THE IMPACT OF NON-PREVENTABLE CRASHES ON COMPLIANCE, SAFETY, ACCOUNTABILITY SCORES

Caroline Boris (Corresponding Author)
American Transportation Research Institute
2277 Highway 36 W, Roseville, MN 55113
Tel: 651-641-6162; Fax: 651-631-9500; Email: cboris@trucking.org

Dan Murray
American Transportation Research Institute
2277 Highway 36 W, Roseville, MN 55113
Tel: 651-641-6162; Fax: 651-631-9500; Email: dmurray@trucking.org

Word count: 6,628 words
Abstract = 237 words, Text = 3,566 words, References = 825 words, + 8 tables/figures x 250 words = 2,000

Submission Date: August 1, 2016

ABSTRACT

The Federal Motor Carrier Safety Administration's (FMCSA's) Compliance, Safety, Accountability (CSA) program identifies high risk motor carriers using crash and inspection data in seven Behavioral Analysis and Safety Improvement Categories (BASICs). The Crash Indicator BASIC ("Crash BASIC") uses *all* prior crash involvement to evaluate carrier safety; no differentiation is made between crashes which could have been prevented by the actions of the driver and/or motor carrier and those which were non-preventable. As a result, the Crash BASIC may not accurately represent a carrier's safety performance.

This case study approach models the impact of excluding non-preventable crashes from the Crash BASIC calculation by mapping the crash records of 15 motor carriers to the Motor Carrier Information Management System (MCMIS), then removing five non-preventable crash types from the calculation of the Crash BASIC. Non-preventable crashes comprised 61 percent of the 15 carriers' crash records, the five identified crash types comprise only a small number of these crashes. The comparison of the FMCSA-generated Crash BASIC with the "adjusted" Crash BASIC that excludes the five crash types shows that removing certain non-preventable crashes impacts carrier measures significantly, shifts of the relative ranking for the 14 motor carriers in the sample in the same peer group. The five crash types represent a small proportion of the carriers' non-preventable crashes; a broader incorporation of non-preventable crashes would therefore result in even more significant changes to carrier Crash BASIC measures and relative rankings.

BACKGROUND

In 2010, the Federal Motor Carrier Safety Administration (FMCSA) replaced its previous safety program, Safety Status Measurement System (SafeStat), with the newly developed Compliance, Safety, Accountability (CSA) program. CSA was intended to be a more targeted, robust system for identifying high-risk carriers and prioritizing carriers for intervention. While many in the trucking industry have found CSA to be an improvement over SafeStat, there are concerns about CSA's accuracy in predicting crash risk, among other issues. Under CSA, both carriers and drivers receive safety scores across seven Behavioral Analysis and Safety Improvement Categories (BASICs) (*1*).

To address some of these concerns, FMCSA has made a number of changes to CSA since its debut in 2010. Some of the changes included adjusting violation severity weights, reorganizing two of the BASICs, and clarifying certain data inputs (*2*). Currently, FMCSA is proposing more changes to the CSA program, including abandoning percentile rankings in favor of absolute intervention thresholds, only assessing the Crash Indicator BASIC ("Crash BASIC") during investigations, limiting the scope of the Crash BASIC to preventable crashes, and reducing the three-tiered safety fitness classification system to only a single determination – "unfit." (*3*) Another recent CSA development includes FMCSA's proposal for a demonstration program to assign preventability determinations to certain crash types (*4*).

INTRODUCTION

A number of studies have investigated the relationship between crash risk and carriers identified as high risk by the CSA program. The first of these studies used linear models to assess the statistical validity of predicting crash risk using SMS data, finding no relationship (*5, 6, 7*). However, the use of linear models for analyzing the relationship between SMS and crash data violates the linear model assumption of a normal distribution of error terms. The American Transportation Research Institute (ATRI) analyzed the relationship between SMS and crash data with the negative binomial model, a statistical model better suited to overdispersed count data (*8*). ATRI's analysis revealed that both the Driver Fitness and Controlled Substances/Alcohol BASICs had inverse relationships to crash risk. In addition, the research indicated that rating carrier safety performance by the cumulative number of alerts across BASICs could better identify high risk carriers than the percentile metrics currently used. Currently, BASIC alerts are based on a carrier exceeding a specific percentile threshold. ATRI also investigated the impact that enforcement disparities across the lower 48 states had on carrier BASIC scores (*9*). This study confirmed corroborated research findings that certain states issue violations at rates considerably higher than national averages (*5, 7*). Furthermore, the research documented that carrier BASIC scores were affected by disparate enforcement activities across the United States.

Similarly, states exhibit disparities in reporting crashes to FMCSA's MCMIS. The University of Michigan Transportation Research Institute (UMTRI) has investigated the disparate crash reporting rates of many states, and their most recent investigations show that crash reporting rates to MCMIS are highly inconsistent across states. The UMTRI analyses of 2010 MCMIS data for Delaware, New Jersey, and Utah revealed MCMIS reporting rates of 71.6 percent, 75.3 percent and 71.4 percent respectively (*10, 11, 12*). In addition to data integrity issues, the statistical validity of the SMS has been called into question.

The Government Accountability Office's (GAO) review of the CSA program concluded that most violations are so rare that validating the relationship between crash risk and violations is difficult (*13*). Additionally, the GAO found that most carriers do not have sufficient safety performance information to make reliable comparisons within carrier peer groups.

These studies exposed general issues within the SMS; however incorporating all crashes in the Crash Indicator BASIC calculation – regardless of preventability – warrants further examination. FMCSA defines a *preventable crash* as a "crash that involved a commercial motor vehicle, and that could have been averted but for an act, or failure to act, by the motor carrier or the [truck] driver." (*14*)

Crash Indicator BASIC

The Crash BASIC evaluates a carrier's crash involvement history for the previous 24 months (*1*). Only state-reported crashes coded as "Department of Transportation (DOT) reportable," meaning the crash involves at least one fatality, one injury where an individual is taken to a medical facility for treatment, or a vehicle is towed due to damages resulting from the crash, are assessed in the Crash BASIC (*15)*. Under the current SMS methodology all DOT-reportable crashes count against a carrier regardless of preventability determinations. Despite the Crash BASIC measure being restricted from the public, all DOT-reportable crashes that are used to calculate a carrier's Crash BASIC measure are available to the public.

Many industry stakeholders have noted that not including a preventability determination in the BASIC formula may generate misleading conclusions about a truck driver's or a carrier's actual safety performance (*16*). For example, if a legally parked commercial motor vehicle (CMV) is struck by another vehicle and is classified as a DOT-reportable crash, this negatively impacts a carrier's Crash BASIC measure. In this scenario, neither the driver of the CMV nor the carrier could have prevented the crash, yet the crash creates the perception that the carrier is less safe. According to FMCSA's Crash BASIC factsheet, "carriers should be aware that crashes in the previous 24 months adversely affect carriers' SMS results and ***only not having*** crashes will improve carriers' percentile ranking."(*17*)

Some safety advocates support the inclusion of all crashes, regardless of preventability, due to the correlation between past crashes and future crash risk (*16*). However, this effect is likely due to the statistical strength of the correlation between historical preventable crashes and future preventable crash risk; removing non-preventable crashes from the all-crash database would ostensibly elucidate this hypothesis. So while the Crash BASIC has a correlation to future crash involvement, it does not distinguish between causation and involvement (*18*). Failing to account for the difference between involvement and causation may mask the statistical strength that non-preventable crashes likely have on future crash risk, and present an inaccurate representation of driver and carrier safety.

CSA scores can directly influence the economic viability of motor carriers (*19, 20*). Therefore, an exposure adjustment should be included in the Crash BASIC that acknowledges the role of the driver in the crash. Removing non-preventable crashes from the Crash BASIC would serve as an exposure adjustment, by removing all crashes where involvement was the result of exposure to an unsafe but non-preventable externality. Thus the change would then better align Crash BASIC calculations with FMCSA's mandate to identify carriers and truck drivers that pose the greatest risk to public safety (*21*).

Despite Crash BASIC scores being restricted from the public, they can still impact carriers and drivers significantly (*5*). Potential areas of impact include:

- Economic harm. Shippers can, and often do, require the disclosure of Crash BASIC measures and percentiles to assess the safety of a carrier (*19,22*). All things being equal, carriers with a "bad" Crash BASIC score may be less likely to receive freight contracts than a "safer" carrier (*20*). Commercial drivers with non-preventable crashes on their record may experience issues – with finding employment – as most data sources used for employment screening

(insurance loss data; Pre-Employment Screening Program [PSP] reports) do not differentiate preventable crashes from non-preventable crashes.

- Higher insurance costs. It is well understood that carrier BASIC scores are used as actuarial inputs for insurance risk assessments and determinations of premium levels.
- Legal consequences. Plaintiff attorneys may cite BASIC scores in legal proceedings, as an indicator of negligence and culpability.
- Lost productivity from more frequent inspections. The Inspection Selection System (ISS), a tool for selecting CMVs to inspect, is influenced by BASIC scores (*23*).

The influence that BASIC scores have on the productivity and viability of carrier make it paramount for the measures to accurately reflect a carrier and commercial driver safety performance.

Crash Preventability Research

In 2012, FMCSA responded to industry concerns surrounding crash preventability determinations by conducting a crash weighting research study (*16*). In the initial phase of its study, FMCSA conducted a police accident report (PAR) coding test. Two researchers independently coded 1,221 crash records to determine the feasibility of assigning crash preventability determinations based solely on PARs. Results from this analysis indicated that the coders reached 93.2 percent agreement when assigning responsibility (*24*). These results suggest that consensus is often possible when determining which party caused a crash.

Subsequent study phases evaluated whether PAR data are adequately reliable and sufficient across the entire United States to be used to determine if the truck driver was responsible for the crash (by cross-referencing PARs with records that are included in the Fatality Analysis Reporting System [FARS] and the National Motor Vehicle Crash Causation Study [NMVCCS]) (*25*). The analysis of PAR data found that 91 percent of the crashes examined had sufficient information to determine if a CMV was involved in the crash, if the CMV was regulated by FMCSA and if the crash was DOT-reportable. Of the PARs meeting these criteria, 61 percent had critical reasons that were not attributed to the CMV driver. The reliability of PARs was tested by comparing them to FARS records. There were significant inconsistencies between PAR and FARS data for areas critical to determining culpability; 82 percent of the PARs were missing car- or truck-driver contributing factors and 47.5 percent of the PARs were missing the first harmful event. Consistency between PARs and NMVCCS was better; with 90 percent of the researcher-examined crashes having critical reason determinations that matched.

In 2015, FMCSA released the final Crash Weighting Analysis report, which attempted to quantify the effect that including preventability determinations in the Crash BASIC would have on predicting future crash risk. FMCSA concluded that including preventability determinations did not significantly improve the predictive power of the Crash BASIC measure (*25*). The methodology used in the FMCSA report, called the effectiveness test, compares the future crash rates of carriers prioritized for intervention with a baseline crash rate (the crash rate of carriers prioritized for intervention under the current methodology)(*26*). However, using all future crashes (not just preventable crashes) to assess the impact of including preventability determinations in the Crash BASIC fails to address whether using only preventable crashes identifies the carriers most likely to *cause* crashes in the future.

Additionally, FMCSA estimated that identifying and incorporating at-fault determinations to the Crash BASIC would cost between $3.9 and $11.2 million annually, with an

initial startup cost of $1.1 million dollars (*25*). The variation in yearly cost estimates results from different projections of appeal rates, between 10 percent and 50 percent. However, these cost projections may be overinflated due to the fact that FMCSA assumes crash responsibility determinations would be made by compiling PARs from states, then reviewing PARs to make crash responsibility determinations. Some industry stakeholders suggest that FMCSA does not need to bear all responsibility for the process of determining crash preventability as state organizations that already investigate crash causes and report crashes to MCMIS could add reporting preventability determinations to the data reported to MCMIS (*27*).

FMCSA's Crash Weighting Report examines the costs FMCSA would incur by assigning crash preventability, but fails to assess the cost to industry stakeholders by not incorporating preventability into the Crash BASIC calculation.

METHODOLOGY

Assigning Crash Preventability

The relationship between crash risk and numerous environmental and behavioral factors – including fatigue, driver health, and personality attributes – have been researched extensively (*28, 29, 30, 31, 32*). The purpose here is to examine the impact of non-preventable crashes on carrier Crash BASIC measures. As a baseline analysis, a conservative approach was taken in the selection and analysis of crash causes. Five primary non-preventable crash causes were selected for this analysis:

- Truck collided with animal in roadway,
- Other driver hits legally parked truck,
- Other driver ran red light or stop sign and hit truck,
- Other driver was under the influence of drugs or alcohol and hit truck, or,
- Truck-assisted suicide by pedestrian.

Data Request Form

Crash BASIC percentile scores are restricted to the public and MCMIS does not include crash causes or preventability determinations, so ATRI employed a carrier case study approach. ATRI researchers developed a data request form which solicited from carriers their FMCSA-generated data on their Crash BASIC. This data included percentile score, measure, safety event group and segment as provided by FMCSA on 9/26/2014 (*1*). In addition, ATRI requested a detailed carrier crash history for the 24-month time period between September 2012 and September 2014. Among the crash record variables requested were the number of fatalities, injuries and vehicles towed, if hazardous materials were released, the primary crash cause and if the crash was coded as preventable according to FMCSA's definition (*14,33*).

Mapping Carrier Records to MCMIS

After carrier records were received, crashes that fell into one of the 5 "primary cause" bins were isolated and matched with crashes in the carrier's MCMIS file.

The differences between the carrier-provided crash data and MCMIS data were significant. As a result of these differences, the carrier-provided data was used to identify which crashes could be attributed to at least one of the five primary cause bins, and the MCMIS data was used to calculate Crash BASIC measures and to validate the five-bin, non-preventable crashes represented in the MCMIS dataset.

Explanations for Variance

There are a multitude of explanations for the variation between the two sources. One explanation is the variation present in state accident reporting procedures. For example, not all states use the same definition of injury as FMCSA. Varying definitions among states influence whether states report applicable injuries to FMCSA. This issue is highlighted in UMTRI's studies on MCMIS reporting rates. For example, the Colorado accident report form uses the KABCN scale – with K being fatal injury, A being incapacitating, B as non-incapacitating but evident, C being complaint of injury, and N being no injury – to classify the severity of an injury but does not identify if individuals were transported for medical treatment (*34*). Conversely, FMCSA defines an injury as "bodily injury to a person who, as a result of the injury, immediately receives medical treatment away from the scene of the accident."(*15*) The inconsistency between these two definitions of injury likely results in crashes that do not meet FMCSA's criteria to be reported to MCMIS.

Additionally, as demonstrated by numerous UMTRI reports, reporting rates to MCMIS vary by state.

Therefore, matching crash records requires some tolerance for ambiguity. To address the differences between the data sources, severity weights from MCMIS were used for Crash BASIC measure calculations. The process for matching crashes from the carrier file to MCMIS is described in Figure 1.

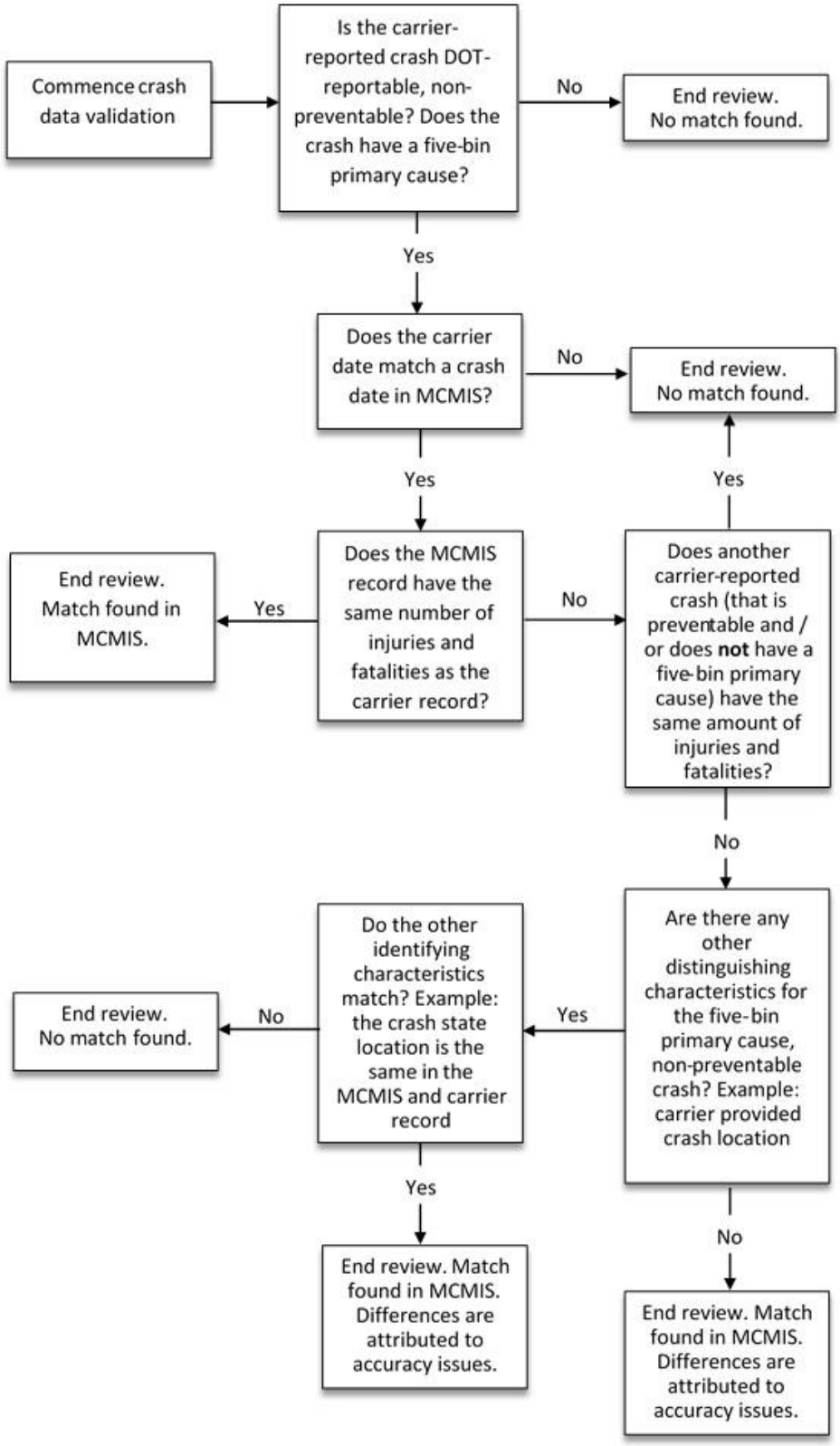

FIGURE 1 Process for Matching Carrier and MCMIS Records

Crash Basic Calculation

First, carrier Crash BASIC calculations were corroborated by replicating the carrier's original, FMCSA-provided Crash BASIC measure. Next, crashes that were coded as non-preventable and had a genesis in one of the five primary cause bins were removed from the Crash BASIC calculation. As a final step, the carrier Crash BASIC was recalculated without the aforementioned crashes.

RESULTS

Demographics

Seventeen carriers responded to the Crash BASIC data request. Of the 17 carriers, 15 had sufficient information in their crash records to assign clear preventability and primary crash cause determinations. Of these 15 carriers, the majority (60%) were Truckload (Table 1). Most carriers reported that their fleet's average length of haul is 100 to 499 miles (40%) or 500 to 999 miles (40%) per trip (Table 2).

TABLE 1 Primary Industry Sector

Business	Percent
Truckload	60.0%
Less-Than-Truckload	20.0%
Flatbed	6.7%
Tanker	6.7%
Other	6.7%

TABLE 2 Average Length of Haul

Average Length of Haul	Percent
Local (less than 100 miles per trip)	0.0%
Regional (100-499 miles per trip)	40.0%
Inter-Regional (500-999 miles per trip)	40.0%
Long Haul (1,000 or more miles per trip)	13.3%
No Response	6.7%

As displayed in Table 3, the smallest participating fleets had between 501 and 1,000 power units (13.3%), while the largest fleets had over 5,000 power units (26.7%). The distribution of fleet size in this sample is not representative of the industry at large, of which 93 percent of fleets have less than 20 power units (PU) (*13*). The sample's skew toward larger carriers is beneficial in that data insufficiency issues associated with small carriers should not influence the present analysis. The GAO's recommended standards for data sufficiency were met by every carrier who participated in this study and the resulting Crash BASIC measures are more precise for the test population group than the BASIC measures of smaller carriers with fewer DOT-reportable crashes.

TABLE 3 Fleet Size

Power Units	Percent
5,001+	26.7%
1,001-5,000	60.0%
501-1,000	13.3%
251-500	0.0%

Distribution of Primary Crash Causes

As noted, researchers identified five primary crash causes that could be removed from the calculation of a carrier's Crash BASIC measure based on the FMCSA definition of non-preventable. The carriers in the sample had 241 crashes coded as non-preventable, with a genesis in at least one of the five crash cause bins. As displayed in Figure 2, crashes where the other vehicle (OV) ran a red light or stop sign accounted for the largest percentage (47.1%) of non-preventable crashes removed from a carrier's Crash BASIC measure, followed animal crashes (28.5%).

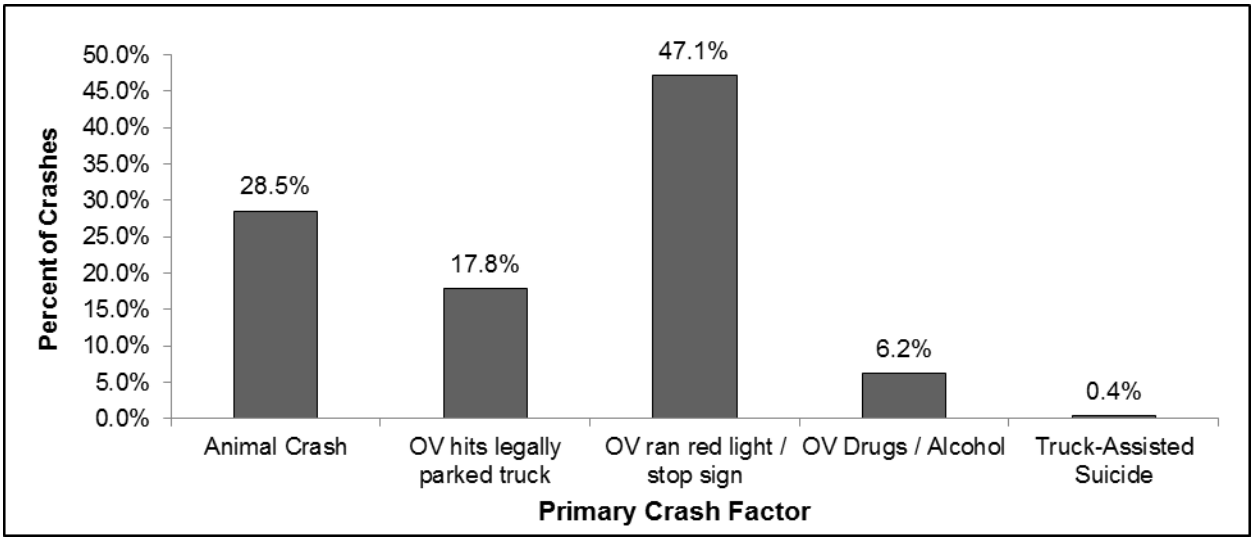

FIGURE 2 Distribution of Crashes Removed from Carrier Records

Of the DOT-reportable crashes in carrier records, the crashes associated with ATRI's five primary cause bins comprised a relatively small proportion of the total non-preventable crashes reported by carriers (Figure 3). For the 15 carriers, crashes associated with the five primary cause bins comprised only 8.9 percent of the carriers' total crash record database. Non-preventable crashes as a whole accounted for 61.0 percent of the carriers' total crash record database. The varied preventability composition of crashes across the 15 carriers in this sample suggests the incorporating preventability determinations into Crash BASIC calculations would not impact all carriers equally.

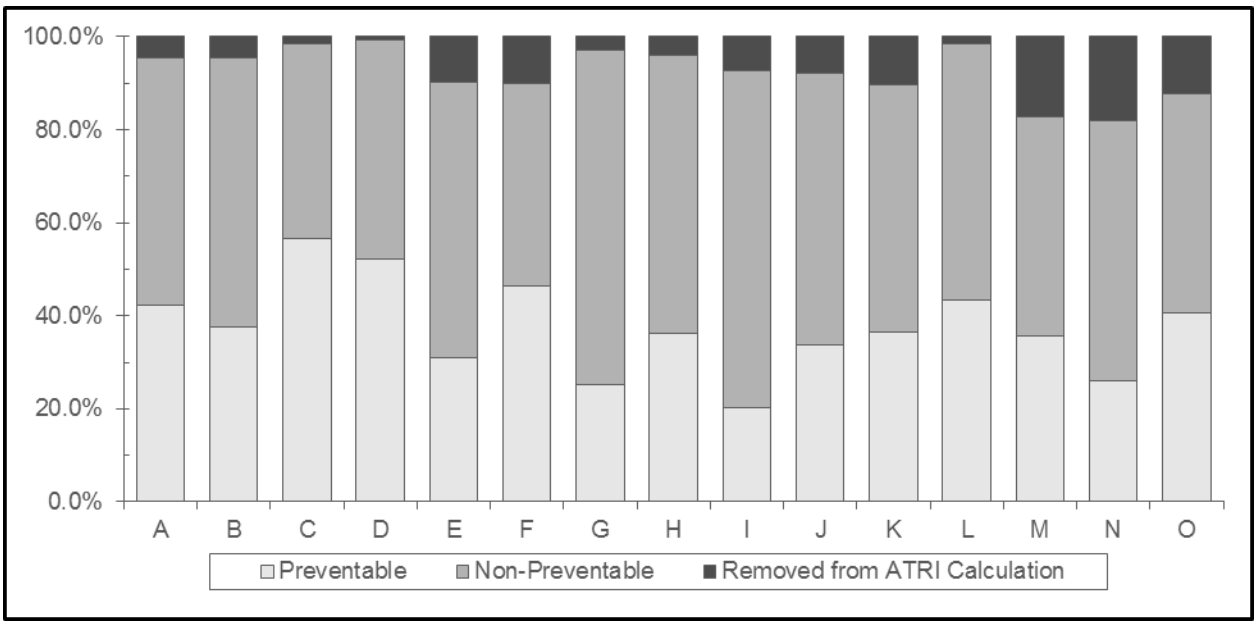

FIGURE 3 Carrier Crash Preventability Distribution

Percent Change in Carrier Crash BASIC Measure

The final step was recalculating a new Crash BASIC measure, by removing the MCMIS records for carrier crashes residing in the five primary cause bins. As shown in Figure 4, Carrier C experienced no decrease in their Crash BASIC measure (0.0%), while Carrier M experienced the largest percentage decrease in their Crash BASIC measure (14.2%). On average, Crash BASIC measures decreased by 5.3 percent.

The five primary cause crashes comprised a small proportion of each carrier's non-preventable crashes, so the changes in Crash BASIC measures are a very conservative estimate of the impact that non-preventable crashes have on a carrier's Crash BASIC measure.

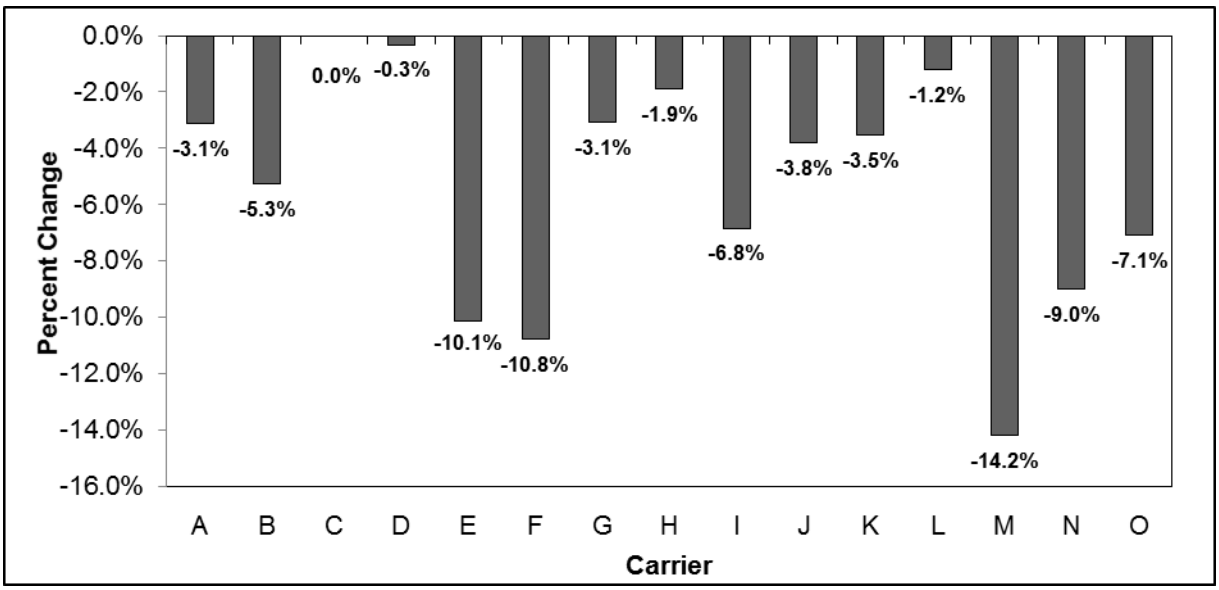

FIGURE 4 Percent Change in Carrier Crash BASIC Measure

The carrier-reported Crash BASIC measure and percentile scores suggest that even small changes in a carrier's measure could significantly impact the carrier's percentile score. For example, two carriers reported identical FMCSA Crash BASIC measures of .16 on September 26, 2014, yet there was an 11 percentage point difference between the carriers' percentile scores; this phenomenon was seen across multiple instances where identical measures generated different rankings. Therefore, even what ostensibly should be a small change in a carrier's Crash BASIC measure could result in a large impact on the percentile ranking of a carrier.

Since carrier Crash BASIC measures and percentile scores are restricted from the public, modeling the impact of the change in Crash BASIC measures on percentile scores was not possible, as that would require access to the entire peer grouping for each carrier. Since all carriers in this sample (except for Carrier O) were in the same peer group, the relative ranking of carriers' Crash BASICs can be compared in a manner similar to FMCSA's method of assigning percentile scores. The ranking of carriers from FMCSA-provided and adjusted Crash BASIC measures are shown in Table 4. Like FMCSA's percentile scoring, a lower value indicates better performance, while a higher value indicates worse performance. For simplicity, the rankings range from one to 14. Despite the relatively small changes to the carriers' Crash BASIC measures, the relative ranking of most carriers did change. Four carriers experienced no change in rank, five carriers' relative rank worsened, and the remaining five carriers' relative ranks improved.

Carrier	**C**	**D**	**M**	**J**	**F**	**A**	**N**	**K**	**I**	**H**	**L**	**B**	**G**	**E**
FMCSA Rank	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Recalculated Rank	2	5	1	4	3	7	6	9	8	10	12	11	13	14
Change in Rank	–	–	+	0	+	–	+	–	+	0	–	+	0	0

TABLE 4 Changes in Rank

CONCLUSION

The objective of this study was to model the impact of removing non-preventable crashes from a carrier's Crash BASIC measure. These results demonstrate that even a conservative approach to defining and assessing preventability can impact a carrier's Crash BASIC measure significantly. Additionally, this analysis found:

- Non-preventable crashes comprise the majority of the sample. Therefore, a broader definition of preventability than the five primary-cause bin approach used in this report, would likely result in dramatic changes to Crash BASIC measures.
- Small differences in Crash BASIC measures result in significantly different percentile rankings, with this sample having a maximum range of 11 percentage points for the same FMCSA-provided score.
- The composition of preventable and non-preventable crashes varies across carriers. A Crash BASIC that only considers preventable crashes would affect carriers differently.

- Small changes in Crash BASIC measures result in significant changes to Crash BASIC percentile rankings, given the range of percentile rankings resulting from a single FMCSA-provided score and the varied composition of preventable and non-preventable crashes across carriers.
- Assigning preventability could also rectify issues beyond the Crash BASIC, such as carrier costs, insurance premiums and driver safety records.

REFERENCES

1. Safety Measurement System (SMS) Methodology Version 3.0.5. (2015). Federal Motor Carrier Safety Administration. Available Online: http://csa.fmcsa.dot.gov/Documents/SMSMethodology.pdf Accessed August 1, 2016.
2. What's New: CSA News and Information. (2012). Federal Motor Carrier Safety Administration. Available Online: http://csa.fmcsa.dot.gov/Whats_new.aspx#ARCHIVE
3. Notice of Proposed Rulemaking Carrier Safety Fitness Determinations. Docket ID FMCSA- 2015-33153. Available Online: https://www.regulations.gov/document?D=FMCSA-2015-0001-0001
4. Federal Register Notice: Crash Preventability Program. (2016). Federal Motor Carrier Safety Administration. https://www.fmcsa.dot.gov/regulations/federal-register-notice-crash-preventability-program
5. Gallo, A. P. & Busche, M. CSA: Another look with similar conclusions. Wells Fargo Securities Equity Research. July 12, 2012.
6. Iyoob, I. SMS BASIC scores are not valid predictors of crash frequency. Alliance for Safe, Efficient and Competitive Truck Transportation. June 25, 2012. Available Online: http://asectt.blogspot.com/2012/06/sms-basic-scores-are-not-valid.html
7. Gimpel, J. Statistical issues in the safety measurement and inspection of motor carriers. Alliance for Safe, Efficient and Competitive Truck Transportation. July 10, 2012. Available Online: http://asectt.blogspot.com/2012/07/news-brief-university-of-maryland-study.html
8. Lueck, M.D. (2012). *Compliance, Safety, Accountability: Analyzing the Relationship of Scores to Crash Risk.* Arlington, VA: American Transportation Research Institute.
9. Weber, A.J., & Murray, D.C. (2014). Evaluating the Impact of Enforcement Disparities on Carrier Safety Performance. Arlington, VA: American Transportation Research Institute.
10. Blower, D., & Matteson, A. (2012). Evaluation of 2010 Delaware Data Reported to MCMIS Crash File. Ann Arbor, MI: The University of Michigan Transportation Research Institute.
11. Blower, D., & Matteson, A. (2013). Evaluation of 2010 New Jersey Data Reported to MCMIS Crash File. Ann Arbor, MI: The University of Michigan Transportation Research Institute.
12. Blower, D., & Matteson, A. (2012). Evaluation of 2010 Utah Data Reported to MCMIS Crash File. Ann Arbor, MI: The University of Michigan Transportation Research Institute.
13. Federal Motor Carrier Safety Modifying the Compliance, Safety, Accountability Program Would Improve the Ability to Identify High Risk Carriers. (2014). Government Accountability Office. Available Online: http://www.gao.gov/assets/670/660610.pdf
14. Part 385. Federal Motor Carrier Safetey Regulations; General. Available Online: http://www.fmcsa.dot.gov/regulations/title49/section/385.3 Accessed August 1, 2016.

15. Part 390. Federal Motor Carrier Safetey Regulations; General. Available Online: http://www.fmcsa.dot.gov/regulations/title49/section/390.5 Accessed August 1, 2016.
16. MCSAC Task 12-03: Evaluation of and Recommendations on the CSA Program—CSA Subcommittee Recommendations (2013). Motor Carrier Safety Advisory Committee, Federal Motor Carrier Safety Administration.
17. Crash Indicator BASIC Factsheet. (2012). Federal Motor Carrier Safety Administration. Available Online: http://csa.fmcsa.dot.gov/Documents/FMC_CSA_12_005_BASICs_Crash_Indicator.pdf c
18. Lueck, M.D., Murray, D.M. (2012). *Predicting Truck Crash Involvement: a 2011 Update.* Arlington, VA: American Transportation Research Institute.
19. Abbott, R. (2015). Comments of The American Trucking Associations on Crash Weighting Analysis Docket FMCSA-2014-0177. Arlington, VA: American Trucking Associations.
20. Lueck, M.D., & Brewster, R.M. (2012). Compliance, Safety, Accountability: Evaluating a New Safety Measurement System and Its Implications. Arlington, VA: American Transportation Research Institute.
21. Mission and Strategy. Federal Motor Carrier Safety Administration. Available Online: https://www.fmcsa.dot.gov/mission Accessed August 1, 2016.
22. Kopecky, R. (2015). Comments of Transwood Carriers Inc. on the FMCSA notice on Crash Weighting Research Findings (FMCSA-2014-0177-0026). Omaha, NE: Transwood Carriers, Inc.
23. Information Systems. Federal Motor Carrier Safety Administration. Available Online: http://www.fmcsa.dot.gov/mission/information-systems/information-systems Accessed August 1, 2016.
24. Craft, R. (2012). Police Accident Report (PAR) Coding Test. Federal Motor Carrier Safety Administration. Available Online: https://csa.fmcsa.dot.gov/Documents/PARCodingTest_7-2012.pdf Accessed August 1, 2016.
25. Crash Weighting Analysis. (2015). Federal Motor Carrier Safety Administration. Available Online: http://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/Crash%20Weighting%20Report%20-%20Full%20January%202015.pdf Accessed August 1, 2016.
26. John A. Volpe National Transportation Systems Center. (2014). The Carrier Safety Measurement System (CSMS) Effectiveness Test by Behavior Analysis and Safety Improvement Categories (BASICs). Federal Motor Carrier Administration. Available Online: https://csa.fmcsa.dot.gov/Documents/CSMS_Effectiveness_Test_Final_Report.pdf Accessed July 30, 2016.
27. McKane, D. (2015). Comments of the Oregon DOT Motor Carrier Transportation Division on the FMCSA notice on Crash Weighting Research Findings (FMCSA-2014-0177-0026).

28. Large Truck Crash Causation Study. Federal Motor Carrier Administration. Available Online: https://ai.fmcsa.dot.gov/LTCCS/default.asp
29. Anderson, Jon and Govada, Manjari and Steffen, Tricia K. and Thorne, Chris and Varvarigou, Vasileia and Kales, Stefanos and Burks, Stephen V., Health Behavior and Accident Risk: Obesity is Associated with the Future Risk of Heavy Truck Crashes Among Newly Recruited Commercial Drivers. IZA Discussion Paper No. 6408. Available at SSRN: http://ssrn.com/abstract=2025324 Accessed July 30, 2016.
30. Rustichini, Aldo and DeYoung, Colin G. and Anderson, Jon C. and Burks, Stephen V., Toward the Integration of Personality Theory and Decision Theory in the Explanation of Economic and Health Behavior. IZA Discussion Paper No. 6750. Available at SSRN: http://ssrn.com/abstract=2119057 Accessed July 30, 2016.
31. Knipling, R. R., L. N. Boyle, J. S. Hickman, J.S. York, C. Daecher, E. C. B. Olsen, and T. D. Prailey. CTBSSP Synthesis of Safety Practice No. 4: Individual Differences and the "High-Risk" Commercial Driver. Transportation Research Board of the National Academies, Washington, D.C., 2004.
32. Knipling, R.R., Rogers, W.C. Commercial Driver Human Factors. Transportation Research Board of the National Academies, Washington, D.C., 2007.
33. A Motor Carrier's Guide to Improving Highway Safety. (2009). Federal Motor Carrier Safety Administration. Accessed July 28 2016. Available Online: https://www.fmcsa.dot.gov/sites/fmcsa.dot.gov/files/docs/ETA-Final-508c-s.pdf Accessed July 30, 2016.
34. Blower, D., Matteson, A. (2010). Evaluation of 2008 Colorado Crash Data Reported to the MCMIS Crash File. University of Michigan Transportation Research Institute. Available Online: http://deepblue.lib.umich.edu/bitstream/handle/2027.42/89598/102790.pdf?sequence=1&isAllowed=y Accessed July 30, 2016.