FMCSA Safety Program Effectiveness Measurement: Carrier Intervention Effectiveness Model (CIEM), Version 1.3 Report for Fiscal Year 2019 Interventions

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

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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 2017–2019.

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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 year 2019.

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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.)

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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

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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 in place of the one-size-fits-all compliance review (CR) that formed the basis of the prior 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 associated with agency interventions. The model incorporates both onsite comprehensive reviews (similar to the original CRs), as well as newer intervention types (i.e., warning letters, offsite investigations, onsite focused investigations, and other non-ratable reviews) when assessing these benefits.

The CIEM produces national-level measurements for the effectiveness of FMCSA's carrier intervention program, measured in terms of crashes and injuries prevented, and lives saved. It is designed to be implemented on an annual basis, focusing on carriers receiving both State- and Federal-conducted interventions in a given fiscal year (FY).

MODEL APPROACH

The model computes combined carrier crash rates—defined in terms of crashes per power unit (PU)—for carriers receiving interventions, for time intervals corresponding to periods occurring both before and after the interventions. The difference between the carriers's pre- and post-intervention crash rates measures how much its safety performance improved during this timeframe. To control for systemic differences in crash rates between small and large carriers, and in how these carriers may respond to interventions, separate before-and-after comparisons are made for various carrier size groups, defined in terms of PU count.

To help remove the effect of external 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 experienced by carriers not receiving interventions during the same timeframe. 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, the initial pre- to post-intervention crash rate changes for carriers receiving interventions in a given month are adjusted, based on the crash rate change in the general (non-intervened upon) 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 2019, based on Version 1.3 of model. Total carriers receiving interventions in FY 2019 dropped by five percent, from 26,884 in FY 2018 to 25,574 in FY 2019 (see Table 2). 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, below.

Table 1. Safety benefits: All interventions.

Fiscal Year	Crashes Prevented	Injuries Prevented	Lives Saved
2017	8,765	4,818	269
2018	9,627	5,153	275
2019	8,379	4,519	246

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 model helps to identify safety benefits specifically linked to safety investigator and program analyst hours dedicated to Agency investigations. This analysis showed that 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 1,998 crashes prevented, 1,078 injuries prevented, and 59 lives saved for FY 2019.

The CIEM also estimates 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 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 intervention type, FY 2017–19.*

Intervention Type	All Carriers Receiving Interventions: Number of Carriers			Crashes Prevented			Injuries Prevented			Lives Saved		
	FY 17	FY 18	FY 19	FY 17	FY 18	FY 19	FY 17	FY 18	FY 19	FY 17	FY 18	FY 19
Onsite Focused	6,772	6,892	5,668	1,100	1,462	955	605	782	515	34	42	28
Onsite Comprehensive	5,929	5,484	5,130	1,271	1,135	809	699	607	436	39	32	24
Offsite Focused	86	223	891	0	0	6	0	0	3	0	0	0
Other Non-ratable Review	687	468	313	29	31	0	16	17	0	1	1	0
Warning Letter	26,889	26,884	25,574	5,865	6,622	6,245	3,224	3,545	3,369	180	189	183

* Due to model calculations being performed at finer levels of granularity for these estimates, estimated safety benefits associated with each intervention type do not add up to the totals shown in Table 1. Much of this disparity can be explained by smaller sample sizes in the size groups, which potentially impacts the statistical significance of the results obtained in each size class.

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 new carrier intervention types, as well as the previously existing CR intervention type developed under the agency's previous enforcement model (renamed to Onsite Comprehensive Investigation, under CSA).

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 program in terms of crashes prevented, lives saved, and injuries prevented. These measurements can be used to assess the effectiveness of FMCSA's carrier intervention program.

This report presents the results of the CIEM's implementation for carrier interventions conducted during fiscal year (FY) 2019, and also describes the methodology used by the model.

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

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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 and 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, for time intervals corresponding to periods occurring both before and after 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 crash rates between small and large carriers, and in how these carriers may respond to interventions, these calculations are performed for various carrier size groupings (based on carrier PU counts) and then aggregated.(3)

To reduce the effect of exogenous 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 or extreme weather).

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 effectiveness of its interventions.

of the model output, and non-statistically significant changes in safety performance improvement 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 both received at least one FMCSA carrier intervention during the fiscal year and passed a set of data filters that check for missing and outlier data.

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

- Warning letters.
- Offsite Focused 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]

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

- Carrier was engaged in active operations and reported current nonzero PU counts to FMCSA for both 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 crash and PU information met outlier tests to identify suspicious 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 for these actions are inconsistent in terms of completeness and accuracy. Safety audits are also not considered by this model, as 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 Section 3.1, Table 5 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 for the CIEM.

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 to account for changes in the general motor 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 assessment period and also passed a set of data filters identical to those applied to the treatment group carriers.

Beginning with Version 1.3 of the model, safety benefits adjustments based on the comparison group are performed separately for treatment group carriers receiving interventions in a particular month. 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 pre- and post-intervention time intervals based on that same month. For example, for treatment group carriers receiving interventions during the month of October, the comparison group's data for the pre-intervention time period comes from the 12-month interval immediately prior to the midpoint of this month (October 15th), and the comparison group's data for the "post-intervention" time period comes from the 12-month interval immediately following this date. 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.(7) 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 groups, 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 submitted to the agency, due to incompleteness in the original reporting. For this study, the most current MCMIS snapshots available—which

[7] 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.

include the most current updates for prior months—are used to capture the most complete and accurate crash data available.[8]

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.[9] 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.

Each treatment carrier's pre-intervention period is defined as the 12-month period preceding its first intervention, while its post-intervention period is defined as 12-month period following this intervention. The last monthly MCMIS snapshot occurring during the carrier's post-intervention period is used to obtain its post-intervention PU value. Pre- and post-intervention period crash rates are calculated for each size group by summing, across all treatment group carriers, the number of carrier crashes occurring during during these assessment periods, and then dividing by the sum of the carrier PU values associated with these periods. Figure 1 illustrates the timeframes delineated by these data points for a hypothetical treatment group carrier with a first intervention in August 2015.[10]

[8] Crash data for this report were taken from the December 2019 MCMIS data snapshot.

[9] 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. However, the impacts of subsequent interventions occurring after the post-intervention period are not taken into account by the model, but rather are captured in the following annual run of the model, where the first follow-up intervention during that particular fiscal year would serve to delineate new "before" and "after" periods for the carrier.

[10] 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.

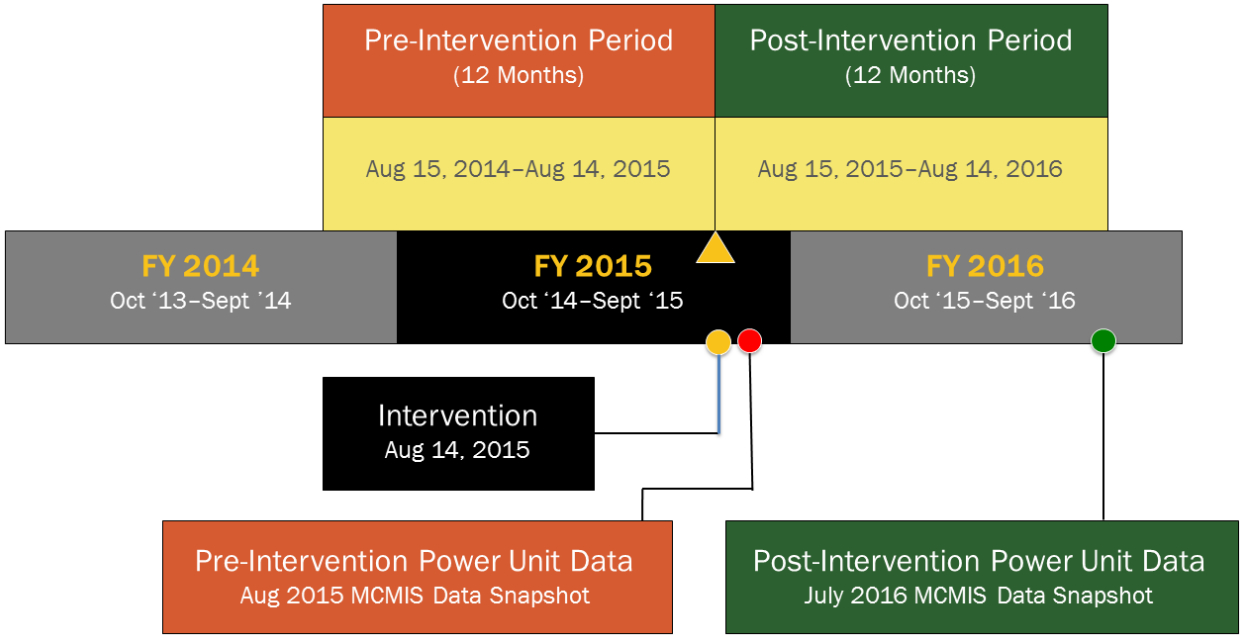

Figure 1. Diagram. Timeline for a carrier with a first intervention on August 14, 2015.

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, according to the month in which their first intervention occurred during the fiscal year.

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 both the carriers whose interventions occurred in that month and for the comparison group carriers, 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' percent change in crash rate, known as the average treatment effect on the treated (ATET), becomes the estimated treatment carrier crash rate reduction attributable to interventions.[11] Figure 2 illustrates the steps used to determine this reduction in each size group.

[11] 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.

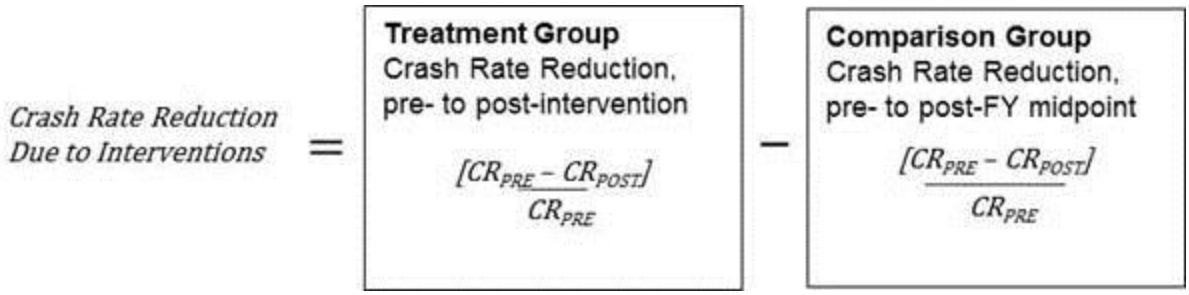

Figure 2. Formula. Estimated size group percent crash rate reduction due to interventions for a given month.

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 then summed across the size groups, yielding an initial estimate of total crashes prevented during the modeled fiscal year among treatment group carriers.

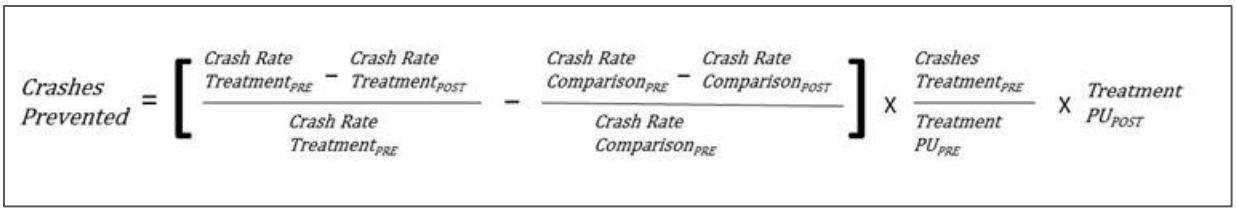

Figure 3. Formula. Initial estimate of crashes prevented as a result of interventions.

Three additional steps are required to estimate crashes prevented across the entire population of interstate and intrastate carriers receiving interventions. The first step identifies those "month by size group" crash rate reduction estimates that 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).(12) 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 crashes prevented for the treatment group 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 group" 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 group" groupings are then summed together.

[12] 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).

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 by size" grouping.

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 estimates the number 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, the model estimates 2-year average probabilities of a crash resulting in an injury or fatality, based on 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.[13]

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

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

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

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

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

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

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

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

Note: All probabilities and 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.

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

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 small (less than 5 percent) and, consequently, the impact of this confounding is considered minimal. Carriers with more than one intervention 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 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 CIEM was implemented for carriers receiving interventions during FY 2019 (based on Version 1.3 of model). Table 3 presents counts of the various intervention types both considered by the model and conducted during FY 2019, as well as the two prior 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.[14]

Table 3. Total interventions by type, and number of carriers receiving interventions, by first intervention, for FYs 2017–2019.

Intervention Type	Number of Interventions FY 2017	Number of Interventions FY 2018	Number of Interventions FY 2019	Number of Carriers Receiving Interventions (by first intervention) FY 2017	Number of Carriers Receiving Interventions (by first intervention) FY 2018	Number of Carriers Receiving Interventions (by first intervention) FY 2019
Warning Letter	26,982	26,970	25,652	26,889	26,884	25,574
Offsite Focused Investigation	91	238	1,013	86	223	891
Onsite Focused Investigation	7,497	7,573	6,177	6,772	6,892	5,668
Onsite Comprehensive Investigation*	6,387	5,925	5,494	5,929	5,484	5,130
Other Non-ratable Review	791	534	342	687	468	313
Total	**41,748**	**41,240**	**38,678**	**40,363**	**39,951**	**37,576**

*Investigations previously labeled as CRs are now included in the "onsite comprehensive investigations" category.
Note: Investigation counts include both State and Federal investigations.

Total interventions decreased by roughly six percent in FY 2019. While both the number of Onsite Comprehensive and Onsite Focused investigations decreased, this drop was partially offset by a large increase in Offsite Investigations in FY 2019.

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 available to the model, for the last 3 years modeled.

[14] 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 2017–2019.

Filter Criteria	FY 2017	FY 2018	FY 2019
Inactive during the pre or post periods	4,997	4,824	4,422
Zero power units during the pre or post periods	5,096	4,902	4,534
New entrant during the pre or post periods	12,772	12,086	11,350
Fails driver-to-PU ratios	145	136	155
Fails change in pre-PU to post-PU or pre-driver to post-driver ratios	828	890	869
Carriers with 500+ PUs and zero crashes	8	6	7
Fails crash rate thresholds	25	22	29
Having an out-of-service order during the pre or post period	2,338	2,338	2,246
Total excluded carriers*	**15,289**	**14,680**	**13,847**
Total carriers receiving interventions	**40,363**	**39,951**	**37,576**
Percent excluded	**38%**	**37%**	**37%**
Total carriers in treatment group	**25,074**	**25,271**	**23,729**

* 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 three years. The remaining filters impact a smaller number of carriers. Table 5 presents the number of treatment and comparison group carriers for fiscal years 2017–2019, by size group.

Table 5. Number of treatment and comparison group carriers for FYs 2017–19, by size group.

Carrier Size Group	FY 2017 Treatment Group	FY 2018 Treatment Group	FY 2019 Treatment Group	FY 2017 Comparison Group	FY 2018 Comparison Group	FY 2019 Comparison Group
1 (1–5 PUs)	13,836	13,938	12,653	912,694	957,145	985,854
2 (6–20 PUs)	7,720	7,751	7,521	74,936	78,052	80,993
3 (21–100 PUs)	2,939	2986	2,969	15,488	16,120	16,576
4 (100+ PUs)	579	596	586	2,381	2,427	2,395
Total	**25,074**	**25,271**	**23,729**	**1,005,499**	**1,053,744**	**1,085,818**

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 2017–2019, by size group.

Carrier Size Group	FY 2017 Treatment Group	FY 2018 Treatment Group	FY 2019 Treatment Group	FY 2017 Comparison Group	FY 2018 Comparison Group	FY 2019 Comparison Group
1 (1–5 PUs)	48.0%	50.9%	56.7%	-5.2%	-0.4%	6.2%
2 (6–20 PUs)	31.0%	35.6%	39.7%	-6.8%	-4.2%	5.5%
3 (21–100 PUs)	17.0%	20.9%	27.2%	-5.1%	-0.7%	7.7%
4 (100+ PUs)	1.6%	3.0%	12.3%	-3.2%	-1.6%	7.6%

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

One notes from the table that, unlike FYs 2017 and 2018, comparison group crash rate reductions in FY 2019 are positive in all size groups, consistent with national trends during this time period. In addition, the magnitude of these changes is slightly higher than what is seen in the two previous years.(15) These values will reduce the final estimated crash rate reductions of the treatment group carriers for the size groups, when the adjusted net crash rate reductions due to interventions are calculated by the model.

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 2017–2019.

Carrier Size Group	FY 2017	FY 2018	FY 2019
1 (1–5 PUs)	53.2%	51.4%	50.3%
2 (6–20 PUs)	37.8%	39.8%	34.1%
3 (21–100 PUs)	21.1%	21.0%	18.7%
4 (100+ PUs)	2.5%	3.1%	1.6%

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.

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 suggests that smaller carriers tend to experience greater net crash rate reductions following Agency interventions than their larger counterparts.

[15] Large truck crashes decreased by roughly ten percent during FY 2020, relative to FY 2019. All other things being equal, this change would tend to lower the "post-intervention" crash rate of the comparison group carriers when the model is run for FY 2019.

[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.

3.1.2 Safety Benefits

Crash severity statistics for fiscal years 2017–2019, calculated using a 2-year average, 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.

Table 8. 2-year average crash severity statistics for FYs 2017–2019.

Fiscal Year	Fatal Crashes (% of Total)	Injury Crashes (% of total)	Fatalities per Fatal Crash	Injuries per Fatal Crash	Injuries per Injury Crash
2017	2.71	35.9	1.13	0.84	1.47
2018	2.56	35.6	1.11	0.83	1.44
2019	2.61	35.8	1.12	0.92	1.44

Table 9 presents estimated safety benefits associated with FMCSA carrier interventions for FYs 2017–19, 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 2017–2019.

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2017	25,074	5,921	3,255	182
2018	25,271	6,599	3,532	188
2019	23,729	5,656	3,051	166

Table 10 extrapolates these benefits to all carriers receiving interventions, 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 2019 prevented 8,379 crashes, resulting in 4,519 injuries prevented, and 246 lives saved.

Table 10. Estimated crashes prevented, injuries prevented, and lives saved for all carriers receiving interventions for FYs 2017–2019.

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2017	39,554	8,764	4,818	269
2018	39,248	9,627	5,153	275
2019	37,367	8,379	4,519	246

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 dedicated 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.

Table 11 presents the number of treatment group carriers, by size group, excluding carriers that received a warning letter as a first intervention for fiscal years 2017–19.

Table 11. Number of treatment group carriers, excluding carriers that received a warning letter as their first intervention, by size group, for FYs 2017–2019.

Carrier Size Group	FY 2017	FY 2018	FY 2019
1 (1–5 PUs)	4,835	4,647	4,205
2 (6–20 PUs)	3,315	3,259	2,969
3 (21–100 PUs)	1,406	1,405	1,284
4 (100+ PUs)	259	303	280
Total	**9,815**	**9,614**	**8,738**

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 2017–2019.

Carrier Size Group	FY 2017 Treatment Group	FY 2018 Treatment Group	FY 2019 Treatment Group	FY 2017 Comparison Group	FY 2018 Comparison Group	FY 2019 Comparison Group
1 (1–5 PUs)	42.6%	46.9%	50.1%	-5.2%	-0.4%	6.2%
2 (6–20 PUs)	25.4%	26.0%	30.9%	-6.8%	-4.2%	5.5%
3 (21–100 PUs)	12.0%	16.7%	21.8%	-5.1%	-0.7%	7.7%
4 (100+ PUs)	-0.2%	3.0%	11.1%	-3.2%	-1.6%	7.6%

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

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

Table 13. Net percent reductions in crash rate, excluding carriers that received a warning letter as their first intervention, by size group, for FYs 2017–2019.

Carrier Size Group	FY 2017	FY 2018	FY 2019
1 (1–5 PUs)	47.5%	46.9%	43.5%
2 (6–20 PUs)	30.9%	27.7%	22.5%
3 (21–100 PUs)	13.5%	14.3%	7.7%
4 (100+ PUs)	2.0%	3.2%	1.6%

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 2019 exhibited statistically 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 slightly lower, by about 6–12 percentage points, depending on the stratum. 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. Potential differences in the safety profiles of carriers receiving different types of interventions make direct comparisons concerning the relative effectiveness of the various intervention types problematic (see Section 3.3.2).

3.2.2 Safety Benefits

Table 14 and Table 15 present estimated safety benefits, by fiscal year, from 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 for this subset of treatment group carriers.

Table 14. Estimated crashes prevented, injuries prevented, and lives saved for treatment group carriers, excluding carriers that received a warning letter as their first intervention, FYs 2017–2019.

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2017	9,815	2,000	1,100	61
2018	9,614	2,219	1,188	63
2019	8,738	1,490	804	44

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 2019 are estimated to be 1,998 crashes prevented, 1,078 injuries prevented, and 59 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 2017–2019.

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2017	13,200	2,601	1,430	80
2018	12,819	2,866	1,534	82
2019	11,853	1,998	1,078	59

3.3 RESULTS FOR INDIVIDUAL INTERVENTION TYPES

This section presents results of implementing the model for carriers receiving specific types of interventions, by size group and type of first intervention, for fiscal year 2019. Table 16, below, presents the number of treatment group carriers for fiscal years 2019, by first intervention type and size group. The table indicates that, with the exception of carriers in the largest size group (101+ power units), treatment group carriers assigned Onsite Focused, Onsite Comprehensive, Offsite Focused interventions, or Warning Letters as a first intervention had markedly higher crash rates during the 12 months prior to their interventions than their counterparts not receiving interventions (i.e., the comparison group). This is most noticable in the smallest group (1–5 power units), where the combined pre-intervention crash rates associated with each of these four interventions are at least one order of magnitude higher than the comparison group crash rate for this size group. Among these intervention types, carriers receiving Warning Letters had the highest combined pre-intervention crash rate in this small size group (13 crashes per 100 power units per year vs. 1 crash per 100 power units per year for the comparison group).

In the largest size group (101+ power units), carriers assigned Onsite Focused, Onsite Comprehensive, Offsite Focused, and Non-Ratable Review interventions all had pre-intervention period crash rates that were moderately higher than the crash rate associated with the comparison group. However, crash rates for carriers assigned Warning Letters were relatively comparable to those of the comparison in this size group.

Generally speaking, the combined carrier pre-intervention crash rates for carriers assigned Onsite Focused interventions were slightly higher than crash rates associated with carriers assigned other intervention types, across the various size groups (the one exception to this occurs with carriers assigned a Warning Letter in the 1–5 power unit size group, where the combined carrier crash rate was slightly higher (0.133 versus 0.128 for carriers assigned Onsite Focused interventions)).

Table 16. Number of treatment group carriers and pre-intervention crash rates for both treatment group and comparison group (crashes per power unit per year), by first intervention type and size group, for FY 2019*

Carrier Size (PUs)	Cmpr. Grp. Crash Rate	Onsite Focused		Onsite Comprehensive		Offsite Focused		Non-Ratable Reviews		Warning Letter	
		Carrier Count	Pre-Interv. Crsh. Rate	Carrier Count	Pre-Interv. Crsh. Rate	Carrier Count	Pre-Interv. Crsh. Rate	Carrier Count	Pre-Interv. Crsh. Rate	Carrier Count	Pre-Interv. Crsh. Rate
1–5	0.011	1,907	0.128	1,859	0.110	317	0.077	122	0.049	8,448	0.133
6–20	0.015	1,557	0.084	1,065	0.067	304	0.054	43	0.053	4,552	0.069
21–100	0.020	667	0.063	464	0.052	136	0.050	17	0.044	1,685	0.044
101+	0.024	128	0.047	102	0.029	41	0.034	9	0.044	306	0.028
Total	**NA**	**4,259**	**NA**	**3,490**	**NA**	**798**	**NA**	**191**	**NA**	**14,991**	**NA**

* Treatment carriers' pre-intervention crash rates are based on each carrier's 12-month crash history prior to its intervention. For each size group, this crash rate is equal to the total treatment group crashes, summed across each carrier's 12-month pre-intervention period, divided by the total number of power units associated with these carriers during these time periods. Comparison group pre-intervention crash rates are based on a weighted average

of the various 12-month pre-intervention crash rates associated with each month where an intervention was performed, as discussed in Section 2.3.

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 FY19, and net crash rate reductions associated with Onsite Comprehensive investigations were statistically significant for the first three size groups. As in previous fiscal years, net crash reductions associated with Warning Letters were statistically significant in all four size groups. For these three intervention types (Onsite Focused investigations, Onsite Comprehensive investigations, and Warning Letters) the largest reductions occurred in the two smallest size groups, as in the case of results based on the overall model (see Table 7).

For Offsite Focused reviews, ATET values were only statistically significant in the 6–20 power unit size group during FY 2019 (most likely due to the small sample size associated with this investigation type in the various size groups; see Table 3),[17]. Non-ratable reviews could not be shown to have a statistically significant impact on crash rates in any size group (again, possibly due, in part, to small sample sizes).

Table 17. Percent net crash rate reductions (treatment minus comparison group) for individual intervention, for FY 2019.

Carrier Size Group	Onsite Focused	Onsite Comprehensive	Offsite Focused	Non-Ratable Reviews	Warning Letter
1 (1–5 PUs)	38.0%	46.9%	-	-	53.1%
2 (6–20 PUs)	19.6%	30.3%	2.9%	-	39.9%
3 (21–100 PUs)	7.2%	4.9%	-	-	23.6%
4 (≥100 PUs)	1.0%	-	-	-	2.7%

Note: dash indicates non-statistically significant net reduction.

[17] 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 should allow for a more accurate assessment of the effectiveness of these particular interventions.

3.3.3 Safety Benefits

Table 18 presents the estimated safety benefits experienced by carriers receiving various types of interventions as a first intervention, for fiscal years 2017–2019.

Table 18. Estimated crashes and injuries prevented, and lives saved, by first intervention type, for FYs 2017–2019.*

Intervention Type	Number of Carriers			Crashes Prevented			Injuries Prevented			Lives Saved		
	FY17	FY18	FY19	FY17	FY18	FY19	FY17	FY18	FY19	FY17	FY18	FY19
Onsite Focused	6,772	6,892	5,668	1,100	1,462	955	605	782	515	34	42	28
Onsite Comprehensive	5,929	5,484	5,130	1,271	1,135	809	699	607	436	39	32	24
Offsite Focused	86	223	891	0	0	6	0	0	3	0	0	0
Other Non-ratable Review	687	468	313	29	31	0	16	17	0	1	1	0
Warning Letter	26,889	26,884	25,574	5,865	6,622	6,245	3,224	3,545	3,369	180	189	183

* 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. Some of this disparity may be due to smaller sample sizes available when calculating safety benefits associated with specific intervention types conducted in a particular month, for the size group.

Carriers whose first intervention during FY 2019 was an onsite focused investigation constitute 15 percent of all carriers represented in the table and account for 11 percent of the estimated crashes and injuries prevented, and estimated lives saved. Carriers whose first intervention began as an onsite comprehensive investigation constitute approximately 14 percent of the carriers represented in the table and account for approximately 10 percent of the estimated crashes and injuries prevented, and estimated lives saved. Carriers whose first intervention began as a warning letter constitute 68 percent of the carriers represented in the table and account for approximately 75 percent of the estimated crashes and injuries prevented, and estimated lives saved. The slightly disproportional amount amount of the safety benefits associated with Warning Letters is most likely attributable to a higher proportion of these intervention being associated with small carriers: 66 percent of the carriers receiving Warning Letters as a first intervention were in the smallest size group (1–5 PUs), compared to 49 percent for carriers receiving Onsite Focused interventions, and 58 percent of carriers receiving Onsite Comprehensive investigations as a first intervention (not shown in tables). Carriers in this size group experienced the largest crash rate reductions across all intervention types (see Table 17).

These findings do not necessarily speak to the relative effectiveness of the individual intervention types, because the safety profile of a carrier assigned one intervention type may drastically differ from the safety profile of a carrier assigned another. However, the data continue to suggest that the major intervention types considered by the model (Onsite Focused and Onsite Comprehensive investigations, as well as Warning Letters) result in positive benefits, based on 1-year pre- and post-intervention assessment periods.[18] One should also note that the total effect of the intervention type (in terms of crashes and injuries prevented and lives saved) is not only a

[18] Positive but small benefits were also measured for Offsite Focused investigations during FY 2019. As sample sizes for this intervention type increase in future years, the agency will be able to better assess the impact of these interventions on crash rates.

function of the percent reduction in carrier crash rates associated with the intervention type (as shown in Table 16), 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 measure the extent to which carriers may experience "regression to the mean" during the post-intervention period. This concept refers to the notion 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 history during 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, since the distribution of the intervention types differs across size groups, as discussed above.

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, Onsite Comprehensive investigations and other non-ratable reviews) when assessing safety benefits.

Overall, the population of carriers targeted for interventions by FMCSA in FY 2019 experienced a reduction in crash rates during the 1-year periods subsequent to their interventions, as in prior years. Consistent with prior years' results, crash rate reductions were 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 2019 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 assigned to it during that year. The model found positive safety benefits for the main intervention types used by the agency, in terms of crashes prevented, injuries prevented, and lives saved. These findings, however, do not necessarily speak to the relative effectiveness of one individual type versus another, for 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 and injuries prevented and lives saved, is not only a function of the achieved 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 that intervention type and the number of drivers associated with those carriers.

It is also important to note that the CIEM cannot measure the extent to which carriers may experience "regression to the mean" during the post-intervention period. This refers to the notion that crashes are rare events and, consequently, 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 history in the pre-intervention period was an anomaly. Smaller carriers are more susceptible to "regression to the mean."

In summary, the FY 2019 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.