FMCSA Safety Program Effectiveness Measurement: Carrier Intervention Effectiveness Model (CIEM), Version 1.3 Report for Fiscal Years 2017 and 2018 Interventions

U.S. Department of Transportation
Federal Motor Carrier Safety Administration

July 2022

FOREWORD

The Federal Motor Carrier Safety Administration (FMCSA), in cooperation with the John A. Volpe National Transportation Systems Center (Volpe), uses a quantitative model called the Carrier Intervention Effectiveness Model (CIEM) to measure the effectiveness of motor carrier interventions in terms of estimated crashes prevented, injuries prevented, and lives saved. This model provides FMCSA management with information needed to address the requirements of the Government Performance and Results Act of 1993 (GPRA), which requires Federal agencies to measure the effectiveness of their programs as part of the budget cycle process. This report documents the results of the CIEM for fiscal years 2016–2018.

NOTICE

QUALITY ASSURANCE STATEMENT

FMCSA provides high-quality information to serve Government, industry, and the public in a manner that promotes public understanding. Standards and policies are used to ensure and maximize the quality, objectivity, utility, and integrity of its information. FMCSA periodically reviews quality issues and adjusts its programs and processes to ensure continuous quality improvement.

Technical Report Documentation Page

1. Report No. **FMCSA-RRA-22-006**	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle **FMCSA Safety Program Effectiveness Measurement: Carrier Intervention Effectiveness Model (CIEM), Version 1.3 Report for Fiscal Years 2017 and 2018 Interventions**		5. Report Date **July 2022** 6. Performing Organization Code
7. Author(s) **Richard Gruberg**		8. Performing Organization Report No.
9. Performing Organization Name and Address **John A. Volpe National Transportation Systems Center Safety Management Systems Technical Center System Measurement and Analysis Division 55 Broadway Cambridge, MA 02142**		10. Work Unit No. (TRAIS) 11. Contract or Grant No. **693JJ418N000045**
12. Sponsoring Agency Name and Address **U.S. Department of Transportation Federal Motor Carrier Safety Administration Office of Analysis, Research, and Technology 1200 New Jersey Ave. SE Washington, DC 20590**		13. Type of Report and Period Covered **Summary, FY 2017 and FY 2018** 14. Sponsoring Agency Code **FMCSA**
15. Supplementary Notes **Contracting Officer's Representative: Scott Valentine Additional support at the Volpe Center was provided by Joseph Lynch**		

16. Abstract

The Federal Motor Carrier Safety Administration (FMCSA), in cooperation with the John A. Volpe National Transportation Systems Center (Volpe), uses a quantitative model called the Carrier Intervention Effectiveness Model (CIEM) to measure the effectiveness of motor carrier interventions in terms of estimated crashes prevented, injuries prevented, and lives saved. This model provides FMCSA management with information needed to address the requirements of the Government Performance and Results Act of 1993 (GPRA), which requires Federal agencies to measure the effectiveness of their programs as part of the budget cycle process. This report documents the results of the CIEM for fiscal years 2017 and 2018 In addition, model estimates for fiscal year 2016 have been rerun, based on Version 1.3 of the model.

17. Key Words	18. Distribution Statement		
Motor carrier, compliance review, CSA, intervention, safety, program effectiveness, commercial motor vehicle, offsite investigation, onsite investigation	**No restrictions**		
19. Security Classif. (of this report) **Unclassified**	20. Security Classif. (of this page) **Unclassified**	21. No. of Pages **33**	22. Price

SI* (MODERN METRIC) CONVERSION FACTORS

Approximate Conversions to SI Units				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		Length		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		Area		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	Acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		Volume (volumes greater than 1,000L shall be shown in m^3)		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		Mass		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or “metric ton”)	Mg (or “t”)
		Temperature (exact degrees)		
°F	Fahrenheit	5(F-32)/9 or (F-32)/1.8	Celsius	°C
		Illumination		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		Force and Pressure or Stress		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

Approximate Conversions from SI Units				
Symbol	**When You Know**	**Multiply By**	**To Find**	**Symbol**
		Length		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		Area		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
Ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		Volume		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		Mass		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or “t”)	megagrams (or “metric ton”)	1.103	short tons (2,000 lb)	T
		Temperature (exact degrees)		
°C	Celsius	1.8c+32	Fahrenheit	°F
		Illumination		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		Force and Pressure or Stress		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003, Section 508-accessible version September 2009.)

TABLE OF CONTENTS

EXECUTIVE SUMMARY VII

1. INTRODUCTION 1

1.1 BACKGROUND 1

1.2 PROJECT SCOPE 1

2. FMCSA CARRIER INTERVENTION EFFECTIVENESS MODEL 3

2.1 MODEL STRUCTURE 3

2.2 CARRIERS WITH INTERVENTIONS: CARRIER TREATMENT GROUP 4

2.3 CARRIERS WITHOUT INTERVENTIONS: COMPARISON GROUP 5

2.4 MODEL DATA AND TIMEFRAMES 5

2.5 CALCULATION OF CRASHES PREVENTED 7

2.6 CALCULATION OF OVERALL DIRECT SAFETY BENEFITS 9

2.7 SAFETY BENEFITS ASSOCIATED WITH INDIVIDUAL INTERVENTION TYPES 9

3. RESULTS OF IMPLEMENTING THE MODEL 11

3.1 RESULTS INCLUDING ALL INTERVENTION TYPES 11

3.1.1 Crash Rate Reduction 12

3.1.2 Safety Benefits 13

3.2 RESULTS EXCLUDING WARNING LETTER AS A FIRST INTERVENTION 14

3.2.1 Crash Rate Reduction 15

3.2.2 Safety Benefits 16

3.3 RESULTS FOR INDIVIDUAL INTERVENTION TYPES 16

3.3.1 Crash Rate Reduction 17

3.3.2 Safety Benefits 18

4. CONCLUSIONS 21

LIST OF FIGURES (AND FORMULAS)

Figure 1. Diagram. Timeline for a carrier with a first intervention on August 14, 2015.....6
Figure 2. Formula. Estimated percent crash rate reduction due to interventions for a given month. 7
Figure 3. Formula. Initial estimate of crashes prevented as a result of interventions.....8
Figure 4. Multiple formulas. Formulas for calculating numbers of fatal crashes prevented, injury crashes prevented, lives saved, and injuries prevented. 9

LIST OF TABLES

Table 1. Safety benefits: All interventions. viii
Table 2. Estimated crashes and injuries prevented, and lives saved, by first investigation type, FYs 2016–2018.* ix
Table 3. Total interventions by type, and number of carriers receiving interventions, by first intervention, for FYs 2016–2018. 11
Table 4. Carriers excluded from treatment group by filter criteria, for FYs 2016–2018. 12
Table 5. Number of treatment and comparison group carriers for FYs 2016–2018, by size group. 12
Table 6. Initial treatment and comparison group crash rate reductions for FYs 2016–2018, by size group. 13
Table 7. Net percent reductions in crash rates for treatment group carriers, FYs 2016–2018. 13
Table 8. 2-year average crash severity statistics for FYs 2016, 2017, and 2018. 14
Table 9. Estimated crashes prevented, injuries prevented, and lives saved in the treatment group for FYs 2016, 2017, and 2018. 14
Table 10. Estimated crashes prevented, injuries prevented, and lives saved for all carriers receiving interventions for FYs 2016, 2017, and 2018. 14
Table 11. Number of treatment group carriers, excluding carriers that received a warning letter as their first intervention, by size group, for FYs 2016–2018. 15
Table 12. Treatment and comparison group percent reductions in crash rate, excluding carriers that received a warning letter as their first intervention, by size group, for FYs 2016–2018. 15
Table 13. Net percent reductions in crash rates, excluding carriers that received a warning letter as their first intervention, by size group, for FYs 2016–2018.....15
Table 14. Estimated crashes prevented, injuries prevented, and lives saved for all carriers within the treatment group, excluding carriers that received a warning letter as their first intervention, FYs 2016–2018. 16
Table 15. Estimated crashes prevented, injuries prevented, and lives saved for all carriers receiving an intervention, excluding carriers that received a warning letter as their first intervention, FYs 2016–2018. 16
Table 16. Number of treatment group carriers by first intervention type and size group, for FYs 2016–2018. 17

Table 17. Percent net crash rate reductions (treatment minus comparison group) for individual intervention, FYs 2016–2018 18
Table 18. Estimated crashes and injuries prevented, and lives saved, by first intervention type, for FYs 2016–2018.* 18

ACRONYMS

Acronym	Definition
ATET	average treatment effect on the treated
CIEM	Carrier Intervention Effectiveness Model
CMV	commercial motor vehicle
CR	compliance review
CREM	Compliance Review Effectiveness Model
CSA	Compliance, Safety, Accountability
FMCSA	Federal Motor Carrier Safety Administration
FY	fiscal year
GPRA	Government Performance and Results Act of 1993
HM	hazardous materials
MCMIS	Motor Carrier Management Information System
MCSAP	Motor Carrier Safety Assistance Program
PRISM	Performance and Registration Information Systems Management
PU	power unit (commercial motor vehicle)
USDOT	U.S. Department of Transportation
Volpe	John A. Volpe National Transportation Systems Center

EXECUTIVE SUMMARY

In 2010, following an operational model test in select States, the Federal Motor Carrier Safety Administration (FMCSA) began a phased implementation of its Compliance, Safety, Accountability (CSA) program, representing a redesign of the Agency's existing enforcement model. The CSA enforcement model includes an array of carrier intervention types that replaced the one-size-fits-all compliance review (CR) that was implemented as part of the old enforcement model. The new enforcement model was designed to improve safety in the operation of commercial motor vehicles (CMVs).

The Carrier Intervention Effectiveness Model (CIEM) provides FMCSA with a tool for measuring the safety benefits of carrier interventions. The model incorporates both comprehensive reviews of motor carriers, as well as newer intervention types currently used by the Agency (i.e., warning letters, offsite investigations, onsite focused investigations, other non-ratable reviews, and onsite comprehensive investigations) when assessing safety benefits.

The model yields national-level measurements of the effectiveness of FMCSA's carrier interventions. It is designed to be implemented on an annual basis, focusing on carriers receiving State and Federal interventions in a given fiscal year (FY). Assessing and comparing results from year to year helps to provide a measure of the safety impact of FMCSA's compliance and enforcement program.

MODEL APPROACH

The model computes crash rates—defined as crashes per power unit (PU)—for carriers receiving interventions, distinguishing between their crash rates in defined periods before and after the interventions. The difference between a carrier's pre- and post-intervention crash rates measures how much its safety performance improved during this timeframe. To control for systemic differences in safety benefits from interventions, based on carrier size, separate before-and-after comparisons are made for various carrier size groups, defined in terms of PU count.

To help remove the effect of confounding factors from calculated changes in safety performance, the difference between the aggregated pre- and post-intervention crash rates is adjusted by the change in crash rates of the general carrier population during the same time period. In addition, a set of carefully designed filters is used to identify and remove carriers with missing and outlier data from the calculations. Beginning with Version 1.3 of the model, this adjustment is performed separately for carriers receiving intervention in a given month. That is, pre- to post-intervention crash rate changes for carriers receiving interventions in a given month receive an adjustment, based on the crash rate change in the general carrier population from the 12-month period prior to the intervention month to the 12-month period subsequent to the intervention month.

The model incorporates statistical significance testing and, as a result, only considers changes in size-group crash rates that are statistically significant when calculating crashes prevented, injuries prevented, and lives saved. Statistically significant results are then extrapolated to

account for carriers that, while receiving interventions, were not included in the initial model calculations, due to missing or inaccurate data.

MODEL FINDINGS

All Carriers Receiving Interventions

The model was implemented for carriers receiving interventions in FY 2017 and FY 2018, based on Version 1.3 of model. In addition, previous estimates for FY 2016, based on Version 1.2 of the model, were recalculated based on Version 1.3. Total interventions in FY 2017 and FY 2018 dropped slightly from 44,359 in FY 2016 to 41,748 in FY 2017 and 41,240 in FY 2018. Statistically significant crash rate reductions occurred for carriers in all four size groups considered by the model. These reductions are estimated to have resulted in the safety benefits shown in Table 1.

Table 1. Safety benefits: All interventions.

Fiscal Year	Crashes Prevented	Injuries Prevented	Lives Saved
2016	7,648	4,213	222
2017	8,765	4,818	269
2018	9,627	5,153	275

Additional Analysis

The model was also run with the exclusion of warning letters. Because the issuance of such a letter does not involve any investigative work on the part of the Agency, removing carriers that received only a warning letter from the analysis helps to identify safety benefits specifically associated with safety investigator and program analyst personnel-hours pertaining to Agency investigations. Based on this analysis, carriers whose first intervention was not a warning letter also exhibited statistically significant crash rate reductions in all carrier size groups. Benefits from this subset of interventions are estimated to be 2,866 crashes prevented, 1,534 injuries prevented, and 82 lives saved for FY 2018.

Beginning with Version 1.2 of the model, the CIEM has estimated safety benefits associated with individual intervention types. Carriers receiving more than one type of intervention during the fiscal year are assigned an intervention type based on the nature of the first intervention it received during that year. Benefits associated with each intervention type are presented in Table 2 below.

Table 2. Estimated crashes and injuries prevented, and lives saved, by first investigation type, FYs 2016–2018.*

Carrier Size Group	All Carriers Receiving Interventions: Number of Carriers			Crashes Prevented			Injuries Prevented			Lives Saved		
	FY 16	FY 17	FY 18	FY 16	FY 17	FY 18	FY 16	FY 17	FY 18	FY 16	FY 17	FY 18
Onsite Focused	6,549	6,772	6,892	972	1,100	1,462	535	605	782	28	34	42
Onsite Comprehensive	5,469	5,929	5,484	822	1,271	1,135	434	699	607	23	39	32
Offsite Focused	122	86	223	0	0	0	0	0	0	0	0	0
Other Non-ratable Review	506	687	468	0	29	31	0	16	17	0	1	1
Warning Letter	30,377	26,889	26,884	5,523	5,865	6,622	3,043	3,224	3,545	160	180	189

*Note: Due to model formulas for calculations performed at finer levels of granularity, estimated safety benefits associated with each intervention type may not add up to the totals shown in Table 1.

1. INTRODUCTION

1.1 BACKGROUND

During the 1980s, Congress passed a series of legislative acts intended to strengthen motor carrier safety regulations. These measures led to the implementation of safety-oriented programs at both the Federal and State levels. The Surface Transportation Assistance Act of 1982 established the Motor Carrier Safety Assistance Program (MCSAP), a grants-in-aid program to States for conducting roadside inspection and traffic enforcement programs aimed at commercial motor vehicles (CMVs). The Motor Carrier Safety Act of 1984 directed the U.S. Department of Transportation (USDOT) to establish safety fitness standards for carriers. The USDOT, in conjunction with the States, implemented MCSAP to fund roadside inspection and traffic enforcement programs and a commercial motor carrier safety rating system based on onsite safety audits called compliance reviews (CRs).

The Safety Program Effectiveness Measurement Project was established to identify major functions and operations (programs) associated with the Federal Motor Carrier Safety Administration's (FMCSA's) mission and develop results oriented performance measures for the Agency's functions and operations, as called for in the Government Performance and Results Act of 1993 (GPRA). From 2002 through 2009, the benefits of CR activities were assessed using the Compliance Review Effectiveness Model (CREM).[1] In 2010, following an operational model test in select States, FMCSA began a phased implementation of its Compliance, Safety, Accountability (CSA) program, a redesign of the Agency's existing enforcement model. The CSA enforcement model includes an array of carrier intervention types, which replaced the one-size-fits-all CR intervention type implemented as part of the old enforcement model. The new enforcement model was designed to improve safety in the operation of CMVs.

1.2 PROJECT SCOPE

The Carrier Intervention Effectiveness Model (CIEM) measures the safety benefits of carrier interventions. The model incorporates both onsite comprehensive investigations and additional interventions, including but not limited to warning letters, onsite focused investigations, and offsite investigations. The model measures the benefits of the programs in terms of crashes prevented, lives saved, and injuries prevented. This approach yields national-level measurements that can be used to measure the effectiveness of FMCSA's carrier intervention program.

This report presents the results of the CIEM's implementation for carrier interventions in fiscal years (FY) 2017 and 2018, and describes the functionality of the model and how it is applied.

[1] Reports documenting these results are available at http://ai.fmcsa.dot.gov/pe/home.aspx.

[This page intentionally left blank.]

2. FMCSA CARRIER INTERVENTION EFFECTIVENESS MODEL

FMCSA employs a data-driven approach to oversee and enforce commercial motor carrier safety. This approach uses a variety of data sources to assign safety risks to motor carriers; the assigned safety risks are then used to prioritize carriers for interventions. The CSA enforcement approach uses a broad set of carrier interventions, giving safety investigators the flexibility to address safety problems more efficiently. This set of interventions includes less labor-intensive alternatives to an onsite comprehensive investigation, which focus on each motor carrier's specific safety problems. As a result, the CSA program enables FMCSA to reach a larger number of carriers. The CIEM measures the safety benefits from carrier interventions currently used by the Agency (including intervention types developed prior to the CSA program that the Agency continues to use), in terms of crashes prevented, injuries prevented, and lives saved.

2.1 MODEL STRUCTURE

The CIEM is a statistical impact evaluation model that uses historical data to compare the safety performance of carriers that have received FMCSA interventions to their safety performance prior to receiving interventions. This comparison is used to establish the extent of safety improvement that can be attributed to interventions. The model is designed to be implemented on an annual basis, focusing on carriers receiving interventions in a given fiscal year.

The model computes crash rates—defined as crashes per power unit (PU)—for carriers receiving interventions, distinguishing between their crash rates in defined periods prior to and following the interventions.(2) The difference between these pre- and post-intervention crash rates, once adjusted for exogenous factors measured by a comparison group, represents the change in the safety performance for these carriers during this timeframe. To control for potential systemic differences in how carriers of different size improve their safety performance after receiving an intervention, these calculations are performed for various carrier size groupings (based on their PU count) and then aggregated.(3)

To reduce the effect of confounding factors impacting the calculated change in safety performance, the difference between pre- and post-intervention crash rates is adjusted by the change in crash rate experienced by a comparison group (representing carriers that did not receive interventions) during a similar timeframe. This adjustment helps to remove the effect of historical trends and events (such as a national recession).

The CIEM uses a set of carefully designed filters to identify and remove carriers with missing or outlier crash or power unit data from the calculations. The model later extrapolates its initial estimates of safety benefits to the entire population of carriers receiving interventions, including those that were screened out of the model. The CIEM also determines the statistical significance

[2] PU values are used as a proxy for carrier exposure to crashes. While vehicle miles traveled (VMT) have the potential to serve as a useful proxy for exposure in the model at a future point in time, FMCSA believes that PU information in MCMIS is currently more reliable.

[3] While additional factors may be used to classify carriers into different groups (e.g., short- versus long-haul operations; for-hire versus private fleets), the Agency believes stratification by size is the best approach for assessing the efficacy of its interventions.

of the model output, and non-statistically significant findings are excluded from the total estimate of safety benefits calculated by the model.

2.2 CARRIERS WITH INTERVENTIONS: CARRIER TREATMENT GROUP

The model's treatment group consists of carriers that received at least one FMCSA carrier intervention during the fiscal year and passed a set of missing and outlier data filters.

The following set of interventions, recorded in FMCSA's Motor Carrier Management Information System (MCMIS), are used to select treatment group carriers:[4]

- Warning letters.
- Offsite State/Federal investigations (non-ratable).
- Onsite focused State/Federal investigations.
- Onsite comprehensive State/Federal investigations.
- State/Federal Security contact reviews.
- State/Federal Hazardous materials (HM) reviews.
- Other State/Federal Non-ratable reviews on interstate carriers.[5]
- FMCSA Performance and Registration Information Systems Management (PRISM) warning letters.

Carriers receiving one of these intervention types were then screened prior to placing them in the treatment group, based on the following requirements:

- Carrier was engaged in active operations and reported current nonzero PU counts to FMCSA for the pre- and post-intervention time periods considered by the model.
- Carrier was not a new entrant at any point in its pre- and post-intervention periods.
- Carrier's reported data met outlier tests to identify suspect crash and PU data.[6]

[4] The model currently does not include follow-up verifications, direct notices of violation, direct notices of claims, or Cooperative Safety Plans because the data currently in MCMIS were shown to be inconsistent in terms of completeness and accuracy. Safety audits are not considered a CSA intervention type. Nor are they assessed separately by this model, because safety audits are performed only on new entrant carriers, which have often not been in full operation during the entire 1-year pre-intervention period.

[5] This category includes non-ratable investigations that focus on specific aspects of a carrier's operations and are generally not triggered by one or more of the carrier's Behavioral Analysis and Safety Improvement Category (BASIC) scores, unlike the other intervention types listed, above.

[6] Outlier tests are: (a) driver-to-PU and PU-to-driver ratios cannot exceed 7.5, with the exception of exclusively driveaway/towaway carriers; (b) pre- to post-intervention and post- to pre-intervention change in PU count cannot exceed a factor of 3 for carrier size groups 1 and 2 or a factor of 1.75 for size groups 3 and 4. The following are exceptions: size group 1 and 2 carriers can exhibit a factor up to 5 if there is a corresponding change in the pre- to post-intervention or post- to pre-intervention driver count (between a factor of 1.5 and 10), and size group 3 carriers can exhibit a factor up to 2.5 if the corresponding change in driver count is by a factor between 1 and 5 (see **Error! Reference source not found.** for size group definitions). This filter allows more variability for smaller carriers because smaller PU changes result in larger proportional changes for these carriers compared to larger carriers; (c) to filter for suspiciously low and suspiciously high crash rates, pre- and post-intervention crash rates must be within five standard deviations of the carrier size group's mean crash rate, once all other filters have been implemented. Based on analysis of carrier crash incidence, this condition is overridden by any of the following conditions: if (i) the carrier is in size group 1 and has 5 or fewer crashes, or (ii) the carrier is in size groups 2, 3, or 4 and has 6 or fewer crashes; alternatively, carriers with 500 or more PUs must exhibit non-zero crashes regardless of how many standard deviations their crash rate is from the size group mean.

These requirements were initially based on those used in the CREM but were strengthened and refined to better identify suspect data.

2.3 CARRIERS WITHOUT INTERVENTIONS: COMPARISON GROUP

To isolate the effects of interventions from other factors that may have influenced carriers' crash rates more broadly, the treatment group's change in crash rate is adjusted for changes in the general carrier population's crash rates through the use of a comparison group. The comparison group consists of carriers that did not receive an intervention during the comparison period and passed a set of data filters similar to those applied to treatment group carriers.(7)

Beginning with Version 1.3 of the model, safety benefits adjustments based on the comparison group are performed at the monthly level. That is, pre- and post-intervention crash data from treatment group carriers with interventions occurring during a given month of the fiscal year are compared against historical data from the comparison group, using similar time intervals. For example, for treatment group carriers receiving interventions during the month of October, the comparison group's data for the pre-intervention time period comprises the 12-month interval immediately prior to the midpoint of this month, and comparison group data for the "post-intervention" time period comprises the 12-month interval immediately following the midpoint of this month. Thus, although there is only one comparison group, the model uses 12 different sets of pre- and post-intervention crash rate calculations, based on this group.(8) This process provides consistency to the data being compared between the two groups, in terms of the time periods being assessed, and helps to eliminate any influence from seasonality on this adjustment process.

Comparison group carriers are assigned to size classes, based on definitions identical to those used for the treatment group, and using similar data filters to control for incomplete or suspicious power unit data. This helps to control for differences associated with carrier size when the model calculates the adjusted crash rate changes for the treatment group.

2.4 MODEL DATA AND TIMEFRAMES

The model uses crash data reported by the States and carrier PU data obtained during interventions or from information submitted by carriers on the Motor Carrier Identification Report (Form MCS-150). These data, stored in MCMIS, are used to calculate pre- and post-intervention crash rates for treatment group carriers and corresponding crash rates for comparison group carriers. Crash data originating from State reporting systems are continuously fed into MCMIS via an automated interface, and a carrier's historical data in MCMIS may change over time, based on updated information received for earlier time periods, due to incompleteness in the original reporting. For this study, the most current MCMIS snapshots

[7] The comparison group filters are identical to the treatment group filters.

[8] Although there is only one comparison group, a few carriers may get excluded from some monthly calculations due to failing to meet particular monthly data filtering criteria.

available—which include the most current updates for prior months—are used to provide the most complete and accurate crash data available.[9]

For the treatment group, a carrier's pre-intervention PU value is based on the MCMIS monthly data snapshot from the time period immediately following the first intervention it receives during the fiscal year. This particular snapshot contains the most recent PU information for the carrier at the time of its intervention. The date of the carrier's first intervention is used in order to delineate the pre- and post-intervention periods during the fiscal year.[10] Some carriers receive multiple interventions within the modeled year. In these cases, the model does not determine the precise impact of each individual intervention type when calculating overall safety benefits derived from the CSA program. Rather, it estimates the combined effect of all interventions performed during the modeled year.

The 12-month period preceding a carrier's first intervention is defined as its pre-intervention period, while the 12-month period following this intervention is defined as its post-intervention period. The final monthly snapshot for a carrier's post-intervention period is used to define its post-intervention PU value. Pre- and post-intervention crash rates are calculated for each size group by summing the number of crashes occurring during each period, and then dividing by each period's PU value. Figure 1 illustrates the timeframes delineated by these data points for a hypothetical treatment group carrier with a first intervention in August 2015.[11]

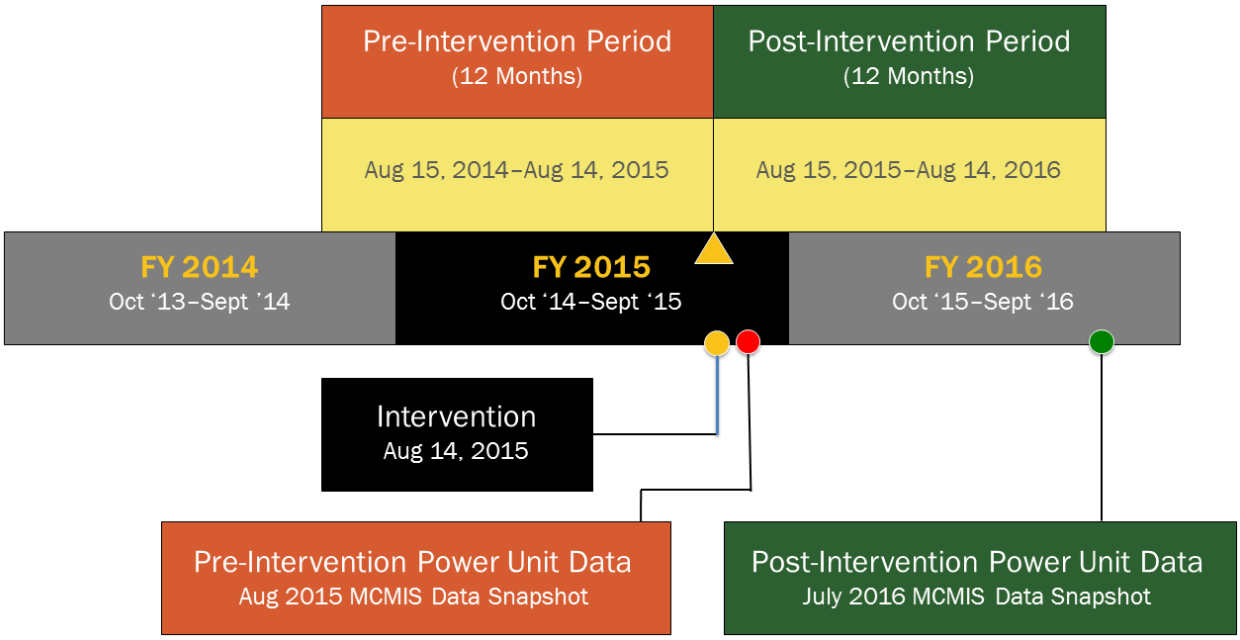

Figure 1. Diagram. Timeline for a carrier with a first intervention on August 14, 2015.

[9] Crash data for this report were taken from the December 2018 MCMIS data snapshot.

[10] Despite the use of the first intervention as a demarcation point, the safety impact of subsequent interventions in the same year is implicitly included in the model. Those subsequent interventions that occur before the end of the carrier's post-intervention period may have sizable impacts during this same period, which will be reflected in the post-intervention crash rates calculated by the model. Conversely, the impacts of subsequent interventions that take place after the post-intervention period are not accounted for in the current model but rather in the next annual implementation of the model, where the first follow-up intervention would serve to delineate new before and after periods.

[11] Crash rate statistics for pre-intervention and post-intervention periods for each carrier size group are based on summations of crash and PU data for all carriers (measured in accordance with the individual carrier's date of intervention) in the size group.

Beginning with Version 1.3 of the model, there are 12 sets of comparison group calculations for each carrier size group, providing 12 sets of pre- and post-intervention crash rates for carriers not receiving interventions, each based on using a different month to define the beginning and end of the 1-year pre- and post-intervention periods for these carriers. Treatment group carriers receiving interventions in a given month are paired with one of the 12 comparison group calculations, based on on the month in which the intervention occurred.

MCMIS monthly data snapshots provide the pre-intervention period PU values for each carrier in in each monthly comparison group, as in the case of the treatment group. As with the treatment group, the comparison group crash rate for each size group is calculated by summing the number of crashes occurring during each period, and then dividing by the corresponding PU value.

2.5 CALCULATION OF CRASHES PREVENTED

For each month in the fiscal year, the model uses pre- and post-intervention crash rates to determine the change in crash rates for the carriers whose interventions occurred in that month and for the comparison group, broken out by carrier size group. This change is converted to a percent measure by dividing the change by the original (pre-intervention) crash rate. The difference between the treatment and comparison groups' crash rate changes, known as the average treatment effect on the treated (ATET), is the estimated crash rate reduction attributable to interventions.[12] Figure 2 illustrates the steps used to determine this reduction in each size group.

$$\textit{Crash Rate Reduction Due to Interventions} = \left[\text{Treatment Group Crash Rate Reduction, pre- to post-intervention } \frac{[CR_{PRE} - CR_{POST}]}{CR_{PRE}}\right] - \left[\text{Comparison Group Crash Rate Reduction, pre- to post-FY midpoint } \frac{[CR_{PRE} - CR_{POST}]}{CR_{PRE}}\right]$$

Figure 2. Formula. Estimated percent crash rate reduction due to interventions for a given month.

Figure 3 shows how the ATET is converted to a measure of crashes prevented, taking into account the treatment group's pre- and post-intervention PU counts. This statistic is calculated separately for each carrier size group and added across the four size groups, yielding an initial estimate of total crashes prevented during the modeled fiscal year among treatment group carriers.

[12] See Abadie, Alberto (2005). *Semiparametric Difference-in-Differences Estimators*, Review of Economic Studies (72, 1-19) for further information on Average Treatment Effect on the Treated.

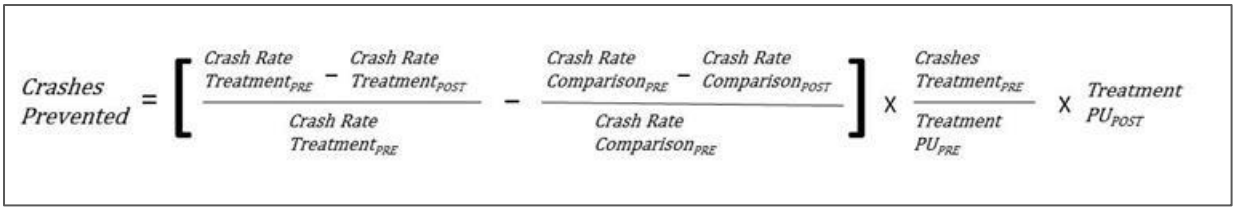

Figure 3. Formula. Initial estimate of crashes prevented as a result of interventions.

Three additional steps are required to estimate crashes prevented across the entire population of interstate and intrastate carriers receiving interventions. The first step identifies which "month by size class" crash rate reduction estimates are statistically significant (using an alpha=0.95 level of statistical significance). This test determines whether the actual ATET values differ from zero at the 0.05 statistical significance level (i.e., the 95 percent confidence interval around the estimated ATET does not include zero).[13] Crash rate changes that do not pass this test are not attributed to the interventions and are not used to estimate crashes prevented.

The next step for calculating crashes prevented across the motor carrier population is to account for the crashes prevented among those carriers receiving interventions but excluded from the treatment group due to missing or outlier data required as model inputs. Such carriers, on average, can be assumed to exhibit a response to interventions similar to that of the observed treatment group. Therefore, the calculated treatment group crash rate reductions are extrapolated to account for potential crashes prevented among these additional carriers. The sum of estimated crashes prevented among the treatment group carriers included in the model, as well as those filtered out of the model, represents the total estimated crashes prevented from the interventions performed in the given fiscal year, for each "month by size class" grouping considered by the model. In the final step of the model, all of the estimates of crashes prevented in each of the "month by size class" groupings are then summed together.

The extrapolated benefits are calculated by multiplying the initial nonextrapolated benefits by an expansion factor, equal to the total number of carriers receiving interventions during the fiscal year divided by the total number of carriers in the treatment group. Carrier counts used in the numerator of this expansion factor are prorated by the number of months they are in operation during the post-intervention period. For example, a carrier that was in business for only 6 months during the post-intervention period would only count as 6/12 (or 0.5) of a carrier. However, in those instances where the carrier is not in operation during all or part of the post-intervention period, due to having been placed out of service by an Agency enforcement action following an intervention, no proration occurs. In such instances, the model credits the Agency for the reduction in crashes associated with the carrier during the post-intervention period, conservatively assigning to the carrier a crash rate reduction equal to the average reduction associated with its month and size group.

[13] In statistical theory, crash rates calculated by the model fall into the category of ratio estimates. For further information on measuring the precision of ratio estimates, see Cochran, William G. (1977). *Sampling Techniques* (third edition).

2.6 CALCULATION OF OVERALL DIRECT SAFETY BENEFITS

Once the model estimates the total crashes prevented due to interventions performed during the fiscal year, it calculates estimates of injuries prevented and lives saved as a result of the crashes prevented, using historical MCMIS data to measure the likelihood of any given crash resulting in a fatality or injury. In this step in the model calculations, the model estimates 2-year average probabilities of a crash resulting in an injury or fatality. Thus for each model year, these probabilities are calculated from crash data in MCMIS spanning the modeled fiscal year and the prior fiscal year. The parameters in Figure 4, shown below, are estimated based on these probabilities.[14] Figure 4 presents the formulas for these calculations.

$$\textit{Number of } \textbf{\textit{fatal crashes}} \textit{ prevented} =$$

$$\textit{probability of a fatal crash given a crash occurred } \boldsymbol{x} \textit{ number of crashes prevented}$$

$$\textit{Number of } \textbf{\textit{injury crashes}} \textit{ prevented} =$$

$$\textit{probability of an injury crash given a crash occurred } \boldsymbol{x} \textit{ number of crashes prevented}$$

$$\textbf{\textit{Lives saved}} =$$

$$\textit{number of fatal crashes prevented } \boldsymbol{x} \textit{ average number of fatalities per fatal crash}$$

$$\textbf{\textit{Injuries prevented}} =$$

$$(\textit{average number of injuries per fatal crash } \boldsymbol{x} \textit{ number of fatal crashes prevented}) + (\textit{average number of injuries per injury crash } \boldsymbol{x} \textit{ number of injury crashes prevented})$$

Note: All averages are for the 2-year period encompassing the modeled fiscal year and the prior year.

Figure 4. Multiple formulas. Formulas for calculating numbers of fatal crashes prevented, injury crashes prevented, lives saved, and injuries prevented.

2.7 SAFETY BENEFITS ASSOCIATED WITH INDIVIDUAL INTERVENTION TYPES

To determine safety benefits associated with individual intervention types, each carrier receiving an intervention during the fiscal year is linked to a particular intervention type based on the nature of the first intervention it received during that year.

Because one carrier can receive more than one type of intervention during a given fiscal year, some degree of confounding occurs among the intervention types with this procedure. However, the number of carriers that receive more than one type of intervention during a given fiscal year is very small (less than 5 percent) and, consequently, the impact of this confounding is considered minimal. Such carriers are kept in the treatment group because removing them from the estimation process could introduce an upward bias in the estimated safety benefits for any

[14] The distribution of crashes by severity is determined at the national level, and is assumed to be constant across the carrier size groups.

given intervention type, given that a carrier generally receives a second intervention only when the carrier continues to underperform.

3. RESULTS OF IMPLEMENTING THE MODEL

3.1 RESULTS INCLUDING ALL INTERVENTION TYPES

The model was implemented for carriers receiving interventions in FY 2017 and FY 2018 based on Version 1.3 of model. In addition, previous estimates for FY 2016, based on Version 1.2 of the model, were recalculated based on the newer model version. Table 3 presents counts of intervention types conducted during these 3 fiscal years. The first three columns give the number of interventions conducted by FMCSA and its State partners. The next three columns give the number of carriers receiving these intervention types as their first intervention in each fiscal year.[15]

Table 3. Total interventions by type, and number of carriers receiving interventions, by first intervention, for FYs 2016–2018.

Intervention Type	Number of Interventions FY 2016	Number of Interventions FY 2017	Number of Interventions FY 2018	Number of Carriers Receiving Interventions (by first intervention) FY 2016	Number of Carriers Receiving Interventions (by first intervention) FY 2017	Number of Carriers Receiving Interventions (by first intervention) FY 2018
Warning Letter	30,530	26,982	26,970	30,377	26,889	26,884
Offsite Investigation	127	91	238	122	86	223
Onsite Focused Investigation	7,111	7,497	7,573	6,549	6,772	6,892
Onsite Comprehensive Investigation*	5,980	6,387	5,925	5,469	5,929	5,484
Non-ratable Review	611	791	534	601	687	468
Total	**44,359**	**41,748**	**41,240**	**43,023**	**40,363**	**39,951**

*The category of investigations previously included as CRs is now included as onsite comprehensive investigations. **Note: Investigations listed here include both State and Federal investigations.**

Total interventions decreased slightly by roughly 6 percent in FY 2017 (primarily due to a decrease in warning letters), and by an additional 1 percent in FY 2018.

Table 4 displays the number of carriers receiving interventions that failed the various data quality filtering criteria used by the model (see Section 2.2), and the resulting number of treatment group carriers for the last 3 years modeled.

[15] As explained in the previous section, model estimates are based on changes in carrier safety performance for those receiving interventions during a given fiscal year.

Table 4. Carriers excluded from treatment group by filter criteria, for FYs 2016–2018.

Filter Criteria	FY 2016	FY 2017	FY 2018
Inactive during the pre or post periods	5,247	4,997	4,824
Zero power units during the pre or post periods	5,332	5,096	4,902
New entrant during the pre or post periods	15,514	12,772	12,086
Fails driver-to-PU ratios	164	145	136
Fails change in pre-PU to post-PU or pre-driver to post-driver ratios	815	828	890
Carriers with 500+ PUs and zero crashes	8	8	6
Fails crash rate thresholds	23	25	22
Having an out-of-service order during the pre or post period*	2,738	2,338	2,338
Total excluded carriers**	**18,069**	**15,289**	14,680
Total carriers receiving interventions	**43,023**	**40,363**	**39,951**
Percent excluded	**42%**	**38%**	**37%**
Total carriers in treatment group	**24,954**	**25,074**	**25,271**

* The "out-of-service" data filter has been revised beginning with the FY 2016 model to correct the computer code identifying out-of-service order dates; hence the large increase in carriers identified by this filter, beginning in this year.

** A carrier may be excluded by multiple criteria; therefore, the total excluded carriers does not equal the sum of the carriers meeting each filter criteria.

The first three filters in Table 4 account for the majority of the carriers excluded from the treatment group across the 3 years. The remaining filters impact a much smaller number of carriers, and the proportion of total carriers screened out by them during each fiscal year is relatively stable. Table 5 presents the number of treatment and comparison group carriers for fiscal years 2016-2018, by size group.

Table 5. Number of treatment and comparison group carriers for FYs 2016–2018, by size group.

Carrier Size Group	FY 2016 Treatment Group	FY 2017 Treatment Group	FY 2018 Treatment Group	FY 2016 Comparison Group	FY 2017 Comparison Group	FY 2018 Comparison Group
1 (1–5 PUs)	13,964	13,836	13,938	878,692	912,694	957,145
2 (6–20 PUs)	7,531	7,720	7,751	79,581	74,936	78,052
3 (21–100 PUs)	2,881	2,939	2986	17,300	15,488	16,120
4 (100+ PUs)	578	579	596	2,856	2,381	2,427
Total	**24,954**	**25,074**	**25,271**	**978,429**	**1,005,499**	**1,053,744**

3.1.1 Crash Rate Reduction

Table 6 presents the initial treatment and comparison group crash rate reductions experienced by both groups during the post-intervention period, by year and carrier size group.

Table 6. Initial treatment and comparison group crash rate reductions for FYs 2016–2018, by size group.

Carrier Size Group	FY 2016 Treatment Group	FY 2017 Treatment Group	FY 2018 Treatment Group	FY 2016 Comparison Group	FY 2017 Comparison Group	FY 2018 Comparison Group
1 (1–5 PUs)	46.4%	48.0%	50.9%	-2.7%	-5.2%	-0.4%
2 (6–20 PUs)	32.3%	31.0%	35.6%	-3.2%	-6.8%	-4.2%
3 (21–100 PUs)	20.0%	17.0%	20.9%	-0.1%	-5.1%	-0.7%
4 (100+ PUs)	0.9%	1.6%	3.0%	-1.0%	-3.2%	-1.6%

Note: Negative crash rate reductions indicate increases in crash rates.

One notes the comparison group crash rate reductions in all size groups are negative for the three fiscal years shown in the table (indicating increases in crash rates). These values will amplify the crash rate reductions of the treatment group carriers for these two size groups, when the adjusted net crash rate reductions due to interventions are calculated.

Table 7 presents the net percent reductions in crash rates, from the pre- to the post-intervention periods, for the treatment group, by fiscal year and carrier size group, after accounting for changes in the comparison group.

Table 7. Net percent reductions in crash rates for treatment group carriers, FYs 2016–2018.

By Carrier Size Group	FY 2016	FY 2017	FY 2018
1 (1–5 PUs)	49.7%	53.2%	51.4%
2 (6–20 PUs)	36.5%	37.8%	39.8%
3 (21–100 PUs)	16.4%	21.1%	21.0%
4 (100+ PUs)	2.1%	2.5%	3.1%

Note: Due to rounding, values in this table may not equal the treatment group crash rate reduction minus comparison group crash reduction from Table 6.

Based on Version 1.3 of the model, the net crash rate reductions, after adjusting for crash rate changes in the comparison group, are positive and statistically significant[16] in each size group, for all three fiscal years, indicating a net decrease in crash rates. The table also indicates, as in previous years, that smaller carriers exhibited greater net crash rate reductions following Agency interventions than did their larger counterparts.

3.1.2 Safety Benefits

Crash severity statistics for fiscal years 2016–2018 are calculated based on a 2-year average, and are shown in Table 8. These statistics are used by the model to convert model estimates of crashes prevented, as a result of the interventions, to additional estimates for injuries prevented and lives saved.

[16] Note that statistical significance indicates that the change appears to be real, rather than a random effect, and does not reflect on the magnitude of the reduction.

Table 8. 2-year average crash severity statistics for FYs 2016, 2017, and 2018.

Fiscal Year	Fatal Crashes (% of Total)	Injury Crashes (% of total)	Fatalities per Fatal Crash	Injuries per Fatal Crash	Injuries per Injury Crash
2016	2.60	36.2	1.11	0.89	1.46
2017	2.71	35.9	1.13	0.84	1.47
2018	2.56	35.6	1.11	0.83	1.44

Table 9 presents estimated safety benefits associated with FMCSA carrier interventions for FYs 2016–18, in terms of crashes prevented, injuries prevented, and lives saved within the treatment group—i.e., carriers receiving interventions that passed the model's data filters.

Table 9. Estimated crashes prevented, injuries prevented, and lives saved in the treatment group for FYs 2016, 2017, and 2018.

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2016	24,954	4,832	2,662	140
2017	25,074	5,921	3,255	182
2018	25,271	6,599	3,532	188

Table 10 extrapolates these benefits to all carriers receiving interventions during each of the 3 fiscal years, including those screened out of the initial model calculations by the data filters. Based on this extrapolation, it is estimated that interventions conducted during FY 2018 prevented 9,927 crashes, resulting in 5,153 injuries prevented, and 275 lives saved.(17)

Table 10. Estimated crashes prevented, injuries prevented, and lives saved for all carriers receiving interventions for FYs 2016, 2017, and 2018.

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2016	42,028	7,648	4,213	**222**
2017	39,554	8,764	4,818	**269**
2018	39,248	9,627	5,153	**275**

3.2 RESULTS EXCLUDING WARNING LETTER AS A FIRST INTERVENTION

Because the issuance of such a letter does not involve any investigative work on the part of the Agency, removing these carriers from the model helps to identify safety benefits specifically associated with safety investigator and program analyst personnel-hours pertaining to Agency investigations. This section presents the results of implementing the model for carriers who received intervention types other than warning letters as their first intervention.

[17] Note that the safety benefits for FY16, based on Version 1.3 of the model, are slightly higher than the previously published estimates produced for FY16, based on Version 1.2.

Table 11 presents the number of treatment group carriers, by size group, excluding carriers that received a warning letter as a first intervention during fiscal years 2016–2018.

Table 11. Number of treatment group carriers, excluding carriers that received a warning letter as their first intervention, by size group, for FYs 2016–2018.

Carrier Size Group	FY 2016	FY 2017	FY 2018
1 (1–5 PUs)	4,429	4,835	4,647
2 (6–20 PUs)	3,082	3,315	3,259
3 (21–100 PUs)	1,370	1,406	1,405
4 (100+ PUs)	306	259	303
Total	**9,187**	**9,815**	**9,614**

3.2.1 Crash Rate Reduction

Table 12 presents the percent reductions in crash rate, by carrier size group, by fiscal year, for treatment group carriers whose first intervention was not a warning letter, and for comparison group carriers. The comparison group comprises the same carriers used for the comparison group in the overall model, as shown in Table 5.

Table 12. Treatment and comparison group percent reductions in crash rate, excluding carriers that received a warning letter as their first intervention, by size group, for FYs 2016–2018.

Carrier Size Group	FY 2016 Treatment Group	FY 2017 Treatment Group	FY 2018 Treatment Group	FY 2016 Comparison Group	FY 2017 Comparison Group	FY 2018 Comparison Group
1 (1–5 PUs)	39.2%	42.6%	46.9%	-2.7%	-5.2%	-4.4%
2 (6–20 PUs)	24.6%	25.4%	26.0%	-3.2%	-6.8%	-4.2%
3 (21–100 PUs)	17.8%	12.0%	16.7%	-0.1%	-5.1%	-0.7%
4 (100+ PUs)	0.1%	-0.2%	3.0%	-1.0%	-3.2%	-1.6%

Note: A negative crash rate reduction indicates an increase in crash rate.

Table 13 presents the crash rate percent reductions, by carrier size group, by fiscal year, for these same treatment carriers, adjusted for the crash rate reductions in the comparison group.

Table 13. Net percent reductions in crash rates, excluding carriers that received a warning letter as their first intervention, by size group, for FYs 2016–2018.

Carrier Size Group	FY 2016	FY 2017	FY 2018
1 (1–5 PUs)	41.1%	47.4%	46.9%
2 (6–20 PUs)	27.7%	30.9%	27.7%
3 (21–100 PUs)	16.7%	13.5%	14.3%
4 (100+ PUs)	2.2%	2.0%	3.2%

Note: Due to rounding, values in this table may not equal the treatment group crash rates minus the comparison group crash rates from Table 12.

Carriers receiving a first intervention other than a warning letter in fiscal years 2017 and 2018 exhibited significant crash rate reductions in all size groups. However, compared to the results for all intervention types, including warning letters (see Table 7), the net crash rate reductions for the first three size groups are about 10–30 percent lower. Hence, the impact of the warning letter

upon carrier crash reduction, at least for those carriers targeted to receive them, appears greater than what was achieved with the other intervention types. However, one should note that carriers slated for non-warning letter interventions as a first intervention type (i.e., investigations) tend to have poorer safety profiles than those receiving warning letters, and may present more of a challenge in terms of changing their behavior. Due to differences in the safety profiles of the carriers receiving different types of interventions, direct comparisons concerning the relative effectiveness of the various intervention types cannot be made (see Section 3.3.2).

3.2.2 Safety Benefits

Table 14 and Table 15 present estimated safety benefits, by fiscal year, as a result of FMCSA interventions, excluding carriers whose first intervention in the fiscal year was a warning letter. Table 14 presents the estimated crashes prevented, injuries prevented, and lives saved among treatment group carriers.

Table 14. Estimated crashes prevented, injuries prevented, and lives saved for all carriers within the treatment group, excluding carriers that received a warning letter as their first intervention, FYs 2016–2018.

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2016	9,187	1,582	871	46
2017	9,815	2,000	1,100	61
2018	9,614	2,219	1,188	63

Table 15 extrapolates these benefits to all carriers receiving these interventions, including those screened out of the initial model calculations by the data filters. The safety benefits presented in Table 14 and Table 15 are based on statistically significant net crash rate reductions, as reported in Table 13. Safety benefits extrapolated to all carriers whose first intervention was not a warning letter in FY 2018 are estimated to be 2,866 crashes prevented, 1,534 injuries prevented, and 82 lives saved.

Table 15. Estimated crashes prevented, injuries prevented, and lives saved for all carriers receiving an intervention, excluding carriers that received a warning letter as their first intervention, FYs 2016–2018.

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2016	12,408	2,054	1,132	59
2017	13,200	2,601	1,430	80
2018	12,819	2,866	1,534	82

3.3 RESULTS FOR INDIVIDUAL INTERVENTION TYPES

This section presents results of implementing the model for carriers with specific types of investigations, by size group, determined by the first intervention received by the carrier during fiscal years 2016–2018. Table 16 presents the number of treatment group carriers during fiscal years 2016–2018, by first intervention type and size group.

Table 16. Number of treatment group carriers by first intervention type and size group, for FYs 2016–2018.

Carrier Size Group	Onsite Focused			Onsite Comprehensive			Offsite Focused			Non-Ratable Reviews			Warning Letter		
	FY16	FY17	FY18	FY16	FY17	FY18	FY16	FY17	FY18	FY16	FY17	FY18	FY16	FY17	FY18
1 (1–5 PUs)	2,275	2,376	2,455	1,931	2,179	1,933	66	22	100	157	258	159	9,535	9,001	9,291
2 (6–20 PUs)	1,848	1,911	1,934	1,125	1,275	1,192	28	42	56	81	87	77	4,449	4,405	4,492
3 (21–100 PUs)	777	771	805	527	585	537	14	12	35	52	38	28	1,511	1,533	1,581
4 (≥100 PUs)	164	129	157	124	119	119	3	3	12	15	8	15	272	320	293
Total	**5,064**	**5,187**	**5,351**	**3,707**	**4,158**	**3,781**	**111**	**79**	**203**	**305**	**391**	**279**	**15,767**	**15,259**	**15,657**

3.3.1 Crash Rate Reduction

Table 17 presents the treatment group initial percent reductions in crash rate from the pre- to the post-intervention period, by intervention type and carrier size group, adjusted for the crash rate reductions in the comparison group. Again, the comparison group comprises the same comparison group carriers used for the overall model, as reported in Table 5.

For Onsite Focused investigations, net crash rate reductions were statistically significant for all size groups in both FY17 and FY18, and net crash rate reductions associated with Onsite Comprehensive investigations were statistically significant in the first three size groups in FY 2017 and statistically significant in all size groups in FY 2018. Net crash reductions associated with Warning Letters were statistically significant in all four size groups in both fiscal years. And, as with the overall model, the largest reductions occurred in the two smallest size groups.

For Offsite Focused reviews, ATET values were not statistically significant in any size group during any year (possibly due to the small sample size associated with this investigation type, making it less likely that statistically significant results will be obtained; see Table 3),[18], and Non-ratable reviews only showed statistically significant net crash rate reductions in the first two size groups in fiscal years 2017 and 2018 (again, possibly due to small sample sizes).

[18] In the case of offsite investigations, the Agency anticipates it will have more data to assess in future years due to policy changes concerning when such investigations may be conducted. This may allow for a more accurate assessment of the effectiveness of these particular interventions.

Table 17. Percent net crash rate reductions (treatment minus comparison group) for individual intervention, FYs 2016–2018

Carrier Size Group	Onsite Focused			Onsite Comprehensive			Offsite Focused			Non-Ratable Reviews			Warning Letter		
	FY 16	FY 17	FY 18	FY 16	FY 17	FY 18	FY 16	FY 17	FY 18	FY 16	FY 17	FY 18	FY 16	FY 17	FY 18
1 (1–5 PUs)	27.5%	28.6%	38.0%	49.0%	62.4%	48.3%	-	-	-	-	16.2%	32.5%	52.8%	55.9%	53.3%
2 (6–20 PUs)	23.1%	20.4%	20.6%	22.6%	38.1%	36.5%	-	-	-	-	21.5%	17.2%	43.0%	42.1%	47.6%
3 (21–100 PUs)	9.9%	7.8%	14.1%	12.6%	13.5%	13.4%	-	-	-	-	0%	-	18.9%	23.9%	23.8%
4 (≥100 PUs)	-	6.6%	2.5%	2.7%	-	2.2%	-	-	-	-	0%	-	3.2%	12.9%	4.7%

Note: Negative crash rate reductions indicate increases in crash rates; dash indicates non-statistically significant net reduction.

3.3.2 Safety Benefits

Table 18 presents the estimated safety benefits experienced by carriers receiving various types of interventions as a first intervention in fiscal years 2016–2018.

Table 18. Estimated crashes and injuries prevented, and lives saved, by first intervention type, for FYs 2016–2018.*

Intervention Type	All Carriers Receiving Interventions: Number of Carriers			Crashes Prevented			Injuries Prevented			Lives Saved		
	FY16	FY17	FY18	FY16	FY17	FY18	FY16	FY17	FY18	FY16	FY17	FY18
Onsite Focused	6,549	6,772	6,892	972	1,100	1,462	535	605	782	28	34	42
Onsite Comprehensive	5,469	5,929	5,484	822	1,271	1,135	434	699	607	23	39	32
Offsite Focused	122	86	223	0	0	0	0	0	0	0	0	0
Other Non-ratable Review	506	687	468	0	29	31	0	16	17	0	1	1
Warning Letter	30,377	26,889	26,884	5,523	5,865	6,622	3,043	3,224	3,545	160	180	189

*Note: Due to model calculations being performed at a finer level of granularity, estimated safety benefits associated with each intervention type may not add up to the totals shown in Table 1.

Carriers whose first intervention during FY 2018 was an onsite focused investigation constitute 17 percent of all carriers represented in the table and account for 16 percent of the estimated crashes and injuries prevented, and estimated lives saved. Carriers whose first intervention began as an onsite comprehensive investigation constitute 14 percent of the carriers represented in the table and account for 12 percent of the estimated crashes and injuries prevented, and estimated lives saved. Carriers whose first intervention began as a warning letter constitute 67 percent of the carriers represented in the table and account for 72 percent of the estimated crashes and injuries prevented, and estimated lives saved. Hence, for the most common types of interventions, the percentage of estimated total lives saved stemming from each intervention type closely aligns with the percentage of interventions associated with that type.

These findings do not necessarily speak to the relative effectiveness of the individual intervention types, because the safety profile of a typical carrier receiving one type of intervention may drastically differ from the safety profile of a carrier receiving another type. However, the data do suggest that all intervention types considered by the model result in positive benefits, based on 1-year pre- and post-intervention assessment periods. Also, the total effect of the intervention type, in terms of crashes prevented and lives saved, is not only a function of the percent reduction in carrier crash rates associated with the intervention type (as shown in Table 17), but also a function of the total number of carriers receiving that intervention type and the number of drivers associated with those carriers.

Lastly, one should bear in mind that the CIEM cannot control for the possibility of carriers experiencing "regression to the mean" during the post-intervention period. This concept refers to the idea that crashes are rare events and many carriers, particularly small ones, may experience a decrease in their post-intervention crash rates simply because their crash experience in the pre-intervention period was an anomaly. In other words, during the post-intervention period carriers may simply revert to a pattern of behavior (in terms of crashes) that is historically more typical for them. In such situations, it is at least conceivable that this "regression to the mean" is a key contributor to crash reduction in the post-intervention period, rather than the intervention.

Whether it is due to regression to the mean or to the possibility that smaller carriers simply respond more positively to Agency interventions, the disparity in net crash rate reductions across carrier size groups becomes relevant when assessing individual intervention types because the distribution of intervention types differs across size groups. For example, Table 16 indicates that 59 percent of the warning letters in FY 2018 sent to treatment group carriers were associated with carriers having 5 or fewer power units, while only 2 percent were associated with carriers having more than 100 power units. This compares to 46 percent of onsite focused and 51 percent of onsite comprehensive reviews being performed on carriers with 5 or fewer power units, and roughly 3 percent of these same reviews being performed on carriers with more than 100 power units.

[This page intentionally left blank.]

4. CONCLUSIONS

CIEM provides FMCSA with a tool for measuring the safety benefits of carrier interventions. The model incorporates intervention types currently used by the Agency, including those measured by the previous model, CREM, and new intervention types (i.e., warning letters, offsite investigations, onsite focused investigations, other non-ratable reviews, and onsite comprehensive investigations) when assessing safety benefits.

Overall, the population of carriers targeted for interventions by FMCSA has experienced reduced post-intervention crash rates in FY 2017 and FY 2018 (as in prior years). Consistent with prior years' results, crash rate reductions are generally more pronounced for the smaller carrier size groups.

Further analysis evaluated the subset of treatment group carriers whose first intervention each year was not a warning letter. Excluding carriers whose first intervention was a warning letter helps to identify those safety benefits specifically associated with safety investigator and program analyst labor hours.

Model estimates for FY 2017 and 2018 included benefits associated with individual intervention types. For this analysis, each carrier receiving an intervention during the fiscal year was linked to a particular intervention type according to the first intervention type it received during that year. The model found that the portion of the total estimated lives saved that stems from each intervention type closely aligns with the percentage of interventions performed for that type. These findings, however, do not necessarily speak to the relative effectiveness of the individual intervention types for at least two reasons. First, the safety profile of a typical carrier receiving one type of intervention may drastically differ from the safety profile of a carrier receiving another type. In addition, the impact of the intervention, in terms of total crashes prevented and lives saved, is not only a function of the achievable percent reduction in carrier crash rates associated with the intervention (as shown in Table 17), but also a function of the total number of carriers receiving the intervention type and the number of drivers associated with those carriers.

It is also important to note that the CIEM cannot control for the possibility of carriers experiencing "regression to the mean" during the post-intervention period. This refers to the notion that crashes are rare events and, due to this fact, many carriers, particularly small ones, may experience a decrease in their crash rates in the post-intervention period, simply by virtue of the fact that their crash experience in the pre-intervention period was an anomaly. Smaller carriers are more susceptible to "regression to the mean."

In summary, the FY 2017 and 2018 data on pre- and post-intervention safety performance provide evidence for the effectiveness of FMCSA's carrier interventions, as in previous years. Future implementation of the model will enable FMCSA to continue to measure the impact of carrier interventions performed by the Agency.