2020. When limited to only those that were drivers involved in a collision during our study period (eliminating those that were only involved as a passenger, pedestrian, or cyclist), there were a total of 187,489 individuals with 640,867 charges. We focus on this subset of charges by drivers involved in collisions for the remainder of the report. The majority of drivers (104,013, 55.5%) with criminal traffic stops had only one stop during the observation period. 54,748 (29.2%) drivers had two or three traffic stops that resulted in criminal charges, and 28,728 (15.3%) drivers had more than three stops. There were 3,284 (1.8%) drivers with 10 or more stops and the greatest number of stops resulting in a criminal traffic charge for one person over our observation period was 45.

Most of the charges included in stops (n = 385,464, 60%) were for unlicensed driving offenses (**Table 2**). Alcohol and drug offenses comprised the next largest category of charges

(n=122,335, 19%) while there were 99,343 (16%) dangerous driving (including speeding and reckless driving) charges. The distribution of charges differed based on the number of stops a driver had. Unlicensed driving offenses were the most common charge for all groups; however, alcohol and drug offenses and dangerous driving charges comprised a greater proportion of offenses for drivers with only one stop during the 11-year period. Unlicensed driving charges comprised over half of all charges for those with 2-3 stops or more than 3 stops (57% and 77% respectively).

Table 2. Number and percent of charges for drivers with criminal traffic stops who were involved in a collision. Percentages shown are column-wise – the percentage of charges in each driver category (1 stop, 2-3 stops, >3 stops).

Charge category	All offenses (n=187,489)	Drivers with 1 stop (n=104,013)	Drivers with 2-3 stops (n=54,748)	Drivers with >3 stops (n=28,728)
Alcohol and drug offenses	122,335 (19.1%)	47,393 (28.9%)	43,941 (22.0%)	31,001 (11.2%)
Dangerous driving	99,343 (15.5%)	46,787 (28.6%)	32,404 (16.2%)	20,152 (7.3%)
Registration/insurance violation	22,611 (3.5%)	6,398 (3.9%)	6,908 (3.5%)	9,305 (3.4%)
Unlicensed driving	385,464 (60.1%)	60,088 (36.7%)	113,524 (56.7%)	211,852 (76.5%)
Other	11,114 (1.7%)	3,127 (1.9%)	3,368 (1.7%)	4,619 (1.7%)

When looking at specific charges, driving while license suspended (DWLS)-3 was the most common offense overall, comprising close to 40% of all charges (**Figure 3, Panel A**). Second most common were driver's license violations, followed by DUI or substance use charges, comprising almost 20% of all charges. DWLS-3 makes up an even larger share of all charges (>50%) when looking at drivers with more than 3 traffic stops resulting in a criminal charge (**Figure 3, Panel D**). Comparatively, for drivers with a single traffic stop, DUI and substance use charges make up the largest category of charges (**Figure 3, Panel B**). The mean number of charges per stop was 1.77, with most stops (56.3%) resulting in two charges. The largest number of charges resulting from a single traffic stop was 16.

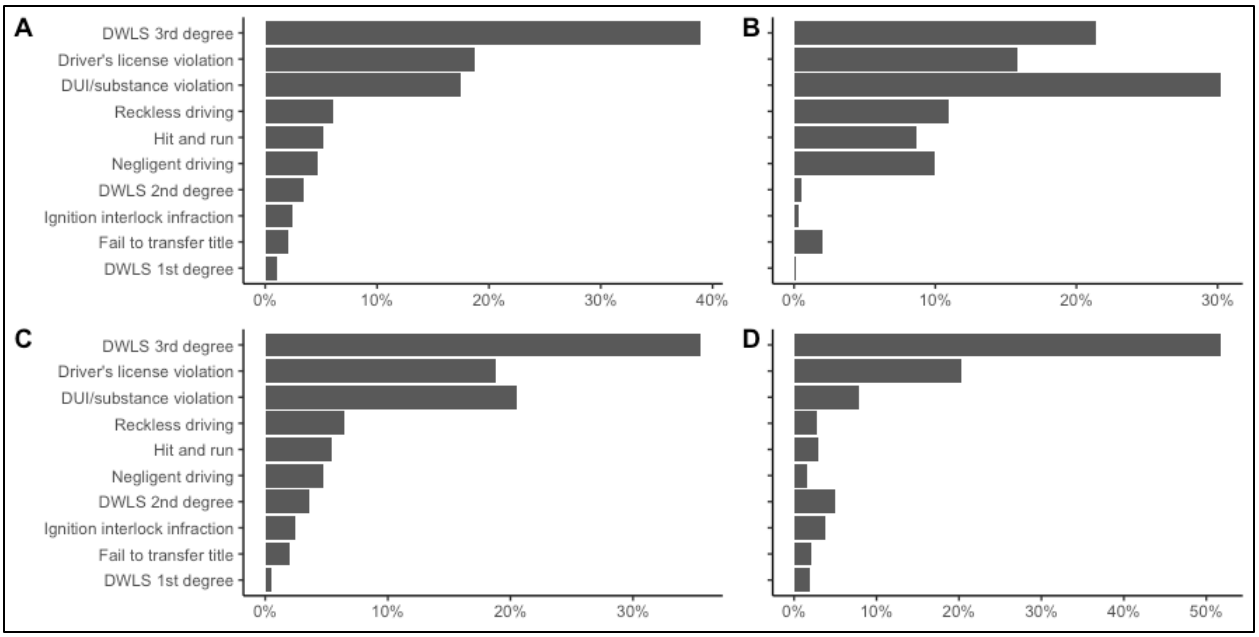

Figure 3. Percentage of specific charges by driver type for (A) All drivers, (B) Drivers with a single traffic stop, (C) Drivers with 2-3 traffic stops, and (D) Drivers with more than 3 traffic stops.

Crash Culpability

Of the 2,489,688 unique driver/crash pairs, data were sufficient to compute a culpability score for 1,771,297 (71%). Of these, 1,006,721 (57%) were identified as culpable in their crash, 298,979 (17%) were indeterminate and 465,597 (26%) were not culpable. Scores were roughly normally distributed (Figure 4) with a peak at 9, corresponding to a case where a driver executed an unsafe action at an intersection with no other contribution to the crash.

Of the 1,006,721 drivers identified as culpable, 555,543 (55%) were listed as executing an unsafe action, and 203,598 (20%) were in single car crashes.

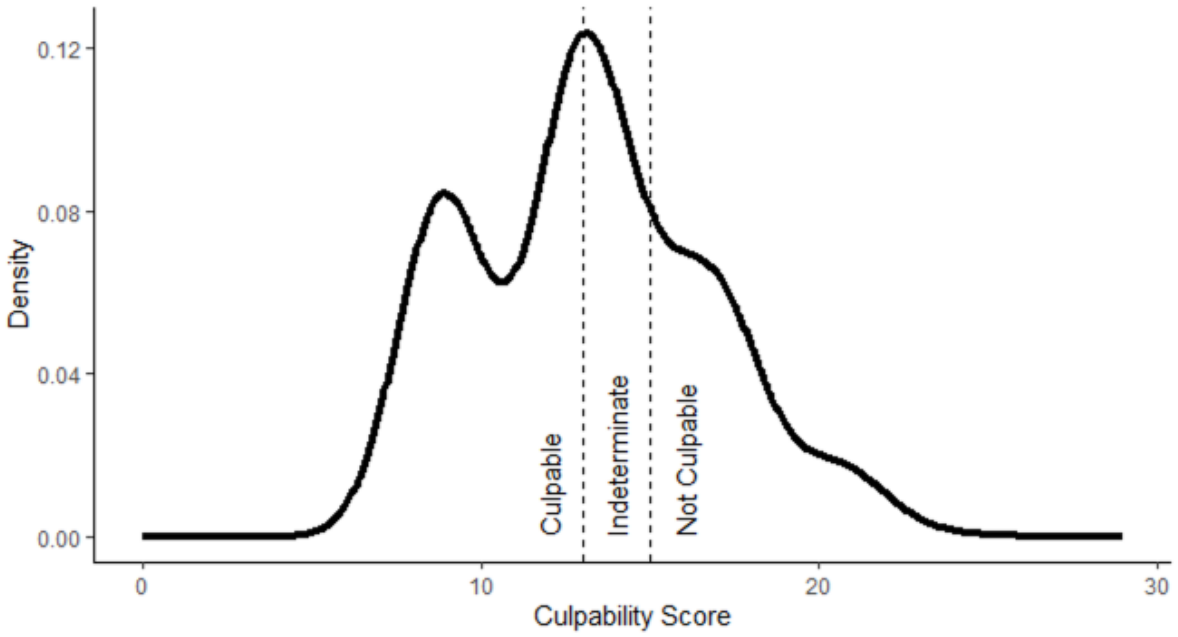

Figure 4. Distribution of culpability scores across 1,777,297 driver/crash pairs for which enough data were available to assess culpability, 2009-2019.

Inferential Results

Primary Analysis

Of 1,339,265 collisions occurring between 2009 and 2019, 1,028,783 (76%) included exactly two-cars. Of these, there were 666,857 (65%) where we were not missing some data element necessary to assess a culpability score for one of the drivers. Of these, there were 281,748 (42%) crashes in which one driver was marked as culpable and the other was not. We used these crash reports for our primary analysis.

In this primary analysis, drivers scored as culpable for their two-car collision had higher odds of history of behavioral criminal traffic citation in 6 months (OR: 2.9, 95% CI: 2.6, 3.2), 1 year (OR: 2.7, 95% CI: 2.4, 2.9), 3 years (OR: 2.2, 95% CI: 2.1, 2.4), and 5 years (OR: 2.0, 95% CI: 1.9, 2.1) prior to the collision as compared with their not culpable counterparts. Visual inspection confirmed a prevalence of higher culpability scores (i.e. less crash responsibility) among those without prior citations (Figure 5)

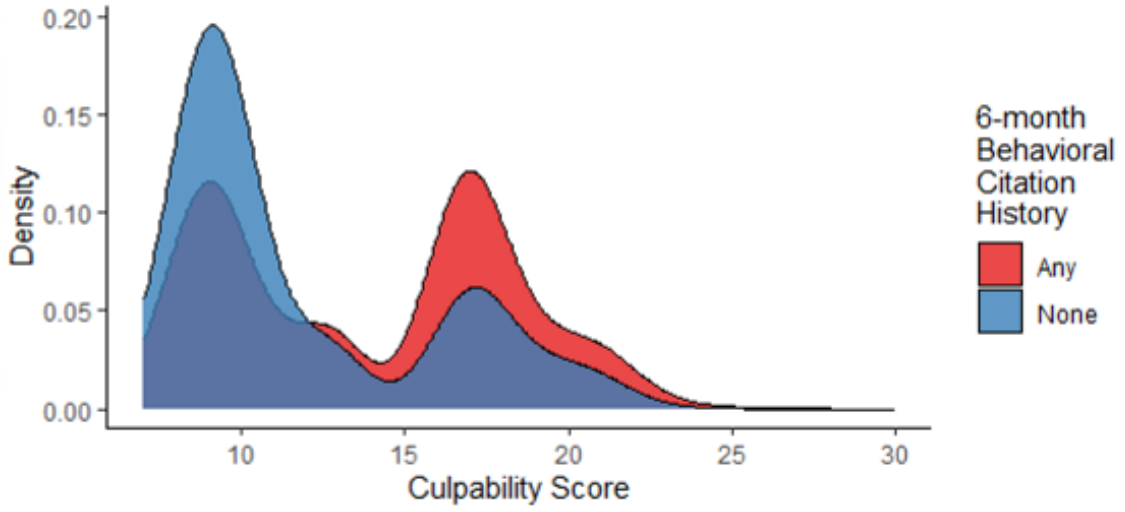

Figure 5. Distribution of culpability scores in 281,748 crashes occurring between 2009 and 2019 in which one driver was deemed culpable and the other was not, stratified by citation history.

Sensitivity Analyses

In a sensitivity analysis in which we grouped drivers of indeterminate culpability with non-culpable drivers, results were nearly identical. Drivers scored as culpable for their two-car collision had higher odds of history of behavioral criminal traffic citation in 6 months (OR: 2.8, 95% CI: 2.6, 3.1), 1 year (OR: 2.6, 95% CI: 2.4, 2.8), 3 years (OR: 2.2, 95% CI: 2.1, 2.3), and 5 years (OR: 1.9, 95% CI: 1.9, 2.0) prior to the collision as compared with their not culpable or indeterminate culpable counterparts .

In a sensitivity analysis in which we considered a driver to have a prior citation if and only if the cited driver was later convicted of the criminal charge, results were again largely similar. There were only 1,651 drivers involved in two-car collisions with a criminal traffic conviction in the last 6 months. Nonetheless, the drivers scored as culpable had higher odds of history of behavioral criminal traffic conviction in the prior 6 months (OR: 2.8, 95% CI: 2.5, 3.1), 1 year (OR: 2.6, 95% CI: 2.4, 2.8), 3 years (OR: 2.2, 95% CI: 2.1, 2.3), and 5 years (OR: 2.0, 95% CI: 1.9, 2.0)

Conclusions

Using Washington State's TRIP-linked database of crash reports and criminal traffic citations, we explored the hypothesis that traffic citation within the past three years was associated with culpability for a crash. As hypothesized, we found that a history of criminal traffic citation was associated with over twice the odds of being responsible for a two-car collision.

The elevation in risk we observed was higher when the period we considered eligible for history was shorter. This may reflect a true underlying variation in risk. For example, it may be that people are riskier drivers during some periods of their lives than others, and those periods of

risk elevation lead to being cited for risky driving and being involved in crashes. However, we caution that this may also be an artifact of study design – drivers move in and out of states and we only have citation history for Washington State. It follows that recent behavioral citation history will always be more reflective of current risky driving than longer-term citation history.

Our results are consistent with prior studies finding that a history of citation was associated with greater risk of future crash responsibility[8] and being in a future crash at all.[9,10] Our work builds on these results in several key ways: by incorporating a culpability tool that automatically assesses culpability from administrative data and by assessing the impact of separate time lags for citation history. Taken together, our findings and prior work strongly suggests that citation history is associated with future risky driving.

Our work has multiple strengths, including the statistical power offered by our use of a novel linkage of criminal traffic citation data with nearly a decade of crash records and the QIE design's implicit matching on factors putting drivers on the road. However, our results are also subject to several key limitations. First, the QIE design implicitly relies on accurate assessment of culpability. While our crash report data were comprehensive and we were able to assign culpability for most drivers in most crashes, our results rely on the indicators used to assign culpability being reported accurately. While we have no reason to believe measurement error would be associated with culpability or history of citation, systematic measurement error would pose a threat to validity. Second, our core hypothesis was that criminal traffic citations for behavioral offenses are an indicator of unsafe driving behaviors. But other factors, including differential police presence in different communities, may affect individual probability of criminal traffic citation.[11] Broadly, however, we would expect that systemic factors that might lead to differential law enforcement,[12] would not be associated with risky behaviors or crash culpability, and thus would bias our results towards the null.

Future work with these data could use culpability approach to assess other exposures available in TRIP, including use of prescription medications, a broader swath of traffic violations, and potential medical experiences that could impact driving safety (e.g. traumatic brain injury).

In conclusion, we used TRIP's linkage of criminal traffic citation records to explore the relationship between recent history of criminal traffic citation for a behavioral action and crash responsibility. We found that drivers who had been recently cited were more likely to be responsible for collisions, and these results were robust to sensitivity analyses regarding whether we only consider citations for which the driver was later convicted and to how we categorize drivers of indeterminate culpability. Taken together, our results suggest that citation history is strongly associated with crash responsibility. Target Zero efforts to increase road safety might consider citation as an opportunity to appropriately encourage road safety.

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Appendix

Table A1. Description of charges by behavioral and non-behavioral. N (%) represents the total number of charges per category and the percentage of overall charges. Driver's license violations include violations related to driver's licenses which are not captured under DWLS (i.e., no valid driver's license on person). DWLS = Driving while license suspended.

Charge	N (%)
Behavioral charges	
DUI/substance violation	183,937 (16.2%)
Reckless driving	60,427 (5.3%)
Hit and run	56,789 (5.0%)
Negligent driving	47,970 (4.2%)
Ignition interlock infraction	29,909 (2.6%)
Attempt to elude police vehicle	13,815 (1.2%)
Failure to cooperate with police	6,069 (0.5%)
Physical control	5,547 (0.5%)
Vehicular assault	5,267 (0.5%)
Racing	1,712 (0.2%)
Vehicular homicide	1,233 (0.1%)
Speeding	668 (<0.1%)
Failure to obey traffic control	124 (<0.1%)
Non-behavioral charges	
DWLS 3rd degree	430,327 (37.9%)
Driver's license violation	195,386 (17.2%)
DWLS 2nd degree	42,050 (3.7%)
Failure to transfer title	21,692 (1.9%)
DWLS 1st degree	15,697 (1.4%)
Registration violation	9,596 (0.8%)
Trip permit violation	4,933 (0.4%)
Allow unauthorized driver	1,372 (0.1%)
Vehicle title violation	1,243 (0.1%)
Insurance violation	571 (<0.1%)
Illegal use of dealer license plate	227 (<0.1%)

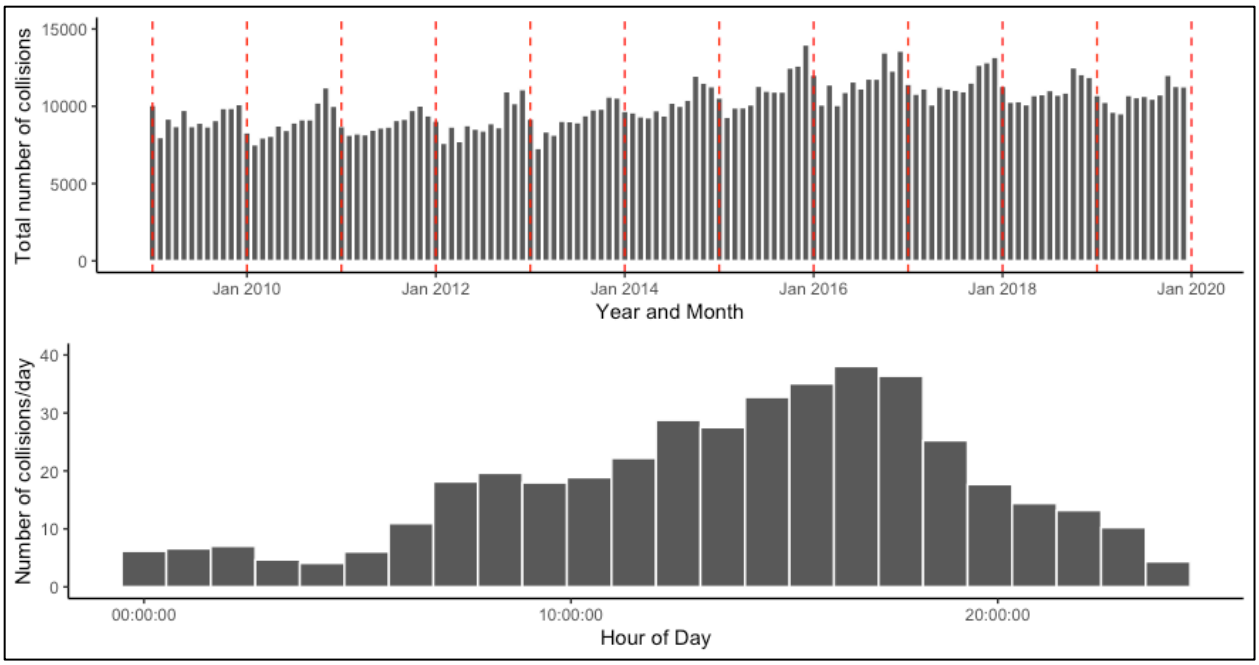

Figure A1. (A) Total number of collisions per month from January 2009 – December 2019. The dashed red line indicates January of each year. **(B)** Average number of collisions per hour of day. Reports the mean number of collisions for each hour of the day from 2009 – 2019.

Table A2. Contributing circumstances coded as to whether we treated them as reflecting unsafe driving

Circumstance	Unsafe
Under Influence of Alcohol	Yes
Under Influence of Drugs	Yes
Exceeding Stated Speed Limit	Yes
Exceeding Reas. Safe Speed	Yes
Did Not Grant RW to Vehicle	Yes
Improper Passing	Yes
Follow Too Closely	Yes
Over Center Line	Yes
Failing to Signal	Yes
Improper Turn/Merge	Yes
Disregard Stop and Go Light	Yes
Disregard Stop Sign - Flashing Red	Yes
Disregard Yield Sign - Flashing Yellow	Yes
Apparently Asleep or Fatigued	Yes
Improper Parking Location	Yes
Operating Defective Equipment	No
Other Contributing Circ Not Listed	Yes
None	No
Improper Signal	Yes
Improper U-Turn	Yes
Light Violation: No Lights/Fail to Dim	Yes
Did Not Grant R/W to Non Motorist	Yes
Inattention	Yes
Improper Backing	Yes
Disregard Flagger / Officer	Yes
Apparently Ill	Yes
Apparently Fatigued	Yes
Had Taken Medication	Yes
Non Motorist on Wrong Side of Road	No
Hitchhiking	No
Failure to Use Xwalk	No
Operating Handheld Cell Phone	Yes
Operating Hands-Free Cell Phone	Yes
Operating Other Electronic Devices (computer, navigation, etc.)	Yes
Driver Adjusting Audio or Entertainment System	Yes
Smoking	Yes
Eating or Drinking	Yes
Reading or Writing	Yes
Grooming	Yes
Driver Interacting with Passengers, Animals or Objects Inside Vehicle	Yes
Other Driver Distractions Inside Vehicle	Yes
Distractions Outside Vehicle	No
Unknown Distraction	Yes
Driver Not Distracted	No
Lost in Thought / Day Dreaming	Yes

Distracted by Other Occupant	Yes
Distracted by Adjusting Vehicle Cntrls	Yes
Other Distractions	Yes
Disregard Traffic Sign and Signals	Yes
Apparently Emotional (Depressed, Angry, Disturbed, etc.)	Yes
Physically Impaired	Yes
Racing	Yes
Operating Recklessly or Aggressively	Yes
Overcorrecting / Oversteering	Yes