FMCSA Safety Program Effectiveness Measurement: Carrier Intervention Effectiveness Model, Version 1.0

Summary Report for Fiscal Years 2009, 2010, 2011

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

January 2015

FOREWORD

The Federal Motor Carrier Safety Administration (FMCSA), in cooperation with the John A. Volpe National Transportation Systems Center (Volpe), has developed a quantitative model to measure the effectiveness of motor carrier interventions in terms of estimated crashes avoided, injuries prevented, and lives saved. The model, documented in this report, is known as the Carrier Intervention Effectiveness Model (CIEM). This model provides FMCSA management with information 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. It also provides FMCSA and State safety program managers with a quantitative basis for improving enforcement processes and optimizing the allocation of safety resources in the field.

NOTICE

QUALITY ASSURANCE STATEMENT

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

Technical Report Documentation Page

1. Report No. **FMCSA-RRA-14-011**	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle **FMCSA Safety Program Effectiveness Measurement: Carrier Intervention Effectiveness Model, Version 1.0**		5. Report Date **January 2015** 6. Performing Organization Code
7. Author(s) **Segev, Eran; Meltzer, Neil**		8. Performing Organization Report No.
9. Performing Organization Name and Address **John A. Volpe National Transportation Systems Center** **Safety Management Systems Technical Center** **System Measurement and Analysis Division** **55 Broadway** **Cambridge, MA 02142**		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address **U.S. Department of Transportation** **Federal Motor Carrier Safety Administration** **Office of Analysis, Research, and Technology** **1200 New Jersey Ave. SE** **Washington, DC 20590**		13. Type of Report and Period Covered **Summary: FY09, FY10, and FY11** 14. Sponsoring Agency Code **FMCSA**

15. Supplementary Notes

Contracting Officer's Representative: Richard Gruberg
Additional support at the Volpe Center was provided by Suzanne Horton, Richard Nguyen and Sean Puckett.
An updated version of this report was published in September, 2015. An error was corrected in Table 14.

16. Abstract

The Federal Motor Carrier Safety Administration (FMCSA), in cooperation with the John A. Volpe National Transportation Systems Center (Volpe), has developed a quantitative model to measure the effectiveness of motor carrier interventions in terms of estimated crashes avoided, injuries prevented, and lives saved. The model, documented in this report, is known as the Carrier Intervention Effectiveness Model (CIEM). This model provides FMCSA management with information 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. It also provides FMCSA and State safety program managers with a quantitative basis for improving enforcement processes and optimizing the allocation of safety resources in the field.

17. Key Words	18. Distribution Statement
Motor carrier, compliance review, CSA, intervention, safety, program effectiveness, commercial motor vehicle, offsite investigation, onsite investigation	**No restrictions**

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	**Unclassified**	**32**	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized.

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

ABBREVIATIONS AND 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
DNOC	Direct Notice of Claim
DNOV	Direct Notice of Violation
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
USDOT	U.S. Department of Transportation
Volpe	John A. Volpe National Transportation Systems Center

[This page intentionally left blank.]

EXECUTIVE SUMMARY

In 2010, following an Operational Model Test in select states, the Federal Motor Carrier Safety Administration (FMCSA) began a phased implementation of Compliance, Safety, Accountability (CSA), a redesign of the preceding enforcement model. The CSA enforcement model includes an array of carrier intervention types that replace the one-size-fits-all compliance review (CR) that was implemented as part of the old enforcement model. It is expected that a major benefit of the new enforcement model will be an improved level of safety in the operation of commercial motor vehicles (CMVs).

The introduction of CSA has necessitated a new approach for measuring the benefits and effectiveness of the interventions at a national level and on an ongoing basis. The Carrier Intervention Effectiveness Model (CIEM) provides FMCSA with a tool for measuring the safety benefits of carrier interventions. During the phased implementation of CSA, the model incorporates both CRs, where safety impacts were previously measured by the Compliance Review Effectiveness Model (CREM), and additional intervention types, including: warning letters, offsite investigations, onsite focused investigations and onsite comprehensive investigations when assessing safety benefits. This approach yields national-level measurements of the effectiveness of FMCSA's carrier interventions. The model is designed to be implemented on an annual basis, focusing on carriers receiving interventions in a given fiscal year (FY). Comparing results over a period of years will provide an indication of the effectiveness of FMCSA's compliance and enforcement program in terms of safety benefits.

MODEL APPROACH

The model computes carrier crash rates, defined as crashes per carrier power unit (PU), for carriers receiving interventions, distinguishing between crash rates for defined periods prior to and following the interventions. The difference between these carriers' pre- and post-intervention crash rates represents the change in their safety performance during this timeframe. To control for systemic differences between small and large carrier operations, these comparisons are made for carriers distributed into size groups based on their PU count. In addition, to remove the effect of confounding factors from the calculation of the change in safety performance, the difference between pre- and post-intervention crash rates is adjusted by the change in crash rates experienced by the general carrier population during a corresponding timeframe. A set of carefully designed filters is used to identify and remove missing and outlier carrier data.

The model incorporates statistical significance testing, which only considers size group changes in crash rates that are statistically significant. Statistically significant results, measured in terms of crashes avoided and lives saved, are then extrapolated to incorporate those carriers that received interventions but were not included in the initial model calculations because of missing or inaccurate data.

MODEL FINDINGS

All Carriers Receiving Interventions

The model was implemented for carriers receiving interventions in FYs 2009, 2010, and 2011. Total interventions exhibit an increase in FY 2010, from 28,331 to 31,372, followed by a larger increase to 58,230 interventions in FY 2011; the latter primarily reflects a surge in CSA warning letters. Onsite focused investigations and onsite comprehensive investigations exhibit year-to-year increases, while Performance and Registration Information Systems Management (PRISM) warning letters and CRs experienced declines as expected during FMCSA's transition to the CSA enforcement model. Offsite investigations and non-rated reviews were relatively constant over the 3 years.

Statistically significant crash rate reductions were obtained for all three years for carriers with up to 20 PUs. For carriers with between 21 and 100 PUs, such a reduction was observed only in FY 2009 and FY 2011 but not in FY 2010. For carriers with more than 100 PUs the results were not statistically significant for any of the 3 years.. As shown in Table 1, these reductions are estimated to have resulted in the following safety benefits:

Table 1. Safety benefits: all interventions.

Fiscal Year	Crashes Avoided	Injuries Prevented	Lives Saved
2009	2,398	1,508	80
2010	1,685	1,051	55
2011	6,145	3,774	201

Additional Analysis

Given the large increase in CSA warning letters issued in FY 2011 compared with the previous year, additional insight can be gained by examining the impact of excluding warning letters from the model, as well as by implementing the model only for carriers whose first intervention is a warning letter. Specifically, these separate model results reveal to what extent the large increase in safety benefits observed in FY 2011 are associated with warning letters versus the other intervention types.

This further analysis points to the following two conclusions for FY 2011, the modeled year with the most statistically significant results:

- First, carriers receiving warning letters as a first intervention in FY 2011—the overwhelming majority of these being CSA warning letters—experienced substantial crash rate reductions (although this reduction was not as large as the reduction experienced by carriers receiving first interventions other than warning letters.) Since the vast majority of the carriers receiving these letters did not receive a follow-up intervention, this suggests that the warning letter in and of itself can be an effective tool for improving motor carrier safety.

- Second, the analysis further suggests that the increase in safety benefits calculated by the model for FY 2011 is related to the fact that this year was the first time onsite and offsite interventions were supplemented by the issuance of a large number of warning letters.

[This page intentionally left blank.]

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 the 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 to 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 Compliance, Safety, Accountability (CSA), a redesign of the preceding enforcement model. The CSA enforcement model includes an array of carrier intervention types replacing the current one-size-fits-all CR intervention type implemented as part of the old enforcement model. It is expected that a major benefit of the new enforcement model will be an improved level of safety in the operation of CMVs. The introduction of the new enforcement model in 2010 has necessitated a new approach for measuring the benefits and effectiveness of the interventions at a national level and on an ongoing basis.

1.2 PROJECT SCOPE

The Carrier Intervention Effectiveness Model (CIEM) provides FMCSA with a tool for measuring the safety benefits of carrier interventions. During the phased implementation of CSA, the model incorporates both CRs, previously measured by the CREM, and additional interventions, including: warning letters, offsite investigations, onsite focused investigations, and onsite comprehensive investigations. This approach yields national-level measurements of the effectiveness of FMCSA's carrier interventions.

While the new model succeeds the CREM, results from the two models are not directly comparable because the models require different methodologies to assess the different safety

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

programs. However, both models measure the benefits of the programs in terms of crashes avoided, lives saved, and injuries prevented.

An objective of this project is to develop and continue to improve the new model and to update the results on an annual basis. This report presents the results of the CIEM's implementation for carriers receiving interventions in fiscal years (FYs) 2009, 2010, and 2011, and describes the functionality of the model and how it is applied. Technical details will be presented in a forthcoming report entitled "Carrier Intervention Effectiveness Model Technical Report."

2. FMCSA CARRIER INTERVENTION EFFECTIVENESS MODEL

FMCSA employs a data-driven approach to oversee and enforce commercial motor carrier safety. This approach utilizes a variety of data sources to assign safety risks to motor carriers, and the assigned safety risks are used to prioritize carriers for interventions intended to reduce their risks. The CSA model introduced a new and broader set of carrier interventions, giving FMCSA enhanced flexibility to address safety problems more efficiently. The new set of interventions includes less labor-intensive alternatives to the CR that focus on each motor carrier's specific safety problems. As a result, CSA enables FMCSA to reach a larger number of carriers. The CIEM measures the impact of both CSA and pre-CSA carrier interventions in terms of safety benefits—crashes avoided, 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 improvement of carriers receiving FMCSA interventions (i.e., the treatment group) to carriers that do not (i.e., the comparison group). 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 carrier crash rates—defined as crashes per carrier power unit (PU)—for carriers receiving interventions, distinguishing between crash rates for 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 systemic differences in how small and large carriers improve their safety performance when faced with interventions, these calculations are first performed for various carrier size groupings (based on their PU count) and then aggregated.[3]

To remove the effect of confounding factors impacting the change in safety performance, the difference between pre- and post-intervention crash rates is adjusted by the change in crash rates experienced by a comparison group representing those that did not receive interventions during a similar timeframe. This adjustment removes the effect of historical trends and events, such as the national recession that occurred during the timeframe represented by the results in this report.

The CIEM replaces the CREM and shares some of its methodology. However, it employs new approaches to address FMCSA's overall enforcement program interventions, including both

[2] PU values are used as a proxy for carrier exposure to crashes. While vehicle miles traveled have the potential to serve as a useful proxy for exposure in the model at a future point in time, FMCSA considers PU information currently in the Motor Carrier Management Information System (MCMIS) to be 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), stratification by size was found to be the most effective classification method given data availability.

CSA and non-CSA interventions completed before, during, and after the transition from the CR program.

The new model also introduces a component estimating the impact of interventions applied to carriers with missing or suspect census data; such carriers would otherwise be left out of the computation of safety benefits attributable to FMCSA interventions. Finally, the model introduces a component determining the statistical significance of its own results. 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 treatment group filters ensure that crash rates are comparable and reliable across carriers and carrier size groups.

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

- CSA Interventions:[4]
  - Warning letter.
  - Offsite investigation.
  - Onsite focused investigation.
  - Onsite comprehensive investigation.
- CRs, including:
  - CR.
  - CR with cargo tank facility review.
  - CR with security contact review.
- Non-ratable CRs on interstate carriers, including focused CRs (which do not receive a rating) and hazardous materials (HM) reviews.[5]
- Performance and Registration Information Systems Management (PRISM) warning letters.[6]

[4] This version of the model does not include follow-up verifications, direct notice of violations (DNOVs), or direct notice of claims (DNOCs), 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. Neither are they included separately in this model, because safety audits are performed only on new entrant carriers, which do not have a reliable pre-intervention period.

[5] This version of the model does not include follow-up verifications, direct notice of violations (DNOVs), direct notice of claims (DNOCs) or cooperative safety plans because the data currently in MCMIS were found to be inconsistent in terms of completeness and accuracy.

[6] Further information on PRISM is provided by FMCSA at http://www.fmcsa.dot.gov/safety-security/prism/prism.aspx.

The treatment group filters require that a carrier:

- Is an interstate or intrastate HM carrier at the time of intervention.
- Is active and reports positive PU counts.
- Is not a new entrant throughout its pre- and post-intervention periods.
- Meets outlier tests to identify suspect crash and PU data.[7]

These filters were initially based on those used in the CREM, but were strengthened and refined to identify suspect data more judiciously.

2.3 CARRIERS WITHOUT INTERVENTIONS: COMPARISON GROUP

To isolate the effects of the 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 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 missing and outlier data filters similar to those applied to treatment group carriers.[8] Similar to the treatment group filters, comparison group filters ensure that crash rates are comparable and reliable across carriers and carrier size groups.

Carriers are assigned to comparison groups based on carrier size groups identical to those in the treatment group. The resulting separate comparison groups allow for eliminating differences associated with carrier size from the model's calculation of adjusted crash rates.

2.4 MODEL DATA AND TIMEFRAMES

The model uses crash data reported by the States and 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

[7] 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 size groups 1 and 2, and a factor of 1.75 for size groups 3 and 4, with the following 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. 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 can be overridden by the following exceptions: carriers in size group 1 can have up to 5 crashes; carriers in size groups 2, 3 and 4 can have up to 6 crashes; carriers with 500 or more PUs must exhibit non-zero crashes.

[8] The comparison group filters are identical to the treatment group filters, but rely on different data snapshots to obtain PU counts due to the absence of intervention dates for comparison group carriers. The latter rely on the modeled year's April snapshot and the subsequent year's September snapshot. In addition, comparison group carriers cannot have received any of the model's interventions during the modeled year, or the prior and subsequent year, to ensure that any changes in crash rates are not the immediate result of such interventions.

interface. Consequently, statistics for previous time periods may change, depending on the timeliness and completeness of the originating reporting. For this study, MCMIS snapshots from the most recent month—which include the most current updates for prior months—are used to provide the most complete and accurate data available.[9]

For the treatment group, a carrier's pre-intervention PU value is based on the MCMIS monthly data snapshot from the time period immediately following the first intervention it receives during the fiscal year. This particular snapshot contains the most recent PU information for the carrier at the time of its intervention. The date of the first intervention is used in order to delineate the pre- and post-intervention periods for carriers that may receive one or more intervention(s) during the fiscal year.[10] Because some carriers receive multiple interventions within the modeled year, the model does not report the precise impacts of each individual intervention type; rather, it estimates the combined impact of all interventions performed during the modeled year.

The 12-month period preceding a carrier's first intervention is defined as its pre-intervention period, while the 12-month period following this intervention is defined as its post-intervention period. The final monthly snapshot for a carrier's post-intervention period is used to define its post-intervention PU value. Pre- and post-intervention crash rates are calculated as the number of crashes occurring during these two periods, divided by each period's PU value. Figure 1 illustrates the timeframes delineated by these data points for the treatment group, using an intervention in FY 2009 as an example.[11]

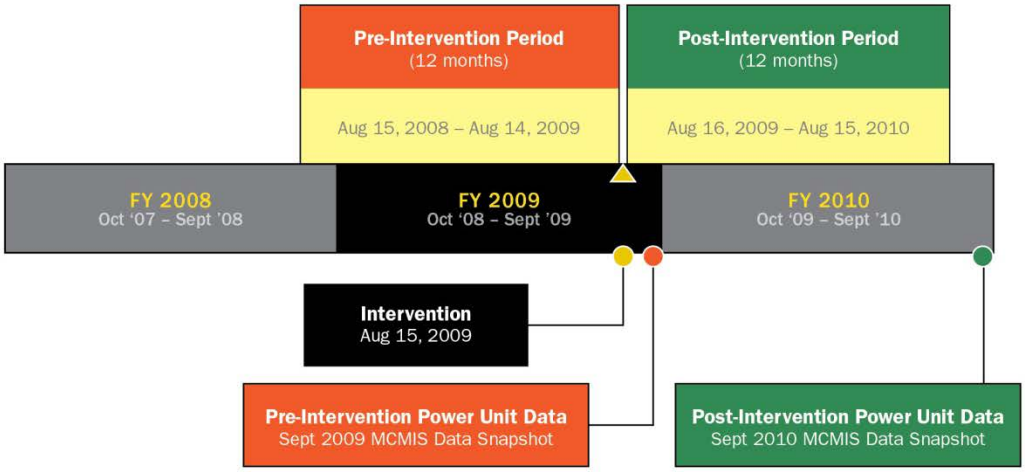

Figure 1. Diagram. Timeline for a carrier with a first intervention on August 15, 2009.

[9] The June 2013 MCMIS data snapshot was used to determine crash counts for this report.

[10] 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. That is, 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 follow-up interventions would serve to delineate new before and after periods.

[11] In this study, crash rates are attributed to size groups, which are aggregations of carriers within the respective ranges of number of PUs operated by each carrier. Thus, crash rate statistics for pre-intervention and post-intervention periods for each 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.

For comparison group carriers, which do not have an intervention during the comparison period, 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). Therefore, by definition, 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 pre- and post-intervention periods for the comparison groups, compared to the treatment groups' 12-month periods, ensure that the comparison group crash rates cover the entire treatment group timeframe; for each model year, the full timeframe covered is 36 months.

The MCMIS data snapshot following March 31 is used to obtain the pre-intervention period PU values for each carrier in the comparison group, and the final snapshot of the post-intervention period is used for post-intervention period PU values. As with the treatment group, comparison group carriers' crash rates are calculated as the number of crashes occurring during each period divided by the corresponding PU values.[12] Figure 2 illustrates the timeframes delineated by these data points for the comparison group, using the FY 2009 model as an example.

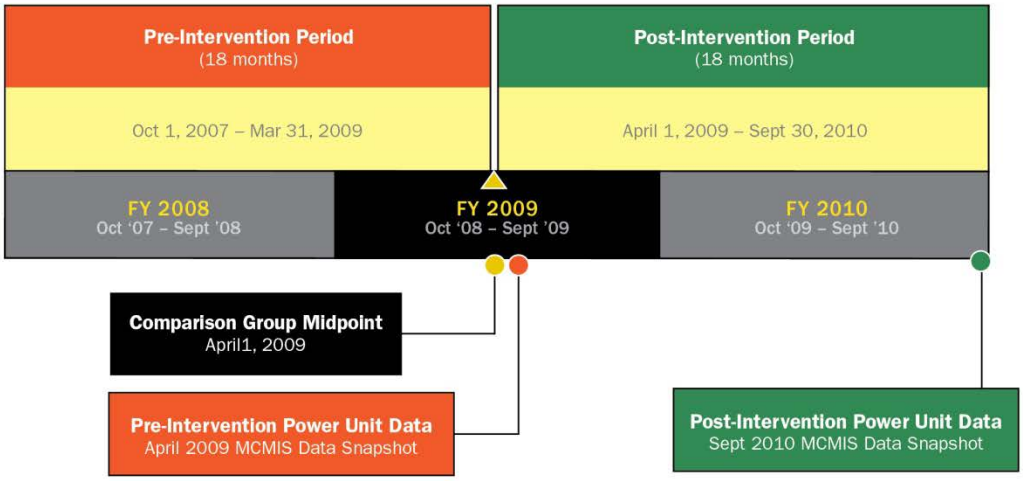

Figure 2. Diagram. Timeline for a FY 2009 comparison group carrier.

2.5 CALCULATION OF CRASHES AVOIDED

Pre- and post-intervention crash rates are used by the model to determine the change in crash rates, by carrier size group, for the treatment and comparison groups. Crash rate 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

[12] To account for the comparison groups' 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 equivalent annual crash rates.

the average treatment effect on the treated (ATET), is the crash rate reduction attributed to interventions.[13] Figure 3 illustrates the steps used to determine this reduction.

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

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

Figure 4 shows how the crash rate reduction due to interventions is converted to a measure of crashes avoided, which also depends on the treatment group's pre-intervention crashes and 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 fiscal year crashes avoided for the modeled year among treatment group carriers.

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

Figure 4. Formula. Crashes avoided by treatment group carriers.

Two additional steps are required to estimate crashes avoided across the entire population of interstate and intrastate HM commercial motor carriers. The first step is a test to identify which of the initial estimates are statistically significant at a target level of significance (in this analysis, the 95 percent level). This test determines if the treatment group crash rate change, adjusted for the comparison group crash rate change by carrier size group, is different from zero at the 0.05 statistical significance level (i.e., the 95 percent confidence interval around the estimated effect on crash rates does not include zero).[14] Crash rate changes that do not pass this test are not attributed to the interventions and are not used to estimate crashes avoided.

The final step for determining crashes avoided across the motor carrier population is to account for the crashes avoided by carriers that received interventions but were excluded from the treatment group due to missing or outlier data. Such carriers, on average, can be assumed to exhibit a response to interventions similar to that of the observed treatment group. Therefore, the results from the observed treatment group crash rate reductions are extrapolated to account for

[13] See Abadie, Alberto (2005). *Semiparametric Difference-in-Differences Estimators,* Review of Economic Studies (72, 1-19) for further information on ATET.

[14] See Cochran, William G. Sampling Techniques, third edition (1977) for further information.

potential crashes avoided by these additional carriers. The sum of crashes avoided by both the treatment group carriers included in the model and by treatment group carriers filtered out of the model represents total crashes avoided across the motor carrier population as a result of the interventions performed in a given fiscal year.

2.6 CALCULATION OF DIRECT SAFETY BENEFITS

Once the model estimates the total crashes avoided from interventions performed during the fiscal year, injuries prevented and lives saved as a result of the crashes avoided can be estimated using historical crash severity data. This model uses 2-year average probabilities of a crash involving an injury or fatality, along with 2-year average values of the number of injuries and fatalities in such crashes. Two-year averages are used, rather than just 1 year of crash statistics, to provide stability to the model's safety benefit calculations. For each model year, the 2-year averages are calculated using data on crashes that occurred during the modeled fiscal year and the prior fiscal year. [15] Figure 5 presents the formulas for these calculations.

$$\textit{Number of } \boldsymbol{fatal\ crashes} \textit{ avoided } = \textit{probability of a fatal crash given a crash occurred } \boldsymbol{X} \textit{ number of crashes avoided}$$

$$\textit{Number of } \boldsymbol{injury\ crashes} \textit{ avoided } = \textit{probability of an injury crash given a crash occurred } \boldsymbol{X} \textit{ number of crashes avoided}$$

$$\boldsymbol{Lives\ saved} = \textit{number of fatal crashes avoided } \boldsymbol{X} \textit{ average number of fatalities per fatal crash}$$

$$\boldsymbol{Injuries\ prevented} = (\textit{average number of injuries per fatal crash } \boldsymbol{X} \textit{ number of fatal crashes avoided}) + (\textit{average number of injuries per injury crash } \boldsymbol{X} \textit{ number of injury crashes avoided})$$

Figure 5. Multiple formulas. Calculating numbers of lives saved and injuries prevented.

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

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

[This page intentionally left blank.]

3. RESULTS OF IMPLEMENTING THE MODEL

3.1 RESULTS INCLUDING ALL INTERVENTION TYPES

The model was implemented for carriers receiving the specified intervention types in FY 2009, 2010, and 2011. Table 2 presents two sets of data. The first three data columns show the number of interventions conducted by FMCSA and its State partners and included in the model, by type, for each of the 3 fiscal years. The last three columns report for each fiscal year the number of treatment group carriers receiving these intervention types as their first intervention for the fiscal year and passing all of the treatment group data filters for missing and outlier data.

Table 2. Carrier interventions by type.

Intervention Type	Number of Interventions			Treatment Group Carriers		
	FY 2009	FY 2010	FY 2011	FY 2009	FY 2010	FY 2011
CSA Warning Letter	2,184	5,790	39,004	1,546	4,011	30,448
PRISM Warning Letter	7,500	7,415	1,764	5,003	5,073	1,206
Offsite Investigation	345	456	375	282	311	277
Onsite Focused Investigation	520	1,207	6,279	387	904	4,137
Onsite Comprehensive Investigation	386	829	1,399	243	507	758
Compliance Review	16,517	14,577	8,274	9,133	8,192	4,253
Non-Rated Review	879	1,098	1,135	235	662	587
Total	**28,331**	**31,372**	**58,230**	**16,829**	**19,660**	**41,666**

Total interventions increased by approximately 10 percent in FY 2010 and by approximately 85 percent in FY 2011, primarily reflecting a surge in CSA warning letters. In addition, onsite focused investigations and onsite comprehensive investigations exhibit year-to-year increases. In contrast, the number of PRISM warning letters and CRs declined. Offsite investigations and non-rated reviews were relatively constant over the 3 years. These trends are consistent with expectations during the rollout of CSA, as new intervention types were utilized in a growing number of States previously relying on CRs. These same trends are also reflected in the number of treatment group carriers receiving each intervention type. Total treatment group carriers rose from 16,829 in FY 2009, to 19,660 in FY 2010, and to 41,666 in FY 2011.

Table 3 presents the number of treatment and comparison group carriers for each fiscal year, by size group. The number of treatment group carriers in all four size groups increased in each of the years, following the general trend observed above for the treatment group as a whole.

Table 3. Treatment and comparison group carriers by size group.

Carrier Size Group	Number of Carriers (Treatment Group)			Number of Carriers (Comparison Group)		
	FY 2009	FY 2010	FY 2011	FY 2009	FY 2010	FY 2011
1 (1–5 PUs)	8,085	9,851	23,661	379,869	376,993	379,343
2 (6–20 PUs)	5,660	6,493	11,683	47,167	41,865	40,176
3 (21–100 PUs)	2,578	2,758	4,998	11,232	8,918	8,324
4 (≥100 PUs)	506	558	1,324	2,115	1,376	1,187
Total	**16,829**	**19,660**	**41,666**	**440,383**	**429,152**	**429,030**

3.1.1 Crash Rate Reduction

Table 4 presents the initial treatment and comparison group crash rate reductions by year and carrier size group.

Table 4. Treatment and comparison group crash rate reductions.

Carrier Size Group	Crash Rate Reduction (Treatment Group)			Crash Rate Reduction (Comparison Group)		
	FY 2009	FY 2010	FY 2011	FY 2009	FY 2010	FY 2011
1 (1–5 PUs)	41.8%	34.0%	38.2%	7.3%	4.7%	9.4%
2 (6–20 PUs)	29.7%	19.2%	28.3%	9.4%	5.3%	-1.7%
3 (21–100 PUs)	19.4%	2.8%	17.2%	12.2%	5.0%	1.3%
4 (≥100 PUs)	13.3%	-3.0%	11.0%	13.5%	1.9%	7.8%

Table 5 presents the crash rate reductions for the treatment group, once adjusted for the crash rate reductions in the comparison group, by year and carrier size group. Carrier size groups 1 and 2 exhibit statistically significant adjusted crash rate reductions across the 3 fiscal years, while size group 3 exhibits a statistically significant reduction in FY 2009 and FY 2011 only. Adjusted crash rate reductions for size group 4 were not statistically significant in any of the 3 fiscal years.

Table 5. Net crash rate reductions.

Adjusted Crash Rate Reduction By Carrier Size Group	FY 2009	FY 2010	FY 2011
1 (1–5 PUs)	34.5%	29.3%	28.8%
2 (6–20 PUs)	20.3%	13.9%	30.0%
3 (21–100 PUs)	7.2%	-2.1%*	15.9%
4 (≥100 PUs)	-0.2%*	-4.9%*	3.2%*

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

*Non-statistically significant adjusted reduction.

As noted in Section 2.5, the adjusted crash rates represent the pre- to post-intervention change in treatment group crash rates adjusted for the corresponding comparison group crash rates. This means that, for example, size group 1 carriers with interventions in FY 2009 experienced a 34.5

percent crash rate reduction as a group, after subtracting out the crash rate change for comparison group carriers in the same size group in the same modeled year. The table suggests that smaller carriers generally exhibit greater crash rate reductions than their larger counterparts. This is consistent with results obtained from the previous enforcement model, CREM, used to calculate safety benefits for fiscal years 2002–09.

3.1.2 Safety Benefits

Table 6 reports safety benefits, by year, as a result of FMCSA interventions. The left side of the table presents crashes avoided, injuries prevented, and lives saved among treatment group carriers, for carriers that passed the model's data filters. The right side of the table extrapolates these benefits to all carriers receiving interventions, including those that did not pass the data filters.

Table 6. Crashes avoided, injuries prevented, lives saved.

Fiscal Year	Treatment Group Carriers				Extrapolated to all Carriers Receiving Interventions			
	Number of Carriers	Crashes Avoided	Injuries Prevented	Lives Saved	Number of Carriers	Crashes Avoided	Injuries Prevented	Lives Saved
2009	16,829	1,569	987	52	26,396	2,398	1,508	80
2010	19,660	1,094	683	36	29,589	1,685	1,051	55
2011	41,666	4,761	2,924	156	56,482	6,145	3,774	201

The safety benefits reported in Table 6 reflect only those associated with statistically significant adjusted crash rates as reported in Table 5. 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 experience no safety benefits.

3.2 RESULTS EXCLUDING WARNING LETTER AS A FIRST INTERVENTION

Given the large increase in the number of CSA warning letters issued in FY 2011 compared with the previous year, additional insight can be gained by examining the impact of excluding these warning letters from the analysis and by implementing the model only for carriers whose first intervention is a warning letter. Specifically, these separate model results can reveal to what extent the large increase in safety benefits observed in FY 2011 are associated with warning letters, as opposed to other intervention types.[16] This section reports the results of implementing the model for carriers receiving intervention types other than warning letters as their first intervention. Section 3.3 reports the results of implementing the model only for carriers whose first intervention is a warning letter.

[16] Because some carriers receive a warning letter followed by a subsequent intervention, this analysis does not identify the safety benefits associated exclusively with warning letters; rather, it identifies the safety benefits associated with warning letters as a first intervention in the fiscal year. Since the vast majority of warning letters are not followed by an intervention in the same fiscal year, the results of implementing the model for carriers with warning letters as the first intervention are likely to be similar to what would be obtained by only considering carriers that received warning letters only during the fiscal year.

Table 7 presents the number of treatment group carriers (by size group) excluding warning letter as a first intervention. Unlike the trends exhibited in Table 3, the number of treatment group carriers in all four size groups shows little year-to-year change when excluding this intervention.

Table 7. Treatment group carriers—by size group—excluding warning letter as first intervention.

Carrier Size Group	Number of Carriers		
	FY 2009	FY 2010	FY 2011
1 (1–5 PUs)	4,888	5,009	4,938
2 (6–20 PUs)	3,408	3,588	3,178
3 (21–100 PUs)	1,631	1,613	1,489
4 (≥100 PUs)	353	366	407
Total	**10,280**	**10,576**	**10,012**

3.2.1 Crash Rate Reduction

Table 8 reports the treatment group and the comparison group crash rate reductions by year and carrier size group for carriers whose first intervention was not a warning letter. The comparison group utilized here is comprised of the same comparison group carriers used for the overall model, as shown in Table 3.

Table 8. Treatment and comparison group crash rate reductions, excluding warning letter as first intervention.

Carrier Size Group	Crash Rate Reduction (Treatment Group)			Crash Rate Reduction (Comparison Group)		
	FY 2009	FY 2010	FY 2011	FY 2009	FY 2010	FY 2011
1 (1–5 PUs)	54.8%	47.8%	40.2%	7.3%	4.7%	9.4%
2 (6–20 PUs)	38.2%	30.6%	28.7%	9.4%	5.3%	-1.7%
3 (21–100 PUs)	20.8%	8.8%	20.1%	12.2%	5.0%	1.3%
4 (≥100 PUs)	14.1%	-3.2%	10.4%	13.5%	1.9%	7.8%

Table 9 reports the adjusted crash rate reductions by year and carrier size group for these same carriers. The carrier size groups exhibit the same pattern as in Table 5. Carrier size groups 1 and 2 exhibit statistically significant adjusted crash rate reductions across the 3 fiscal years, while size group 3 exhibits a statistically significant reduction in FY 2009 and FY 2011 only. Adjusted crash rate reductions for size group 4 were not statistically significant in any of the 3 fiscal years.

Table 9. Net crash rate reductions, excluding warning letter as first intervention.

Adjusted Crash Rate Reduction (Treatment Minus Comparison Group)	FY 2009	FY 2010	FY 2011
1–5 Pus	47.5%	43.1%	30.7%
6–20 PUs	28.8%	25.3%	30.4%
21–100 PUs	8.7%	3.8%*	18.8%
≥100 Pus	0.5%*	-5.2%*	2.5%*

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

* Non-statistically significant adjusted reductions.

For the three size groups with statistically significant crash rate reductions, Table 9 shows results similar, but somewhat higher than those reported for all treatment group carriers in Table 5; one exception is size group 2 in FY 2011, which had almost identical crash rate reductions in both model runs.

3.2.2 Safety Benefits

Table 10 reports safety benefits, by year, as a result of FMCSA interventions, excluding carriers whose first intervention in the fiscal year was a warning letter. The left side of the table reports crashes avoided, injuries prevented, and lives saved among treatment group carriers. The right side of the table reports these benefits for all carriers receiving these interventions, including those that did not pass the data filters.

Table 10. Crashes avoided, injuries prevented, lives saved: excluding warning letter as first intervention.

Fiscal Year	Treatment Group Carriers				Extrapolated to all Carriers Receiving Interventions			
	Number of Carriers	Crashes Avoided	Injuries Prevented	Lives Saved	Number of Carriers	Crashes Avoided	Injuries Prevented	Lives Saved
2009	10,280	1,597	1,004	53	16,744	2,542	1,599	84
2010	10,576	1,173	732	38	16,432	1,846	1,152	60
2011	10,012	1,633	1,003	53	15,807	2,348	1,442	77

The safety benefits reported in Table 10 reflect only those associated with statistically significant adjusted crash rate reductions as reported in Table 9. 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 experience no safety benefits.

3.3 RESULTS FOR WARNING LETTER AS A FIRST INTERVENTION

This section reports the results of implementing the model only for carriers whose first intervention was a warning letter.

As reported in Table 2, the total number of CSA warning letters roughly triples from FY 2009 to FY 2010. In the following year, CSA warning letters increase more than six-fold to 39,004. PRISM warning letters, on the other hand, declined slightly from FY 2009 to FY 2010 and more

dramatically the following year; only 1,764 such letters were issued in FY 2011. The number of treatment group carriers receiving warning letters as a first intervention follows a similar trend.

Table 11 presents the number of treatment group carriers, by year and size group, receiving a warning letter as a first intervention. Consistent with the year-to-year increase in total warning letters issued, each carrier size group exhibits growth across the 3-year timeframe.

Table 11. Treatment group carriers receiving warning letter as first intervention, by size group.

Carrier Size Group	Number of Carriers		
	FY 2009	FY 2010	FY 2011
1–5 PUs	3,197	4,842	18,723
6–20 PUs	2,252	2,905	8,505
21–100 PUs	947	1,145	3,509
≥100 PUs	153	192	917
Total	**6,549**	**9,084**	**31,654**

3.3.1 Crash Rate Reduction

Table 12 reports the treatment group and the comparison group crash rate reductions by year and carrier size group for carriers whose first intervention was a warning letter. The comparison group utilized here is comprised of the same comparison group carriers used for the overall model, as reported in Table 3.

Table 12. Treatment and comparison group crash rate reductions for carriers receiving warning letter as first intervention.

Carrier Size Group	Crash Rate Reduction (Treatment Group)			Crash Rate Reduction (Comparison Group)		
	FY 2009	FY 2010	FY 2011	FY 2009	FY 2010	FY 2011
1–5 PUs	-0.2%	8.6%	37.5%	7.3%	4.7%	9.4%
6–20 PUs	6.2%	-4.9%	28.0%	9.4%	5.3%	-1.7%
21–100 PUs	14.9%	-11.6%	15.6%	12.2%	5.0%	1.3%
≥100 PUs	11.9%	-3.2%	11.5%	13.5%	1.9%	7.8%

Table 13 reports the adjusted crash rate reductions, by year and carrier size group. None of the size groups exhibits a statistically significant reduction in FY 2009. In FY 2010, size groups 2 and 3 exhibit statistically significant crash rate increases, while size groups 1 and 4 do not exhibit statistically significant crash rate reductions. In FY 2011, size groups 1, 2 and 3 exhibit statistically significant crash rate reductions.

Table 13. Net crash rate reductions for carriers receiving warning letter as first intervention.

Adjusted Crash Rate Reduction (Treatment Minus Comparison Group)	FY 2009	FY 2010	FY 2011
1–5 PUs	-7.5%*	3.9%*	28.0%
6–20 PUs	-3.2%*	-10.2%	29.7%
21–100 PUs	2.7%*	-16.5%	14.3%
≥100 PUs	-1.6%*	-5.1%*	3.6%*

Note: Negative crash rate reductions indicate increases in crash rates.
* Non-statistically significant adjusted reduction.

Because there is no evidence of an overall crash rate reduction in FY 2009and FY 2010 (either due to lack of statistical significance or due to a result indicating an increase in crash rate), we consider the benefits to be zero for those years for carriers that received a warning letter as the first intervention. Statistically significant crash rate reductions for carriers receiving warning letters as the first intervention are similar in magnitude in FY 2011 to those reported for all interventions (see Table 5 for comparison) and slightly lower than those reported for other intervention types (see Table 9 for comparison) ranging from 14.3 percent for size group 3 to 29.7 percent for size group 2. The reductions associated with FY 2011 warning letters compared with FY 2009 and FY 2010 is noteworthy: more than half of the letters in FY 2010 were issued through the PRISM program, and more than 75% in FY 2009, while the overwhelming majority of letters in FY 2011 were issued through CSA. This finding suggests that, on average, warning letters issued as part of the CSA enforcement model have more impact on crash rate reduction than their PRISM predecessors. It is not clear whether this is due to CSA, differing timeframes (e.g., 2010 versus 2011), or some other external factors.

3.3.2 Safety Benefits

Table 14 reports safety benefits, by year, experienced by carriers receiving a warning letter as their first intervention. The left side of the table reports crashes avoided, injuries prevented and lives saved among treatment group carriers. The right side of the table extrapolates these benefits to all carriers receiving warning letters as a first intervention, including those that did not pass the data filters.

Table 14. Crashes avoided, injuries prevented, lives saved: carriers receiving warning letter as first intervention.

Fiscal Year	Treatment Group Carriers				Extrapolated to all Carriers Receiving Interventions			
	Number of Carriers	Crashes Avoided	Injuries Prevented	Lives Saved	Number of Carriers	Crashes Avoided	Injuries Prevented	Lives Saved
2009	6,549	-	-	-	9,650	-	-	-
2010	9,084	-	-	-	13,155	-	-	-
2011	31,654	3,117	1,914	102	40,673	3,849	2,364	126

The safety benefits reported in Table 14 reflect only those associated with statistically significant adjusted crash rates and positive crash rate reductions as reported in Table 13. Carrier size groups not yielding statistically significant or positive crash rate improvements during the post-intervention period, after adjusting for crash rate changes in the comparison group, are assumed

to experience no safety benefits. In FY 2011 the model estimates there were 3,849 crashes avoided, 2,364 injuries prevented and 126 lives saved for carriers that received a warning letter as their first intervention. These benefits primarily reflect the surge in warning letters during FY 2011.

4. CONCLUSIONS

CIEM Version 1.0 provides FMCSA with a means for measuring the safety benefits of both CSA and pre-CSA carrier interventions. As such, it can be used for annual measurement of safety benefits during the phased CSA implementation and beyond. The model builds on the approach of the CREM, used to measure the effectiveness of CRs until FY 2009. However, in contrast to the CREM, the CIEM now incorporates the various intervention types that comprise FMCSA's overall enforcement program, which has expanded with CSA. A number of intervention types not recorded consistently at this time are not included explicitly in the CIEM, but can easily be incorporated into the model structure in the future. The model also introduces a component addressing statistical significance and an approach for extrapolating directly measured safety benefits to carriers with missing or outlier crash or PU data.

Overall, the set of FMCSA intervention types specified in the model are shown to have reduced motor carrier crash rates in FY 2009, FY 2010, and FY 2011. For all three years, this reduction is observed among carriers in size groups 1 and 2, while size group 3 showed a reduction in FY 2009 and FY 2011, but not in FY 2010. Size group 4 does not exhibit a statistically significant change in crash rate in any of the modeled years. Consistent with CREM results in prior years, crash rate reductions are generally more pronounced for the smaller carrier size groups. Both the results for the treatment group and the results extrapolated for all carriers receiving interventions exhibit positive safety benefits in terms of crashes avoided, injuries prevented, and lives saved during the 3-year timeframe. The largest increases in safety benefits were achieved in FY 2011, with considerable greater benefits than the previous years. This large increase in benefits appears to be mostly attributable to a sharp increase in warning letters issued during this time period.

Further analysis was performed by implementing the model for two subsets of the full treatment group: carriers whose first intervention each year was not a warning letter and those whose first intervention was a warning letter. For the first subset, statistically significant crash rate reductions are observed for carrier size groups 1 and 2 in all 3 fiscal years and for size group 3 in FY 2009 and FY 2011. These results were generally higher than those reported for the full treatment group. For the second subset, statistically significant, positive crash rate reductions were found for only size groups 1, 2 and 3 in FY 2011 (all of which were lower than those reported for the full treatment group).

This further analysis points to the following: first, carriers receiving warning letters as a first intervention in FY 2011 (the overwhelming majority of these being CSA warning letters) experienced substantial crash rate reductions. Second, the analysis suggests that the large increase in safety benefits derived from performing interventions on motor carriers in FY 2011 can be explained by the dramatic increase in the number of warning letters issued during that year. Given the large increase in carriers receiving warning letters issued in FY 2011, and the fact that the vast majority of these letters were not associated with follow-up interventions, warning letters appear to account for the bulk of the increase in safety benefits reported for that year. This observation confirms the effectiveness of CSA warning letters issued based on current carrier safety thresholds. The lower, almost negligible, cost of a CSA warning letter compared with other more labor-intensive interventions further makes it an efficient tool in reducing motor carrier crashes.

In summary, the results from implementing the CIEM for FY 2009 to FY 2011 identify the benefits of FMCSA carrier interventions during the phased CSA implementation. Future implementation of the model will enable FMCSA to continue to measure the impacts of carrier interventions.