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Safety benefits of mandatory OSHA 10 h training

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ABSTRACT

Construction is an inherently dangerous industry. Its injury rates for the industry annually rank near the top of all U.S. industries. The Occupational Safety and Health Administration (OSHA) is charged with regulating U.S. workplace safety. Towards this end, they provide enforcement and promote training. A standardized 10 h training course sanctioned by OSHA is available for construction workers in all states. In 2004, Massachusetts became the first of seven states to legislate mandated OSHA 10 h training for construction workers on most public projects. Previous studies have shown that occupational safety training has beneficial effects on knowledge gain and improved behavior but there is weak evidence for improved safety outcomes. The natural experiment created by mandated training provided the opportunity to study the effects of mandated training on these outcomes. This study uses the Bureau of Labor Statistics (BLS) 2004–2012 State Occupational Injury and Illness data in a random effects multiple regression analysis and BLS 2008–2011 fatality data from the Census of Fatal Occupational Injuries to examine fatality trends across different strata. The results are highly encouraging but fall short of definitive evidence. The post-mandate fatality trend results compare favorably against other state groupings and the non-fatal injury regression indicated a nearly statistically significant marginal effect for mandated training. However these results are clouded by the short duration of trend data and injury data known to be underreported. Recommendations include more extensive recordkeeping for OSHA 10 h training and improved injury surveillance.

1. Introduction

Construction is an inherently dangerous industry. In 2012, there were 775 private sector construction fatalities in the U.S.[1]; more than any other industry. The Occupational Safety and Health Administration (OSHA) is charged with the regulation of construction safety. With approximately 2200 inspectors for 8 M worksites,[2] only a tiny percentage of worksites ever get inspected. Therefore, punishment for safety infractions may have limited effectiveness in accident prevention. Prevention through education and training appears to be the preferred and more effective alternative.

Recognizing the value of safety training, OSHA approves individuals and organizations to conduct a standardized 10 h course for construction workers. The OSHA 10 h construction training[3] teaches recognition and awareness of common hazards as well as prevention measures.

Construction unions have played a huge role in safety training during the last thirty years. In 1994, The Center for Construction Research and Training (CPWR) was a partner in forming the National Resource Center (NRC). The NRC worked with affiliated trade unions to structure an OSHA 10 curriculum and become an authorized education center eligible to train-the-trainers for OSHA 10. Commercial and industrial building trade unions have since made OSHA 10 a mandatory part of their apprenticeship programs and campaigned for government agencies to mandate the training on public construction contracts. As a result, it is estimated that 25 percent of U.S. construction workers (Sinyai et al., 2013) have now received this training from OSHA authorized trainers.

This ten hour training module must be conducted by OSHA authorized trainers who possess at least five years of construction safety experience supplemented by 60 h of train-the-trainer training. The ten hours of training topics always contains two hours of Introduction to OSHA, one hour each on the 'Focus Four' hazards (falls, electrocutions, struck by, and caught-in or between), and one hour on protective equipment and other construction health hazards. The remaining three hours consist of elective modules such as cranes and derricks, scaffolds, ladders, and power tools.

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[1] https://www.osha.gov/oshstats/commonstats.html.
[2] Includes all industries, not just construction.
[3] For ease of composition, this training will be referred to as just OSHA 10 hereafter.

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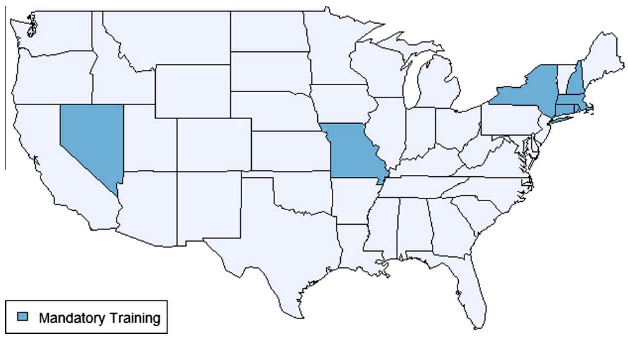

Fig. 1. States having mandatory OSHA 10 training.

In 2004, Massachusetts became the first of seven states[4] to legislate mandated OSHA 10 training for workers on public projects. In the study period public work comprised over 30 percent of all construction nationally.[5] Since the state mandates cover nearly all public construction falls in their jurisdiction, a measurable state level reduction in injuries and illnesses might be anticipated in those states.[6] One study (Roelofs, 2012) clearly demonstrated qualitative benefits from this mandated training within Massachusetts where union workers were much more likely to receive OSHA 10 (97 percent) than nonunion workers (17 percent). No follow up quantitative study has been made to determine if these seven mandates have yielded improvements in fatality and injury rates.

With seven states (see Fig. 1) now requiring OSHA 10 trained workers for most public projects, sufficient data is available to attempt a quantitative analysis.[7] The collective state mandates effectively created a natural experiment allowing the testing of a marginal effect on injury rates. Given sufficient data, marginal effects can be estimated by using regression analysis. Unfortunately, insufficient observations exist for regression on fatality data, but trend comparisons can be made.

2. Background

There is such an abundance of available literature regarding training's effectiveness as a component of occupational safety and health that a detailed review would be cumbersome. Many of the previous studies were small, narrowly focused, and of questionable quality. Therefore, gleaning useful information is extremely difficult except for the existence of three meta-analyses (Cohen and Colligan, 1998; Burke et al., 2006; Robson et al., 2012). These and a few other applicable studies supply the necessary background for previous studies on training effectiveness.

The three meta-analyses pose common questions in their evaluations. They are:

- Does training increase safety knowledge?
- Does training result in safer workplace behavior?
- Does training result in better safety outcomes?

See Table 1 for a summary of results. Given the relatively positive results on knowledge and behavior, it is puzzling that the evidence on improved outcomes is so weak.

Burke's work was alone in answering yes to all three questions. The amount of improvement and retained improvement was generally tied to the training's level of engagement. Lectures, videos, and pamphlets were considered the least engaging with hands-on exercises allowing development of knowledge in stages being the most engaging and successful. For knowledge, the most engaging produced three times the gain of the least engaging without knowledge loss after four weeks. Surprisingly, behavior improved similarly for all engagement levels. Lastly, the more engaging forms produced better safety outcomes on average. Using Burke's guidelines, OSHA 10 would be low to moderately engaging training.

Table 1
Meta-analyses selected results.

Study	Knowledge	Behavior	Outcomes
Cohen et. al.	+	+	?
Burke et al.	+	+	+
Robson et al.	?	+	?

+ Improved, ? Not Conclusive.

In contrast to Burke, Cohen and Colligan found no impact on outcomes and thought that some training might even be harmful. Referring to three separate smaller studies, they posit, "...one could argue that faulty or bad training may have worse consequences than no training at all". Of note, OSHA online training denounced by Roloefs' study, now comprises twenty percent of OSHA outreach training.[8]

In a study with important implications for an injury analysis, non-fatal injury rates were shown to be vastly underreported (Probst et al., 2008). The authors showed construction injuries were underreported by over 80 percent in organizations with negative safety climates and by 47 percent in those with positive safety climates. Other studies (Dong et al., 2011; Glazner et al., 1998) confirmed substantial injury underreporting in construction. Underreporting was more prevalent in firms with 20 or fewer employees.

Since both fatal and non-fatal injuries are to be considered here, it is relevant that the two have been shown to have a negative correlation (Saloniemi and Oksanen, 1998). In a study of Finnish workers, a strong negative relationship existed for the construction industry ($r = -0.82$ with $p < 0.001$). As a possible explanation, they hypothesized that different causations exist for differing construction accident types. Therefore, a reduction in either type is not to be assumed in the other.

When examining other correlations, another study (Conway and Svenson, 1998) found that lower injury rates were correlated with the business cycle. Specifically, lower injury rates accompanied the recession beginning in 1993. Another researcher (Dorman, 1996) stated "there is clearly a 'cyclical' component to safety: it rises during periods of economic hardship, and falls during periods of growth. This may be due either to the speedup in the pace of work when orders pile up (this is implicit in Okun's law, according to which fluctuations in output exceed fluctuations in employment), or to the influx of new, inexperienced workers when hiring expands". This correlation is also seen in the data for this study.

As mentioned earlier, Roelofs' 2012 Massachusetts work found a strong correlation between union membership and having received OSHA 10. This study interviewed 13 key informants and surveyed 100 Massachusetts construction workers to ascertain the perceived effectiveness of mandated OSHA 10. Almost universally, the surveyed union workers had received the training while non-union and immigrant workers were much less likely. Most

[4] The others are CT, NH, NY, NV, MO, and RI. Though MA legislated first, RI implemented earlier.

[5] U.S. Census Bureau, Historical Value Put in Place.

[6] Fatality reductions are harder to assess since individual state counts are typically small and subject to much annual variation.

[7] Data is available for six of the seven states. No data is available for NH.

[8] https://www.osha.gov/dte/outreach/outreachgrowth.html. Downloaded October 2013.

surveyed believed the mandate raised the bar and provided a beneficial yet modest impact on safety. The study concluded there were gains in knowledge and improved behavior. Specific study recommendations to strengthen OSHA 10 included a supplementary refresher course every 4–5 years and limiting or eliminating online training.

Roelofs' qualitative evaluation of improvements in knowledge and behavior lacked a quantitative verification of improved safety outcomes as it made no attempt to assess effects on injury rates. A key finding stated, "More research is required to better understand the impact of construction safety training on safety performance". Cohen and Colligan previously reached the same conclusion stating, "Especially challenging and needed are studies to definitively tie immediate training results, e.g. increased knowledge of hazards and safer work behaviors, to outcome indicators such as reduced worker injuries and illness". The lack of evidence supporting the critical metric of training effectiveness, improved safety outcomes, led to the idea of extending Roelofs' work to assess the marginal effect of mandated OSHA 10.

3. Data

This analysis focuses primarily on annual injury and illness data because comparable Bureau of Labor Statistics (BLS) fatality rates are available only in years 2008–2011. To clarify, fatality counts and rates were published by the BLS prior to 2008 but the older rates were employment-based rather than the current exposure-based rates. BLS expressly cautions against comparing the two measures. Although count data exist for all years, constructing comparable employment-based fatality rates proves extremely difficult because of the lack of consistent and reliable state employment denominators. Instead a trend analysis using the most current BLS rates was performed.[9]

The annual injury and illness data for the construction industry (NAICS industry code 23)[10] were obtained from the website of the BLS Survey of Occupational Injuries and Illness (SOII).[11] The state level data were available for most but not all states in the years 2001–2012. The injury analysis time frame will be restricted to 2004–2012 for current relevance. For comprehensiveness, the injury statistic used is the rate of recordable cases as defined by OSHA.

Basically an injury is recordable if there is medical treatment beyond first aid or if the injury results in missed work or work restrictions. Rates are per 100 full-time equivalent workers and compiled using weighted sampling techniques. The natural log of these continuous numeric data constitutes the response variable in the regression model utilized. A preliminary plot (see Fig. 2) of the injury data revealed an obvious set of outliers corresponding to data for Louisiana. It has been suggested that the petrochemical industry in Louisiana utilizes an inordinately large number of temporary workers in construction and that injury underreporting is greater for temporary workers.[12] Louisiana was dropped from the analysis. A numerical check revealed no other outliers. Also obvious is a downward shift in the injury rates corresponding to the economic downturn of 2008. The subsequent regression analysis considers this shift.

To identify the states and years of mandatory OSHA 10, a 0–1 indicator variable is utilized. In the mandatory training states, see Table 2, the value is 1 (Yes) in the first and all subsequent years if the mandate was in effect before July 1 of the first year. The value is 0 (No) for all other observations. These data resulted from a web search of the individual state mandates. New Hampshire is among the states for which no injury data is available and is not included.

Another data element[13] is the percentage of the unionized construction workforce for each state. This continuous variable is expressed as a percentage and a three-year moving average is used for smoothing. It is important as an explanatory variable because multiple studies indicate that union workers are much more likely to receive OSHA 10. See Fig. 3 to see a representation of the 2012 smoothed union density.

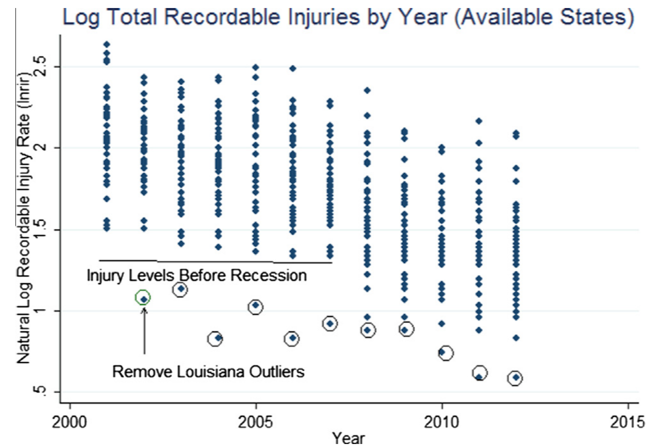

Fig. 2. Preliminary data check for response variable.

Table 2
Mandatory OSHA10 training by state.

State	No	Yes
CT	2004–2006	2007–2012
MA	2004–2005	2006–2012
MO	2004–2009	2010–2012
NV	2004–2009	2010–2012
NH	–	–
NY	2004–2007	2008–2012
RI	–	2004–2012

4. Analytical methods and results

4.1. Fatalities

The construction fatality counts used to compile the BLS fatality state rates[14] represented in Fig. 4 are considered complete and accurate. Therefore, fatality rate numerators are not subject to sampling variation. In this respect fatality rates are preferred to non-fatal injury rates as a measure of safety outcomes. Unfortunately, fatality rates are subject to higher relative variations especially in the smaller states. Keeping these limitations in mind, we observe some useful information from the stratified trends in Figs. 5 and 6.

Among all the subgroup strata, the lowest fatality rates are clearly found in the mandatory training states (post-mandate). Also note that this group has a four year non-increasing trend. Fig. 5 clearly shows both the lower fatality rates and a more favorable trend. Finally, note that Fig. 5 suggests a composite fatality

[9] There are no 2008–2011 BLS published fatality rates in the Census of Fatal Occupational Injuries for CO, DE, HI, NH, ME, RI, and VT.

[10] North American Industry Classification System.

[11] In construction only about 3 percent of recordable cases are for illness. For brevity, injury will be used hereafter to refer to illness and injury.

[12] http://www.lexisnexis.com/legalnewsroom/workers-compensation/b/recent-cases-news-trends-developments/archive/2014/08/29/new-study-points-to-significant-underreporting-of-injuries-to-bureau-of-labor-statistics.aspx.

[13] From www.unionstats.com. Downloaded October 2013.

[14] Descriptive Statistics; $n = 155$, Mean = 11.7, Std. dev.=6.4, Min. = 3.7, Max. = 40.5 (per 100,000 FTE).

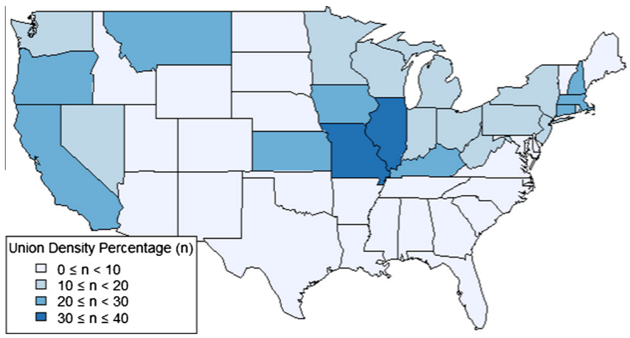

Fig. 3. 2012 Three-year smoothed union density percentage for construction private sector (AK-22% and HI-34%).

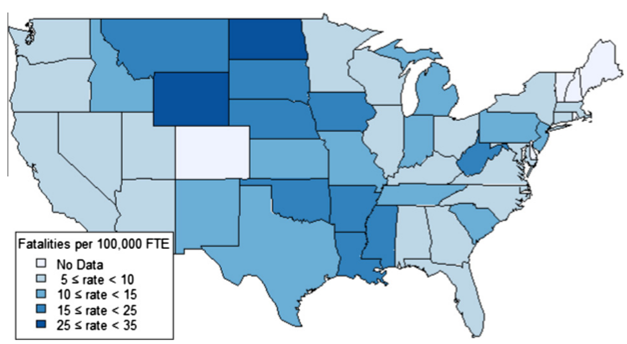

Fig. 4. 2008–2011 BLS state fatality rate averages (AK – 40.5 in 2010).

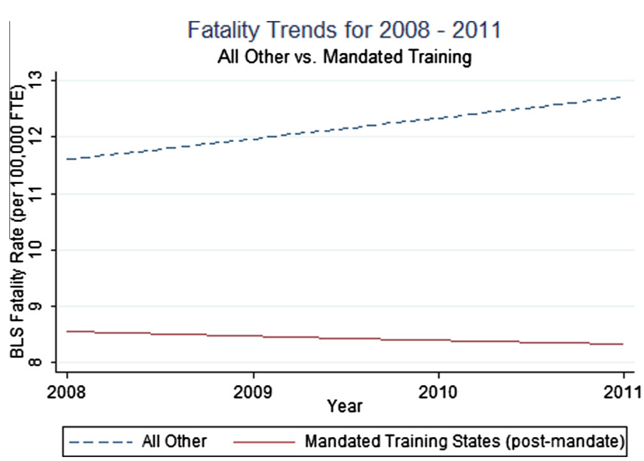

Fig. 5. Trends in fatalities – training strata.

rate that is increasing as contrasted with declining non-fatal injury rates in Fig. 2. This negative relationship agrees with the findings of Saloniemi and Okansen referenced earlier.

Fig. 6 is also interesting. Considering that union density and training are generally highly correlated, it is noteworthy that the mandated training group in Fig. 5 had lower fatality rates and a more favorable trend as compared to the highest union density states of Fig. 6. Though cause and effect cannot be established, this association between mandatory training and lower fatality rates seems both interesting and encouraging.

4.2. Non-fatal injuries

Obviously many factors affect non-fatal construction injury rates. Among them are construction culture, management

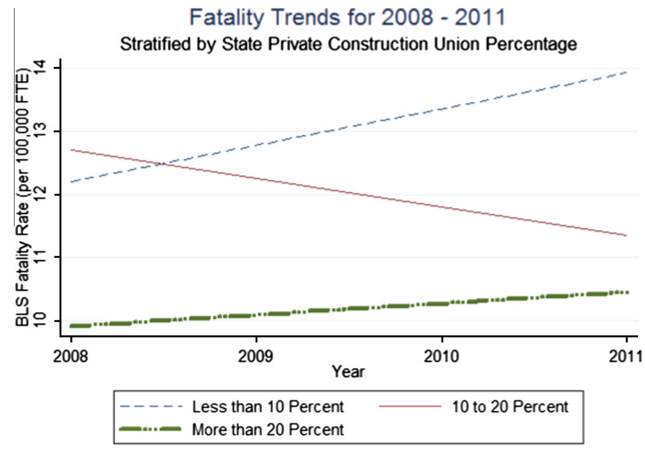

Fig. 6. Trends in fatalities – union density strata.

commitment, and training. The training component alone has sub factors such as quality, quantity, and level of engagement. With the available data, it is impossible to determine the share contribution of all of these factors. However, using marginal analysis it is possible to estimate the contribution of mandated OSHA 10 towards reducing injuries.

The panel structure of the data suggests employing either fixed effects (FE) or random effects (RE) analysis. In accordance with common practice, both methods were explored and tested. The model whose assumptions best fit the data was chosen.

The fundamental difference between the FE and RE models is that the unobserved effects in a FE model are assumed to be correlated with the explanatory variables whereas they are uncorrelated in a RE model. The FE analysis revealed a correlation of only 0.0118 and a Hausman test failed to show the difference in the FE and RE models was systematic with $\chi^2_5 = 1.27 (p = 0.94)$. Therefore the RE specification was validated as being both consistent and efficient. Using Stata 10, a generalized least squares (GLS) multiple regression with random effects and robust standard errors was performed. Again, note the response variable is the natural log of the OSHA recordable injury and illness rate (log *RIR*).

- RE Regression model

$$\log\ RIR_{it} = \alpha + \beta_1 * (Trend)_t + \beta_2 * (PctUnion)_{it} + \beta_3 * (TrainReq)_{it} + \beta_4 * (PctUnion * TrainReq)_{it} + \beta_5 * (Econ)_t + \epsilon_{it} \quad (1)$$

Table 3 gives descriptive statistics for variables used in the injury analysis. A log-linear functional form was used so that the distribution of the response variable would more closely approximate the normal distribution in the GLS regression. *Trend* is a variable to accommodate the general annual decline in injury rates. *PctUnion* is the smoothed average of the percentage of union membership in private sector construction. It is a proxy for the percentage of OSHA 10 trained workers in individual states. *TrainReq* is an indicator variable in which "0" represents control states in all years

Table 3
Descriptive statistics for injury analysis 2004–2012 (base group *n* = 363).

Variable	Mean	Std. dev.	Minimum	Maximum
Trend	–	–	1	9
PercentUnion	15.0	10.5	0.7	45.4
TrainingRequired	0.07	0.26	0	1
PercentUnion ∗ *TrainingRequired*	1.7	6.1	0	32.8
EconomicChange	0.55	0.50	0	1
log *RecordableInjuryRate*	1.64	0.34	0.83	2.49

Table 4
Injury analysis summary 2004–2012.

Analysis	Sample	Regression
1A	Base Group	GLS
2A	Peer Group	GLS
1B	Base Group	MLE
2B	Peer Group	MLE

and "1" represents treatment states post-legislation. The economic recession of the last decade had far reaching consequences including an apparent decline in injury rates as seen in Fig. 2. *Econ* absorbs this impact by effectively shifting the post-2007 observations.

The interaction variable, *PctUnion* ∗ *TrainReq*, is key to this analysis. Recall that Roleofs' study determined that primarily union workers received OSHA 10. This interaction is a proxy for the percentage of OSHA 10 trained workers available and also provides a distinction between mandatory training states and the control group. It is feasible that legislative mandates and additional trained workers could create downstream effects beyond their separate immediate impacts. For example, a synergistic effect might occur for training mandates combined with a change in the percentage of trained workers beyond their individual effects on public projects. Consider that as workers initially trained to be eligible for public projects inevitably cross over to private projects and thereby increase the 'work share' performed by OSHA 10 workers. The work share might be further augmented if improved safety culture induces private owners to also require OSHA 10. Therefore, the significance and magnitude of the $\hat{\beta}$ coefficient of this interaction variable is a measure of the mandatory training marginal effect and is the crux of this analysis.

For completeness, the RE model was also estimated using maximum likelihood estimators (MLE) with standard errors from the observable information matrix. Table 4 summarizes the injury analyses conducted. Those analyses with the numeral 1 refer to the larger base group of states and 2 is the smaller peer group. The letters A and B designate GLS and MLE methods respectively.

Using a RE analysis for panel data is key to overcoming the fact that some variables are unobservable (e.g. safety culture). It is assumed the unobservables are time invariant within states absent an exogenous shock but that unobservables can and do vary between states. Since these match the underlying assumptions of the RE model, the issue of unobservable variables is minimized.

The most comprehensive data set ($n = 363$) used in analyses 1A and 1B included state data for the base group (see Fig. 7) for years 2004–2012. The GLS model had an overall $R^2 = 0.357$ and Wald $\chi^2_5 = 711.85$ ($p < 0.0001$). The coefficient on the interaction term was −0.0132. Since the model is log-linear, the proper interpretation is that the coefficients have a multiplicative effect of $\exp(\hat{\beta})$ on the response variable. Since $\exp(-0.0132) = 0.987$, each percentage point increase in union membership combined with state mandated training has the effect of multiplying the response variable by 0.987. This is equivalent to a 1.3 percent decrease in the magnitude of the response.[15] Under GLS, the coefficient was not significant, but the MLE *p*-value was 0.056 and narrowly missed being significant at the five percent significance level. Table 5 contains the regression results for the base group.

The results show explanatory variables that were significant at the 1, 5, and 10 percent levels. *Trend* was highly significant indicating a declining injury rate over time. The relatively large and positive coefficient for *TrainReq* indicates an upward shift in injury levels for mandated training states. This is plausible if training states by their nature have less underreporting, if mandated training creates a decrease in the level of injury underreporting, or both. It is relevant that two hours of OSHA 10 are devoted to an *Introduction to OSHA* which includes a section on the duty to report injuries. It seems likely that the *TrainReq* coefficient reflects increased injury levels from decreased underreporting. The upward shift is of no consequence to the marginal effect under investigation.

As an additional check, analyses 2A and 2B were used to further restrict the control group making it more homogeneous (see Fig. 8). These analyses used a peer group of states having more than ten percent of the private construction workforce unionized. The smaller data set yielded results of similar magnitude, but with higher standard errors than in the base analysis. The interaction variable (*PctUnion* ∗ *TrainReq*) coefficient was −0.0124 ($p = 0.146$) for GLS and −0.123 ($p = 0.083$) for MLE.

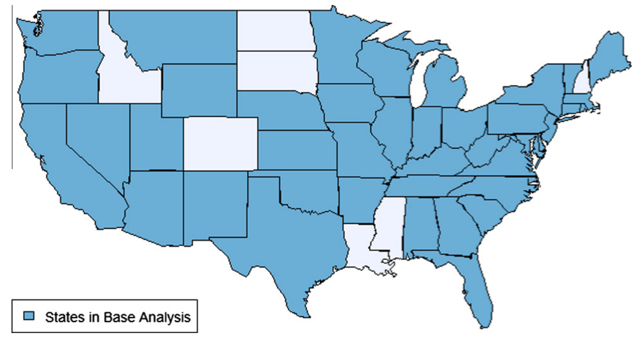

Fig. 7. States in the base analysis (also AK and HI).

Table 5
Coefficients for injury analysis of base group (standard errors).

Variable	Analysis 1A GLS	Analysis 1B MLE
Trend	−0.0553***	−0.0553***
	(0.0059)	(0.0056)
PercentUnion	$\hat{\beta}_2 = 0.0028$	0.0029
	(0.0022)	(0.0021)
TrainRequired	$\hat{\beta}_3 = 0.3571$*	0.3578**
	(0.2013)	(0.1766)
PercentUnion ∗ *TrainRequired*	$\hat{\beta}_4 = -0.0132$	−0.0133*
	(0.0085)	(0.0070)
EconomicChange	$\hat{\beta}_5 = -0.1166$***	−0.1168***
	(0.0271)	(0.0288)
Intercept	$\hat{\alpha} = 1.930$***	1.929***
	(0.0575)	(0.0526)
R^2	0.3568	–

* Significance: $p < 0.10$.
** Significance: $p < 0.05$.
*** Significance: $p < 0.01$.

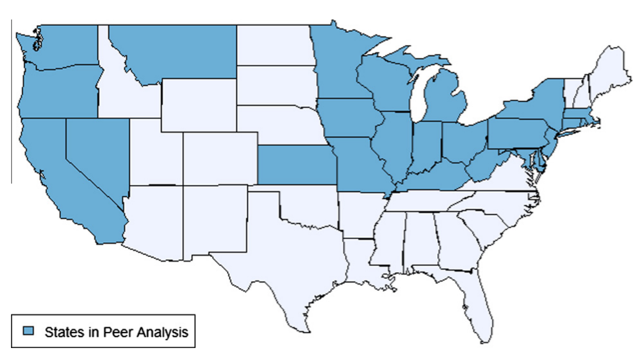

Fig. 8. Peer group states for supplemental analysis (also AK and HI).

[15] In the log-linear functional form, for small values of $\hat{\beta}$, the coefficient ∗ 100 may be interpreted as the percent increase or decrease in the response variable for a one unit change in the explanatory variable.

5. Discussion

5.1. Key findings

This study analyzed the results of the RE regressions were promising but failed to conclusively extend the qualitative results of Roelofs' Massachusetts study. Mandated OSHA 10, prevalent in the union sector, shows only mild evidence of reducing recordable injuries. In the base and peer analyses, the marginal effect was a 1.2–1.3 percent reduction in injuries with p-values ranging from 0.056 to 0.143. In summary, the results are highly encouraging but fall short of statistical significance. As more post-mandate data becomes available in coming years, it may be possible to attain statistically significant results. Similarly the fatality trends observed can be construed as encouraging but the data is too sparse to establish mandatory training as a definitive cause.

5.2. Study strengths and limitations

This analysis involves both strengths and weaknesses. A trial analysis demonstrated the appropriateness of RE over FE. The unobserved effects (e.g. safety culture, weather, etc.) clearly lacked correlation with the explanatory variables thus enabling this model to capture between state variation. In other words, each state has a unique random effect to capture its individual unobservables and thus the between state variation. At the same time, RE models are able to capture the serial relationship of data within states to produce more efficient estimators than a pooled cross section analysis. The ease of interpretation is a strength of the fatality analysis.

Study limitations include the limited time frame of the fatality trend analysis, sampling variation in the BLS injury data, the effects of rounding on the effective date of the individual state implementations, and the use of union density as a proxy for trained workers. Better data is always preferred so the first three limitations are not uncommon. Regarding the fourth, OSHA training statistics are not available at the state level and a proxy is needed. Given Roelofs' Massachusetts findings, union density seems a reasonable approximation.

Perhaps the biggest weakness is the well-documented underreporting of injuries. Though certainly undesirable, this weakness many not be as damaging as it appears. Three studies spanning between 1998 and 2011 all indicate substantial underreporting. There is no evidence to suggest that the level of underreporting changes without an exogenous shock. The model includes shift variables to absorb the shocks from the economic recession and the institution of the state training mandates. Assuming the underreporting is consistent absent a shock and independent of the regressors, the underreporting effect on the analysis is a biased intercept and biased shift variables that are of no consequence to the matter of a marginal effect (Wooldridge, 2006).

5.3. Future work

Establishing state level training counts and obtaining more information on the effectiveness of online training could help overcome one of the study's weaknesses by enumerating effectively trained workers and thereby eliminating the union density proxy variable. Also, a future analysis would be greatly aided by comprehensive injury databases which mitigated the injury underreporting issue. Encouraging is the fact that the National Institute of Occupational Safety and Health, the National Academies, and other stakeholders have called for development of workers compensation databases. These databases, accessible to researchers, should be far more comprehensive and accurate than the current sampling estimates. These improvements would yield greater insight into training's effects on non-fatal injuries.

More and better non-fatal injury data might also allow additional work on the effect of mandated training on leading indicators of safety such as knowledge and behaviors. Past studies have indicated favorable results for training on these indicators but a selection bias may be present where there is a voluntary component to training. Establishing a correlation between improved knowledge and behaviors with mandated training would extend the past findings.

The fatal injury results could also be solidified. Mandatory training states had a more favorable baseline and trend during the four year study period. Since OSHA 10 includes four hours of specific training dedicated to the leading fatality causes, fatality data over a longer period might conclusively show impacts for this specific training. It would be useful to determine if the usual negative correlation between fatal and non-fatal injury rates extends to those receiving mandated training.

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Further reading

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