FMCSA Safety Program Effectiveness Measurement: Carrier Intervention Effectiveness Model (CIEM), Version 1.2 Report for Fiscal Year 2016 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 year 2016.

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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 2016.

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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.)

TABLE OF CONTENTS

LIST OF FIGURES (AND FORMULAS)

LIST OF TABLES

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 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, 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 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 between small and large carrier operations, 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 a corresponding timeframe. In addition, a set of carefully designed filters is used to identify and remove carriers with missing and outlier data from the calculations.

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 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 2016. Total interventions increased from 34,695 in FY 2015 to 44,359 in FY 2016.

Statistically significant crash rate reductions occurred for carriers in three of the 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
2015	7,136	3,965	212
2016	7,405	4,079	214

Additional Analysis

Additional insight can be gained by excluding warning letters from the model. 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. In this further analysis, carriers whose first intervention was not a warning letter also exhibited statistically significant crash rate reductions in three of the four carrier size groups. Benefits from this subset of FY16 interventions are estimated to be 2,100 crashes prevented, 1,157 injuries prevented, and 61 lives saved.

Version 1.2 of the CIEM 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 it received during that year. Benefits associated with each intervention type are presented in Table 2, below.

Table 2. Estimated crashes avoided, injuries prevented, and lives saved, by investigation type, FY 2016.*

Intervention Type	All Carriers Receiving Interventions: Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
Onsite Focused	6,548	1,193	657	35
Onsite Comprehensive	5,470	902	497	26
Offsite Focused	122	0	0	0
Non-rateable Review	506	0	0	0
Warning Letter	30,377	5,385	2,966	156

*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.

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, the safety fitness determination process, and a commercial motor carrier 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 invetigations 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 year (FY) 2016 and describes the functionality of the model and how it is applied. Technical details of the model are presented in the "FMCSA Safety Program Effectiveness Measurement: Carrier Intervention Effectiveness Model, Version 1.1, Technical Report," available at: https://doi.org/10.21949/1502628.

[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, 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 carriers' pre- and post-intervention crash rates, once adjusted for exogenous factors based on the comparison group, represents the change in their safety performance 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 comparison groups (e.g., short- versus long-haul operations; for-hire versus private fleets), the agency believe stratification by size provides the most useful information for assessing the efficacy of its interventions.

of its own results, and non-statistically significant findings are excluded from the total estimation of safety benefits calculated in 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 investigations.
- Onsite focused investigations.
- Onsite comprehensive investigations.
- Cargo tank facility reviews.
- Security contact reviews.
- Hazardous materials (HM) reviews.
- Other Non-ratable reviews on interstate carriers.
- Performance and Registration Information Systems Management (PRISM) warning letters.[5]

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 active and reported nonzero PU counts.
- 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] This version of the model 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] Further information on PRISM is provided by FMCSA at https://www.fmcsa.dot.gov/information-systems/prism/performance-and-registration-information-systems-management-prism.

[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 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.

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)

Comparison group carriers are assigned to size groups based on definitions identical to those used for the treatment group. 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 available—which include the most current updates for prior months—are used to provide 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.

[7] The comparison group filters are identical to the treatment group filters. However, since the comparison group carriers do not have intervention dates, their power unit data for these calculations are always based on the modeled year's MCMIS April data snapshot for the pre-intervention period and on the subsequent year's September snapshot for the post-intervention period.

[8] Crash data for this report were taken from the December 2017 MCMIS data snapshot.

[9] Despite the use of the first intervention as a demarcation point, the impacts of subsequent interventions in the same year are 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.

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.[10]

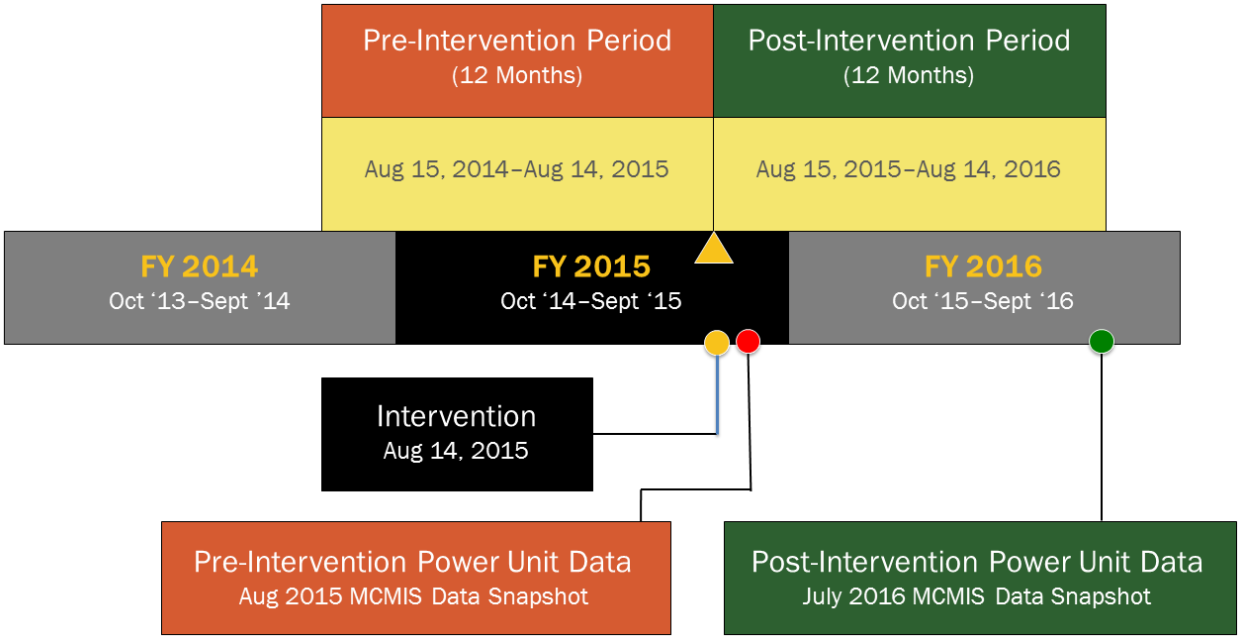

Figure 1. Diagram. Timeline for a carrier with a first intervention on August 14, 2015.

For the comparison group, periods corresponding to the treatment group's pre- and post-intervention periods are defined as the 18 months preceding and following the midpoint of the fiscal year (March 31st), respectively. Hence, the comparison group pre-intervention period covers the entire fiscal year prior to the modeled year, while the post-intervention period covers the entire fiscal year following the modeled year. These longer periods for the comparison group (compared to the treatment group's 12-month periods) ensure that the comparison group pre- and post-intervention periods cover the entire range of potential pre- and post-intervention periods for any given carrier in the treatment group.

The MCMIS data snapshot following March 31 provides the pre-intervention period PU values for each carrier in the comparison group, and the final snapshot of the post-intervention period provides post-intervention period PU values. 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.[11] Figure 2 gives the pre- and

[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.

[11] To account for the comparison group's pre- and post-intervention periods being longer than those for the treatment group (18 versus 12 months), comparison group crash rates are divided by 1.5 to yield annual crash rates that may be compared to those of the treatment group..

post-intervention timeframes and corresponding MCMIS snapshot dates for the FY 2015 comparison group.

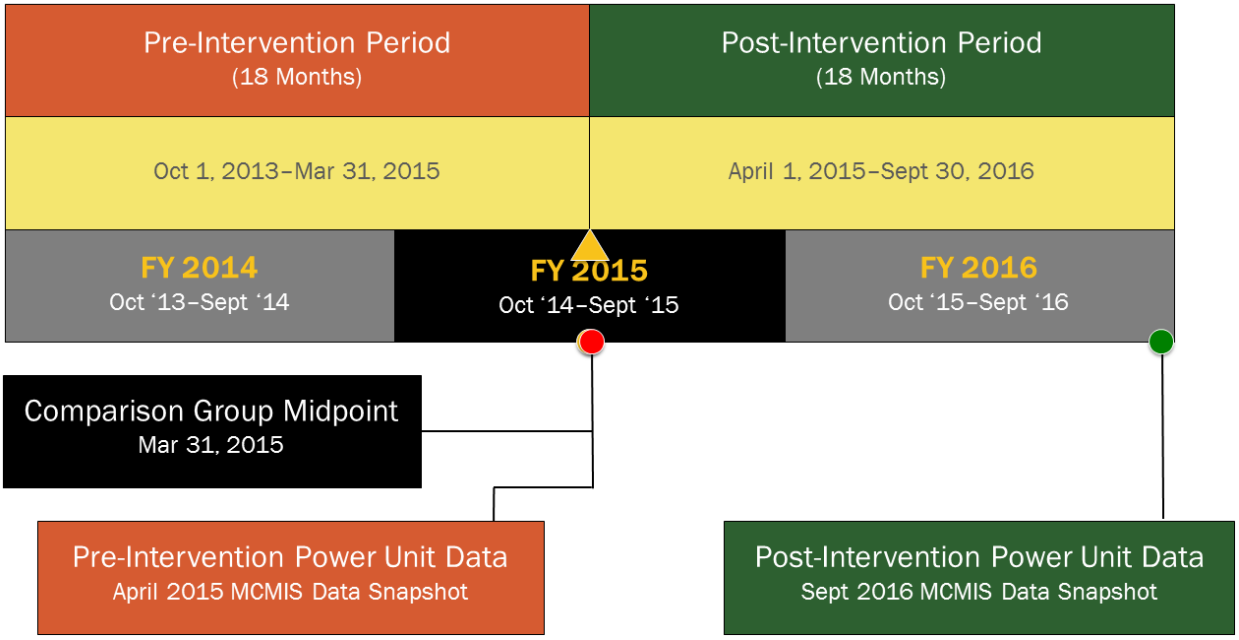

Figure 2. Diagram. Timeline for an FY 2015 comparison group carrier.

2.5 CALCULATION OF CRASHES PREVENTED

The model uses pre- and post-intervention crash rates to determine the change in crash rates, by carrier size group, for the treatment and comparison groups. 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 3 illustrates the steps used to determine this reduction in each size group.

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

Figure 3. Formula. Estimated Percent Crash rate reduction due to interventions.

[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 4 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 reduction 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.

$$\text{Crashes Prevented} = \left[\frac{\text{Crash Rate Treatment}_{PRE} - \text{Crash Rate Treatment}_{POST}}{\text{Crash Rate Treatment}_{PRE}} - \frac{\text{Crash Rate Comparison}_{PRE} - \text{Crash Rate Comparison}_{POST}}{\text{Crash Rate Comparison}_{PRE}} \right] \times \frac{\text{Crashes Treatment}_{PRE}}{\text{Treatment PU}_{PRE}} \times \text{Treatment PU}_{POST}$$

Figure 4. Formula. Initial estimate of crashes prevented as a result of interventions.

Two additional steps are required to estimate crashes prevented across the entire population of interstate and intrastate carriers. The first step identifies which initial crash rate reduction estimates are statistically significant (using an alpha=0.95 level of significance). This test determines whether the actual (as opposed to estimated) 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 final 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 and those filtered out of the model represents the total estimated crashes prevented as a result of the interventions performed in a given fiscal year.

The extrapolated benefits are calculated by multiplying the initially calculated 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. Version 1.2 of the CIEM introduces several changes to this extrapolation step for FY 2016. In Version 1.2, 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 agency is credited for the reduction in crashes associated with the carrier during the post-intervention period,

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

conservatively assigning to the carrier a crash rate reduction equal to the average reduction associated with its size group.

2.6 CALCULATION OF OVERALL DIRECT SAFETY BENEFITS

Once the model estimates the total crashes prevented due to interventions performed during the fiscal year, injuries prevented and lives saved as a result of the crashes prevented can be estimated using historical MCMIS data to estimate the likelihood of any given crash resulting in a fatality or injury. The model estimates 2-year average probabilities of a crash resulting in an injury or fatality, along with 2-year average values for the number of injuries and fatalities in such crashes. Hence, for each model year, these probabilities are calculated using crashes in MCMIS that occurred during the modeled fiscal year and the prior fiscal year. The parameters in Figure 5, shown below, are estimated based on these probabilities.[14] Figure 5 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 5. 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

Version 1.2 of the CIEM introduces additional estimates of safety benefits associated with individual intervention types. For this step of the model, 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,

[14] The distribution of crashes by severity is determined at the national level, assuming the same distribution holds across the carrier size groups.

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 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 the specified intervention types during FY 2016. Table 3 presents information on interventions conducted during FY 2016 and for the 2 preceding fiscal years. The first three columns show the number of interventions conducted by FMCSA and its State partners. The next three columns report the number of carriers receiving these intervention types as their first intervention in each fiscal year. As explained in the previous section, the model uses the number of carriers that had one or more interventions in a given fiscal year. Hence the totals in the last three columns represent the total number of carriers considered by the model for each modeled year.

Table 3. Total interventions by type, and number of carriers receiving interventions, by first intervention, for FY 2014, 2015, and 2016.

Intervention Type	Number of Interventions FY 2014	Number of Interventions FY2015	Number of Interventions FY 2016	Number of Carriers Receiving Interventions (by first intervention) FY 2014	Number of Carriers Receiving Interventions (by first intervention) FY 2015	Number of Carriers Receiving Interventions (by first intervention) FY 2016
CSA Warning Letter	20,535	20,443	30,530	20,529	20,437	30,377
Offsite Investigation	381	169	127	334	146	122
Onsite Focused Investigation	7,376	7,911	7,110	6,995	7,471	6,549
Onsite Comprehensive Investigation*	5,891	5,395	5,981	5,587	5,140	5,469
Non-ratable Review	749	777	611	687	740	506
Total	**34,932**	**34,695**	**44,359**	**34,132**	**33,934**	**43,023**

*CRs are now included as onsite comprehensive investigations.

Total interventions increased from FY 2015 to FY 2016 by 28 percent, due primarily to a 49-percent increase in warning letters from the previous year. The increase in total interventions in FY 2016 follows a slight decline (less than 1 percent) in total interventions in FY 2015.

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

Table 4. Carriers excluded from FY 2016 treatment group, by filter criteria.

Filter Criteria	FY 2014	FY 2015	FY 2016
Inactive during the pre- or post- periods	1,954	2,004	5,247
Zero power units during the pre- or post- periods	2,001	2,066	5,332
New entrant during the pre- or post- periods	8,144	8,514	15,514
Fails driver-to-PU ratios	153	126	165
Fails change in pre-PU to post-PU or pre-driver to post-driver ratios	594	575	815
Carriers with 500+ PUs and zero crashes	5	6	8
Fails crash rate thresholds	17	20	23
Having an out-of-service order during the pre or post period*	46	57	2,738
Total excluded carriers**	**9,793**	**10,071**	**18,070**
Total carriers receiving interventions	**34,680**	**33,934**	**43,023**
Percent excluded	**28.2%**	**29.7%**	**42.0%**
Total carriers in treatment group	**24,339**	**23,863**	**24,953**

* 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 in this year. However, the impact on the total excluded carrier count in the table is minimal because most carriers failing this data filter were already excluded by one or more of the other filters.

** 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 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 FY 2016 and the 2 preceding fiscal years by size group.

Table 5. Number of treatment and comparison group carriers for FY 2014–16, by size group.

Carrier Size Group	FY 2014 Treatment Group	FY 2015 Treatment Group	FY 2016 Treatment Group	FY 2014 Comparison Group	FY 2015 Comparison Group	FY 2016 Comparison Group
1 (1–5 PUs)	13,652	13,185	13,963	888,154	756,119	797,214
2 (6–20 PUs)	7,199	7,207	7,531	77,184	68,190	71,037
3 (21–100 PUs)	2,879	2,855	2,881	15,613	13,975	14,557
4 (100+ PUs)	609	616	578	2,235	2,253	2,314
Total	**24,339**	**23,863**	**24,953**	**983,186**	**840,537**	**885,122**

3.1.1 Crash Rate Reduction

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

Table 6. Initial treatment and comparison group crash rate reductions for FY 2014–16, by size group.

Carrier Size Group	FY 2014 Treatment Group	FY 2015 Treatment Group	FY 2016 Treatment Group	FY 2014 Comparison Group	FY 2015 Comparison Group	FY 2016 Comparison Group
1 (1–5 PUs)	44.3%	51.8%	46.4%	-2.6%	-1.6%	-1.2%
2 (6–20 PUs)	28.2%	35.9%	33.0%	-7.3%	-1.3%	-1.6%

Carrier Size Group	FY 2014 Treatment Group	FY 2015 Treatment Group	FY 2016 Treatment Group	FY 2014 Comparison Group	FY 2015 Comparison Group	FY 2016 Comparison Group
3 (21–100 PUs)	17.4%	22.8%	20.0%	-3.4%	0.4%	0.8%
4 (100+ PUs)	2.7%	4.3%	0.9%	2.6%	3.1%	-0.3%

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

Note that the comparison group crash rate reductions for size groups 1, 2, and 4 are negative in FY 2016 (indicating increases in crash rates); these values will amplify the crash rate reductions of the treatment group carriers for these two size groups in the subsequent step of the model, when the adjusted, net crash rate reductions due to interventions are calculated. Conversely, the positive reduction in crash rate for size group 3 of the comparison group will reduce the net crash rate reduction for this size group.

Table 7 presents the net percent reductions in crash rates, from the pre- to the post-intervention periods, for the treatment group, by 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, FY 2016.

By Carrier Size Group	FY 2014	FY 2015	FY 2016
1 (1–5 PUs)	47.0%	53.4%	47.7%
2 (6–20 PUs)	35.5%	37.2%	34.5%
3 (21–100 PUs)	20.9%	22.4%	19.2%
4 (100+ PUs)	0.2%*	1.2%*	1.1%*

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

*Non-statistically significant adjusted reduction.

The table indicates that, as in previous years, smaller carriers exhibited greater net crash rate reductions following Agency interventions than did their larger counterparts. This finding is consistent with results obtained from the previous enforcement model, CREM, used to calculate safety benefits for years 2002–09.

As in the two previous years, which showed statistically significant net crash rate reductions occurring in all size groups except size group 4, the FY 2016 crash rate reduction was not statistically significant for size group 4.

3.1.2 Safety Benefits

Crash severity statistics FY 2014–16 are calculated based on a 2-year average and shown in Table 8.

Table 8. Lives saved and injuries prevented are calculated using 2-year average crash severity statistics, as follows.

Fiscal Year	Fatal Crashes (% of Total)	Injury Crashes (% of total)	Fatalities per Fatal Crash	Injuries per Fatal Crash	Injuries per Injury Crash
FY 2014	2.6%	36.7%	1.12	1.02	1.48

Fiscal Year	Fatal Crashes (% of Total)	Injury Crashes (% of total)	Fatalities per Fatal Crash	Injuries per Fatal Crash	Injuries per Injury Crash
FY 2015	2.6%	36.3%	1.13	0.91	1.47
FY 2016	2.6%	36.2%	1.11	0.89	1.46

Table 9 presents estimated safety benefits associated with FMCSA carrier interventions for FY 2014–16 in terms of crashes prevented, injuries prevented, and lives saved within the treatment group—e.g., the carriers that passed the model's data filters.

Table 9. Estimated crashes prevented, injuries prevented, and lives saved in the treatment group for FYs 2014, 2015, and 2016.

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2014	24,339	4,339	2,476	126
2015	23,863	5,232	2,907	155
2016	25,511	4,692	2,585	136

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. After extrapolating to all carriers receiving interventions in FY 2016, it is estimated that these interventions prevented 7,405 crashes, resulting in 4,079 injuries prevented, and 214 lives saved.

Table 10. Estimated crashes prevented, injuries prevented, and lives saved for all carriers receiving interventions for FYs 2014, 2015, and 2016.

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2014	34,132	5,811	3,316	168
2015	33,934	7,136	3,965	212
2016	41,833*	7,405	4,079	214

*Adjusted extrapolation; subtracted months in which a carrier was inactive unless inactivity coincided with OOS.

The safety benefits reported in Table 9 reflect only those associated with statistically significant net crash rate reductions within the size groups, as shown in Table 7. Carrier size groups not yielding statistically significant crash rate improvements during the post-intervention period, after adjusting for crash rate changes in the comparison group, are assumed to have had no safety benefits.

3.2 RESULTS EXCLUDING WARNING LETTER AS A FIRST INTERVENTION

Additional insight can be gained by excluding from the model carriers receiving warning letters 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 helps to identify safety benefits specifically associated with safety investigator and program analyst personnel-hours pertaining

to agency investigations. This section reports 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. The number of treatment group carriers not receiving a warning letter as a first intervention declined slightly (5 percent) from FY 2015 to FY 2016.

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

Carrier Size Group	FY 2014	FY 2015	FY 2016
1 (1–5 PUs)	5,255	5,116	4,711
2 (6–20 PUs)	3,203	3,250	3,230
3 (21–100 PUs)	1,415	1,466	1,404
4 (100+ PUs)	348	341	306
Total	**10,221**	**10,173**	**9,651**

3.2.1 Crash Rate Reduction

Table 12 presents the percent reductions in crash rate, by carrier size group, 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. Both treatment group and comparison crash reductions for FY 2016 are similar to those achieved in FY 2015.

Table 12. Treatment and comparison group percent reductions in crash rate, excluding carriers that received a warning letter as their first intervention.

Carrier Size Group	FY 2014 Treatment Group	FY 2015 Treatment Group	FY 2016 Treatment Group	FY 2014 Comparison Group	FY 2015 Comparison Group	FY 2016 Comparison Group
1 (1–5 PUs)	36.2%	46.7%	39.2%	-2.6%	-1.6%	-1.2%
2 (6–20 PUs)	17.4%	30.7%	24.6%	-7.3%	-1.3%	-1.6%
3 (21–100 PUs)	12.2%	16.8%	17.8%	-3.4%	0.4%	0.8%
4 (100+ PUs)	2.5%	5.1%	0.1%	2.6%	3.1%	-0.3%

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

Table 13 presents the crash rate percent reductions, by carrier size group, 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.

Carrier Size Group	FY 2014	FY 2015	FY 2016
1 (1–5 PUs)	38.9%	48.3%	40.4%
2 (6–20 PUs)	24.7%	32.0%	26.2%
3 (21–100 PUs)	15.5%	16.4%	17.0%
4 (100+ PUs)	-0.1%*	2.0%*	0.4%*

Note: A negative crash rate reduction indicates an increase in crash rate. Due to rounding, values in this table may not equal the treatment group crash rates minus the comparison group crash rates from Table 10.

* Non-statistically significant net reductions.

As in previous years, carriers receiving a first intervention other than a warning letter in FY 2016 exhibited significant crash rate reductions in all size groups except size group 4 (100+ PUs). However, compared to the results for all intervention types, including warning letters (see Table 7), these net crash rate reductions are about 10–15 percent lower, as in previous years. 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. One should bear in mind, however, that carriers slated for non-warning letter interventions (i.e., investigations) tend to have poorer safety profiles than those receiving warning letters, and may present more of a challenge in changing their behavior. Due to such differences in the safety profiles of the carriers receiving different types of interventions, direct comparisons concerning the relative effectiveness of the various intervention types are problematic (see Section 3.3.2).

3.2.2 Safety Benefits

Table 14 and Table 15 present estimated safety benefits, by 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 receiving an intervention, excluding carriers that received a warning letter as their first intervention.

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2014	10,221	1,384	790	40
2015	10,173	1,990	1,106	59
2016	9,561	1,618	891	47

Table 15 extrapolates these benefits to all carriers receiving these interventions, including those screened out of the initial model calculations by the data filters.

Table 15. Estimated crashes prevented, injuries prevented, and lives saved within the treatment group, excluding carriers that received a warning letter as their first intervention.

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2014	13,603	1,775	1,013	51

Fiscal Year	Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
2015	13,497	2,565	1,425	76
2016	12,329	2,100	1,157	61

The safety benefits reported in Table 14 and Table 15 reflect only those associated with statistically significant net crash rate reductions, as reported in Table 13. Carrier size groups not yielding statistically significant crash rate improvements during the post-intervention period, after adjusting for crash rate changes in the comparison group, are assumed to have yielded no safety benefits.

Safety benefits extrapolated to all carriers whose first intervention was not a warning letter in FY 2016 are estimated to be 2,100 crashes prevented, 1,157 injuries prevented, and 61 lives saved.

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 FY 2016. Table 16 presents the number of treatment group carriers during FY 2016, by first intervention type and size group.

Table 16. Number of treatment group carriers during FY 2016, by first intervention type and size group.

Carrier Size Group	Onsite Focused	Onsite Comprehensive	Offsite Focused	Non-Rateable Reviews	Warning Letter
1 (1–5 PUs)	2,275	1,931	66	157	9,534
2 (6–20 PUs)	1,848	1,125	28	81	4,449
3 (21–100 PUs)	777	527	14	52	1,511
4 (100+ PUs)	164	124	3	15	272
Total	**5,064**	**3,707**	**111**	**305**	**15,766**

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. The comparison group comprises the same comparison group carriers used for the overall model, as reported in Table 5.

In the case of onsite focused and onsite comprehensive investigations, the net crash rate reductions are statistically significant for size groups 1, 2, and 3, but not for size group 4, which is similar to the results obtained for the overall model in Section 3.1. And, as with the overall model, the largest reductions occurred in the two smallest size groups.

ATET values were both negative (indicating an increase in crash rates during the post-intervention period) and statistically non-significant in all four size groups for off-site focused reviews. The lack of statistical significance in this instance likely stems from the small sample

size associated with this investigation type (see Table 13). Non-rateable reviews showed positive values for the percent net crash reduction in the two smallest size groups, although none of the net rate crash reductions was statistically significant in any size group. Again, the number of treatment group carriers receiving a non-rateable review in FY 2016 was small, which likely accounts for the lack of statistical significance in this instance.

Table 17. Percent net crash rate reductions (treatment minus comparison group) for individual intervention types, FY 2016.

Carrier Size Group	Onsite Focused	Onsite Comprehensive	Offsite Focused	Non-rateable Reviews	Warning Letter
1 (1–5 PUs)	34.9%	51.7%	-288%*	18.0%*	50.1%
2 (6–20 PUs)	25.1%	30.2%	-380%*	14.7%*	41.4%
3 (21–100 PUs)	17.4%	17.6%	-49%*	-1.5%*	21.7%
4 (≥100 PUs)	-0.1%*	3.4%*	-9.3%*	-2.4%*	2%*

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

*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 FY 2016.

Table 18. Estimated crashes avoided, injuries prevented, and lives saved sorted by first intervention type, FY 2016.*

First Investigation/ Intervention Type	All Carriers Receiving Interventions: Number of Carriers	Crashes Prevented	Injuries Prevented	Lives Saved
Onsite Focused	6,549	1,193	657	35
Onsite Comprehensive	5,469	902	497	26
Offsite Focused	122	0	0	0
Non-rateable Review	506	0	0	0
Warning Letter	30,377	5,385	2,966	156

*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 2016 was an onsite focused investigation constitute 15 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 13 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 71 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 estimated number of 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. Also, the effect of the intervention, in terms of 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.

One should also bear in mind that the CIEM cannot control for the possibility of carriers experiencing "regression to the mean" during the post-intervention period. This refers to the idea that crashes are rare events and many carriers, particularly small ones, may experience a decrease in 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 the main contributor to the 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 relevent when assessing individual intervention types because the distribution of intervention types differs across size groups. For example, Table 16 indicates that 70 percent of the warning letters in FY 2016 were sent to carriers having 5 or fewer power units (which are more likely to experience regression to the mean due to fewer vehicle miles traveled during any assessment period), while only 1.5 percent were sent to carriers with more than 100 power units. This compares to 50 percent of onsite focused and 57 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.

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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, 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 2016 (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 two subsets of the full treatment group: carriers whose first intervention each year was not a warning letter, and carriers whose first intervention was 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 manhours.

Version 1.2 of the CIEM estimated benefits associated with individual intervention types for FY 2016. For this analysis, each carrier receiving an intervention during the fiscal year was linked to a particular intervention type, according to the first intervention 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 various 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.

One should also bear in mind 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 virture of the fact that their crash experience in the pre-intervention period was an anomaly. Smaller carriers are more succeptable to "regression to the mean."

In summary, the FY 2016 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.