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Systematic review of the prevention incentives of insurance and regulatory mechanisms for occupational health and safety

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1 Additional tables (2–6)

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Table 2: Summary of high and intermediate level studies examining the effect of introduction of experience rating on illness and injury outcomes

Author & year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
Bruce and Atkins (21) Ontario 1951-1989 industry	variable indicating industry experience rated in that year (1984 or after)	frequency: fatalities per worker employed (in first difference form)	aggregate time series Cointegrating regression model using ordinary least squares with several statistical tests undertaken to test model fit (Durbin-Watson, Dickey-Fuller and augmented Dickey-Fuller tests)	39	1) -0.609*** (forestry); 2) -0.142* (construction).	introduction of experience rating reduces frequency of fatalities	High
Hyatt and Thomason (2) British Columbia 1983-1992 firm	variable indicating firm participating in experience rating (not stated when ER began-- 1986)	1) frequency: total first paid claim rate; 2) frequency: health care only claim rate; 3) frequency: short-term disability claim rate: 4) frequency: long-term disability claim rate; 5) severity: average cost of first paid claim rate; 6) severity: average cost of health care only claims; 7) severity: average cost of short-term disability claims; 8) severity: average cost of long-term disability claims; 9) severity: duration of short-term disability benefits. (N.B.: denominator for frequencies not stated)	panel micro data Random effects Poisson regression model	1) 28737 (small firms) 1) 9900 (large firms) 2) 28737 (small firms) 2) 9900 (large firms) 3) 28737 (small firms) 3) 9900 (large firms) 4) 28737 (small firms) 4) 9900 (large firms) 5) 17084 (small firms) 5) 9081 (large firms) 6) 12748 (small firms) 6) 8182 (large firms) 7) 12127 (small firms) 7) 8227 (large firms) 8) 608 (small firms) 8) 1486 (large firms) 9) 8341 (small & large firms)	1) -0.077*** (small firms) 1) -0.108*** (large firms) 2) - 0.061** (small firms) 2) -0.157*** (large firms) 3) -0.087*** (small firms) 3) -0.076*** (large firms) 4) 0.385** (small firms) 4) 0.354*** (large firms) 5) 355.733* (small firms) 5) 198.736* (large firms) 6) 13.684*** (small firms) 6) -0.118 (large firms) 7) 467.82*** (small firms); 7) 251.040** (large firms) 8) -7207.239 (small firms) 8) -9567.426** (large firms) 9) 3.580*** (small firms) 9) 3.088*** (large firms) (small firms defined as those with less than $100,000 of assessable payroll in 1992).	introduction of experience rating reduces frequency of all types of injuries (first paid, health care, short-term, long - term), but increased injury severity	High

***significant at 1%
** significant at 5%
* significant at 10%

(continued)

Table 2: Summary of high and intermediate level studies examining the effect of introduction of experience rating on illness and injury outcomes

Author & year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
Cheadle et al. (22) Washington State 1987-1989 claim	Feature A: dummy variable indicating firm participating in a retrospective rating program at the time of the injury vs. not participating Feature B: firm participated in the retrospective rating program for the entire sample period Feature C: firm entered retrospective rating program after 1986 Feature D: firm transitioned in and out of program during study period.	severity: duration of time loss claims (data censored at the end of the study)	panel micro data Cox proportional hazard model	28473	1) 1.00 2) 1.14** 3) 1.08** 4) 1.02	severity of claims decreases if firm is experience rated	Medium
Deland (23) Alberta 1951-1992 industry	variable indicating year in which Alberta's experience rating program came in effect (1987+)	frequency: fatalities per 1,000 workers	aggregate time series Ordinary least squares regression with testing for cointegration using Augmented Dickey-Fuller test	42	1) -0.24** (construction); 2) -0.1 (manufacturing); 3) -0.6*** (mining); 4) -1.01*** (services); 5) -0.42** (trade); 6) -0.44** (transportation)	introduction of experience rating reduces frequency of fatalities	Medium
Kralj (24) Ontario 1983 & 1988 claim	variable indicating the implementation of the CAD-7 program	severity: log of the number of calendar days the claimant received temporary total disability benefits censored at 90 days	panel micro data Ordinary least squares regression with correction for heteroskedasticity	i) 4407 (full sample) ii) 2157 (2-21 day duration) iii) 1886 (28 days or more duration) iv) 1679 (35 days or more duration)	i) 0.0807* ii) -0.0237 iii) -0.0314* iv) -0.0376**	severity of claims increases with introduction of experience rating, but severity of the most severe claims decreases (N.B.: impact may be driven by claims management)	Medium

***significant at 1%
** significant at 5%
* significant at 10%

Table 3: Summary of high and intermediate quality studies examining the effect of degree of experience rating on illness and injury outcomes

Author & year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
Kotz and Schafer (25) Germany 1955-1980 industry	Feature A: total amount of "WC" surcharges and rebates applied to member firms (adjusted for inflation) Feature B: total amount of "WC" surcharges and rebates applied to member firms (adjusted for inflation) divided by the total number of employees.	1) frequency: number of reported work accidents (3 or more days lost from work) per 1000 workers per year (2 equations); 2) frequency: number of work accidents (all, not just reported) per 1000 workers per year (2 equations); 3) severity: costs of medical treatment and pensions divided by the total number of accidents (2 equations).	aggregate time series Ordinary least squares regression with testing for autocorrelation and multicolinearity	26	Feature A 1) -0.2** 2) -0.21** 3) -9.2*** Feature B 1) -0.15 2) -0.14 3) -14.2	increased degree of experience rating decreases frequency and severity of injuries	Medium
Lanoie and Stréliski (26) Québec 1983-1990 industry	lagged value of number of manual rating classes per 1,000 full-time employees	1) frequency: log of probability ratios based on the injury rate 2) severity: log of average number of days lost due to a workplace accident 3) frequency: log of probability ratios based on the permanent impairment rate 4) frequency: log of probability ratios based on the injury rate (15 high risk industries) 5) severity: log of average number of days lost due to a workplace accident (15 high risk industries) 6) frequency: log of probability ratios based on the permanent impairment rate (15 high risk industries)	aggregate cross-sectional, time series Generalized least squares regression with correction for heteroskedasticity and autocorrelation	1-3) 224 4-6) 120	1) -0.099** 2) -0.015 3) -0.041 4) -0.094 5) -0.036* 6) -0.108	increased degree of experience rating decreases frequency of injuries in low risk industries, and decreases severity in high risk industries	Medium
Ruser (27) United States 1972-1979 industry at state level	(benefit x size)	1) frequency: all injuries per 100 worker years at the three digit SIC level by state. 2) frequency: all lost days per 100 worker years at the three digit SIC level by state (exclude fatalities).	aggregate cross-sectional, time series Two single equation models with correction for heteroskedasticity using Harvey's Method	3243	1) -0.97 *** 2) -0.151***	increased degree of experience rating decreases frequency of all injuries and lost workday injuries	Medium

***significant at 1%
** significant at 5%
* significant at 10%

(continued)

Table 3: Summary of high and intermediate quality studies examining the effect of degree of experience rating on illness and injury outcomes

Author & year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
Ruser (28) United States 1979-1984 firm	(benefit x size), four firm size categories based on number of employees: a) 1-99 b) 100-249 c) 250-499 d) 500+	frequency: lost-workday injury and illness cases per 100 worker years excluding fatalities	Several single equation models run using different statistical methodologies starting with OLS and ending with most statistically accurate model: 1) ordinary least squares estimation 2) weighted least squares estimation: 3) quasi-generalized pseudo-maximum-likelihood estimation 4) negative binomial maximum-likelihood estimation 5) fixed-effect negative binomial maximum-likelihood estimation	16788	1) a) 4.11***; b) 1.46***; c) 1.04***; d) 0.92*** 2) a) 4.29***; b) 1.56***; c) 1.12***; d) 1.07*** 3) a) 2.755 ***; b) 1.091 ***; c) 1.082 ***; d) 0.633 ** 4) a) 3.744 ***; b) 2.037 ***; c) 0.975 ***; d) 1.084; *** 5) a) 2.004**; b) 0.689; c) 0.919**; d) -0.097	increased degree of experience rating increases lost workday injuries (impact likely dominated by effect of wage replacement rate)	Medium
Ruser (29) United States 1979-1984 firm	(benefit x size), four firm size categories based on number of employees: a) 1-99 b) 100-249 c) 250-499 d) 500+	1) frequency: annual number of non-lost-workday injury cases per establishment; 2) frequency: annual number of restricted workday injury cases per establishment; 3) frequency: annual number of days away from work cases per establishment; 4) frequency: annual number of fatality cases per establishment; 5) frequency: annual number of non-lost-workday injury cases per establishment (excludes illnesses); 6) frequency: annual number of restricted workday injury cases per establishment (excludes illnesses); 7) frequency: annual number of days away from work cases per establishment (excludes illnesses); 8) frequency: annual number of fatality cases per establishment (excludes illnesses);	panel micro data, Several single equation models using four different injury frequency outcome measures using mixed negative binomial, multinomial logit estimation (1-4) and mixed fixed effect negative binomial, multinomial logit estimation (5-8)	16788	percentage of effects on injury rate at sample mean: 1) a) 0.12**; b) 0.059; c) 0.016; d) -0.038 2) a) 0.92; b) -0.151**; c) -0.275***; d) 0.256*** 3) a) 0.427***; b) 0.209***; c) 0.196***; d) 0.043*** 4) a) -0.987; b) -1.18**; c) -0.719; d) -1.103*** 5) a) 0.16; b) 0.216***; c) 0.217***; d) 0.066 6) a) 0.131; b) 0.051; c) -0.074; d) 0.361*** 7) a) 0.467***; b) 0.411***; c) 0.397***; d) 0.232*** 8) a) -0.948; b) -0.978**; c) -0.518; d) -0.999***	increased degree of experience rating decreases fatalities, increases other injury types (impact likely dominated by effect of wage replacement rate)	Medium

Table 4: Summary of high and intermediate quality studies examining the effect of introduction of OHS regulation on illness and injury outcomes

Author & year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
Curington (30) New York, Texas 1966-1968 1973-1974 industry at state level	dummy indicating years in which OSHA regulation in effect	frequency: number of claims per 100 full-time workers-- 15 different frequency equations estimated with different injury categories and sub-categories	aggregate cross-sectional, time series, Generalized least squares	75	New York Sample: Aggregate: 4.24***; sub-category of struck-by-machine: 1.68*; falls: 0.88***; sub-category of falls to work surfaces: 0.70***; sub-category of inhale or absorb chemicals: 0.11*; temperature extremes: 0.28***; overexertion: 2.50*** Other injury categories/sub-categories: not significant Texas Sample: 2) Caught-in: -1.70***; sub-category of caught-in-machine: -2.66***; sub-category of struck-by-machine: -1.55***; sub-category of struck-by-power-transmission-device: -1.50**; sub-category of falls to work surfaces: -0.94***; sub-category of inhale or absorb chemicals: 0.20***; sub-category of temperature extremes involving chemicals: 0.22***; Other injury categories/sub-categories: not significant	introduction of OHS regulation in New York increased frequency of some injury types introduction of OHS regulation in Texas reduced injury frequency of some types, increased other types	Medium
Lanoie (31) Quebec 1974-1987 industry at province level	dummy variable for each industry indicating years in which OHS regulation in effect	1) frequency: log of probability ratio based on the injury rate including injuries and illness with at least one workday lost; 2) frequency: log of probability ratio based on the permanent disability rate.	aggregate cross-sectional, time series, Instrumental variable regression with testing for heteroskedasticity and serial correlation	1) 420 2) NOT STATED	Outcome 1: Construction: -0.355*; transportation equipment: -0.288*; electrical products: -0.346*; miscellaneous manufacturing: -0.475* 26 others not significant Outcome 2: Hosiery and apparel: 0.354*; miscellaneous manufacturing -0.579*; trade: -5.87* 27 others not significant	introduction of OHS regulation in Quebec reduced frequency in some industries	Medium

***significant at 1%
** significant at 5%
* significant at 10%

Table 5: Summary of high and intermediate quality studies examining the effect of OHS inspections on illlness and injury outcomes

Author & year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
Chung (12) South Korea 1984-1987 firm	Feature A) number of remaining days of the year after inspection Feature B) dummy variable indicating inspected in t-1	1) severity: percentage change in lost workdays; 2) frequency: percentage change in injury frequency	panel micro data Ordinary least squares regression (not explicitely stated)	516	Feature A 1) -0.0413** 2) -0.0362** Feature B 1) B) -9.1664 2) B) -4.2105	inspections reduce frequency and severity- - impact with a lag-- previous inspections do not have an impact	High
Gray and Mendeloff (32) United States 1979-1985, 1987-1991 1992-1998, firm	any inspection in period: Feature A) t Feature B) t-1 Feature C) t-2 Feature C) t-3	frequency: log of change in total number of lost workday injuries	panel micro data Ordinary least squares with testing for autocorrelation	i) 27368 1979-1985 ii) 32765 1987-1991 iii) 25603 1992-1998	Feature A i) A) -0.019** ii) A) 0.014 iii) A) 0.01 Feature B i) B) -0.025*** ii) B) -0.023** iii) B) 0.006 Feature C i) C) -0.024*** ii) C) 0.003 iii) C) -0.012 Feature D i) D) -0.005 ii) D) -0.025 iii) D) -0.008	in early years of OSHA inspections reduced frequency whereas they do not in more recent times-- impact is with a lag	High
Gray and Scholz (11) United States 1983-1985 firm	percentage change in predicted probability of inspection in year: Feature A) t Feature B) t-1 Feature C) t-2	frequency: percentage change in lost workday injury rate	panel micro data Maximum likelihood regression with autoregressive error structure	i) 5352 (small plants) ii) 15672 (medium plans) iii) 6368 (large plants)	Feature A i) 1.55; ii) 0.88; iii) 0.86*** Feature B i) -2.51**; ii) -2.18***; iii) -0.98*** Feature C i) 2.31**; ii) -1.5***; iii) -0.63***	inspections reduce frequency-- more effect among medium and large firms-- impact is with a lag	High
Ruser and Smith (33) United States 1980-1985, 1981-1985 firm	Feature A) dummy variable indicating early inspection in the year, i.e., March or April versus November or December of year t Feature B) interaction term of early dummy with previous year's injury rate-- firm more likely to have a reduction in injury rate	1) frequency: lost workday injury rate per 100 FTEs in year t; 2) frequency: lost workday injury rate per 100 FTEs in year t+1;	panel micro data Ordinary least squares regression (not explicitly stated)	i) 835 ii) 1468 iii) 918 iv) 893 v) 509 vi) 893 vii) 526 viii) 468	Feature A - Outcome 1 i) -0.319; ii) 1.153; iii) 0.187; iv) 0.896 Feature A - Outcome 2 v) -1.173*; vi) 0.76; vii) -0.348; viii) 0.102 Feature B - Outcome 1 i) 0.052; ii) -0.178***; iii) 0.016; iv) -0.18*** Feature B - Outcome 2 v) -0.043; vi) -0.071*; vii) 0.086; viii) 0.069	inspections reduce frequency and severity- - impact with a lag-- previous year's injury has incremental impact on inspections-- primarily small and mid sized firms	High

***significant at 1%
** significant at 5%
* significant at 10%

(continued)

Table 5: Summary of high and intermediate quality studies examining the effect of OHS inspections on illness and injury outcomes

Author & year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
Scholz and Gray (34) United States 1979-1985 firm	percentage change in predicted probability of inspection in year: Feature A) t Feature B) t-1 Feature C) t-2	1) frequency: percentage change in lost workday injuries; 2) severity: percentage change in lost workdays	panel micro data Generalized least squares with autoregressive errors	27368	Feature A 1) 1.208*** 2) 1.023*** Feature B 1) -1.357*** 2) -0.84*** Feature C 1) -0.591** 2) -0.401	inspections reduce frequency and severity-- impact is with a lag	High
Scholz and Gray (13) United States 1979-1988 firm	Feature A: log of complaint inspections without penalties in year a) t-1; b) t-2; Feature B: log of regular inspections without complaint in year a) t-1; b) t-2.	frequency: log change in injuries	panel micro data Generalized leasts squares with autoregressive errors	27368	Feature A a) -0.026; b) -0.055*** Feature B a) -0.001; b) 0.034***	when no penalties imposed, complaint inspections reduce frequency whereas regular inspections increase it-- both have impact with a lag	High
Sha (35) United States 1979-1984 firm	number of State or Federal inspections per 1,000 manufacturing employees in year t	1) frequency: number of non-lost workday cases per establishment; 2) frequency: number of restricted workday cases per establishment; 3) frequency: number of days away from work cases per establishment; 4) frequency: number of deaths per establishment.	panel micro data, Two step model estimated through Maximum Likelihood-- first step determines total number of injuries using a negative binomial regression, second step determines severity of injuries	i) 2015 (1-99 size) ii) 4815 (100-249 size) iii) 3670 (250-499 size) iv) 3485 (500+ size)	Outcome 1 i) -0.2243***; ii) -0.1877***; iii) -0.0387***; iv) -0.1237*** Outcome 2 i) 0.0389***; ii) 0.0286***; iii) 0.0207***; iv) 0.1275*** Outcome 3 i) 0.1378***; ii) 0.0626***; iii) -0.0103***; iv) 0.0536*** Outcome 4 i) 0.0117***; ii) 0.0094***; iii) 0.0119***; iv) 0.0510***	inspections reduce frequency of non-lost workdays but increase more serious injuries (restrited workday, lost workday, and death cases)-- evidence contradicts other studies and intuition-- unusual statistical methodology	High

***significant at 1%
** significant at 5%
* significant at 10%

(continued)

Table 5: Summary of high and intermediate quality studies examining the effect of OHS inspections on illness and injury outcomes

Author & year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
Smith (36) United States 1972-1973, 1973-1974 1972-1974 firm	Feature A) dummy variable indicating early inspection in the year, i.e., April or May vs. November or December of 1973; Feature B) interaction term of early inspection dummy for 1973 times injury rate in 1972-- measure for higher probability of rates being reduced; Feature C) dummy variable indicating early inspection in the year, i.e., April or May vs. November or December of 1974 Feature D) interaction term of early inspection dummy for 1974 times injury rate in 1973-- measure for higher probability of rates being reduced.	1) frequency: lost workday injury rate in 1973; 2) frequency: lost workday injury rate in 1974.	panel micro data Ordinary least squares regression (not explicitly stated) with joint significance testing of inspection variables	sample size (corresponding firm size -- number of employees) i) 816 (1-99) ii) 799 (100-249) iii) 378 (250-500) iv) 816 (500+) v) 816 (1-99) vi) 799 (100-249) vii) 378 (250-500) viii) 369 (500+) ix) 889 (1-99) x) 829 (100-249) xi) 418 (250-500) xii) 356 (500+)	Feature A - Outcome 1 i) 0.204; ii) -0.448; iii) -0.051; iv) -0.296; Feature A - Outcome 2 v) -0.64; vi) .02; vii) -0.543; viii) -0.841** Feature B -Outcome 1 i) -0.122**; ii) 0.017; iii) -0.058; iv) 0.138** Feature B - Outcome 2 v) -0.063; vi) -0.059; vii) -0.081; viii) 0.363** Feature C - Outcome 2 ix) -0.244; x) 0.336; xi) 0.06; xii) -0.191; Feature D - Outcome 2 ix) -0.001; x) -0.7; xi) -0.016; xii) 0.029	in general, no evidence that inspections reduce frequency with exception of larger firms-- impact with a lag	High
Baggs et al. (37) Washington 1999-2000 firm	Feature A) all inspections Feature B) all inspections x time period Feature C) inspection: programmed inspections Feature D) programmed inspections x time period Feature F) complaint inspections Feature E) complaint inspections x time period	1) frequency: change in compensable claim rate per year; 2) frequency: change in compensable claim rate per quarter.	panel micro data Repeat measures Poison regression	i) 7424 ii) 1505 iii) 7424 iv) 1505 v) 7000+ vi) 1505	i) 0.5745***; -0.1816** (inspections; inspections x time period-- fixed site sample with yearly rate-- decrease of -22.5%); ii) 0.1553; -0.06 (inspections; inspections x time period-- non-fixed site sample with yearly rate-- decrease of -12.8%); iii) 1.026***; -0.0437** (inspections; inspections x time period-- fixed site sample with quarterly rate-- decrease of -22.4%); iv) 0.5399**; -0.0334* (inspections; inspections x time period-- non-fixed site sample with quarterly rate-- decrease of -13.5%); v) 0.6455***; -0.1732*; 0.4337***; -0.2027 (programmed inspections;programmed inspections x time period; complaint inspections; complaint inspections x time period-- fixed site sample with yearly rate-- decrease of -21.8% and -24.1%); vi) 0.1361; -0.0819; 0.2167; 0.0006 (programmed inspections;programmed inspections x time period; complaint inspections; complaint inspections x time period-- non-fixed site sample with yearly rate-- decrease of -14.7% and -7.4%);	results suggest that inspections increase frequency	Medium

***significant at 1%
** significant at 5%
* significant at 10%

(continued)

Table 5: Summary of high and intermediate quality studies examining the effect of OHS inspections on illness and injury outcomes

Author & year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
Guo (38) United States 1986-1991 firm	inspection without penalty in: a) t b) t-1 c) t-2 d) t-3	1) frequency: percentage change in lost workday injuries; 2) severity: percentage change in number of lost workdays.	panel micro data Maximum likelihood estimation	242	1) a) -0.07 b) -0.05 c) 0.03 d) 0.02 2) a) -0.11 b) 0.1 c) -0.22 d) 0.23	no evidence that inspections reduce frequency or severity	Medium
Kim (39) United States 1976-1988 industry at state level	number of inspections per 1000 manufacturing workers in t-1	1) frequency: total injury rate per 1,000 manufacturing employees; 2) frequency: serious injury rate per 1,000 manufacturing employees; 3) frequency: nonfatal injury rate per 1,000 manufacturing employees.	aggregate cross-sectional, time series, Two-equation regression model with total inspections as the dependent variable of the second regression, testing for under-identification, autocorrelaton and heteroskedasticity	585	1) 0.034*** 2) 0.063*** 3) 0.015***	probability of inspection increases frequency	Medium
Lanoie (40) Quebec 1983-1987 industry	total number of inspections in previous year divided by 1,000 full-time employees	1) frequency: log of probability ratios based on the rate of injury, including diseases, and only including injuries with at least one lost workday; 2) severity: log of average number of workdays lost per injury, including only injuries with at least one lost workday, and fatalities and permanent disabilities assinged a duration of 6,000 days	aggregate cross-sectional, time series, Ordinary least squares with adjustment for heteroskedasticity, testing for serial correlation, and testing for endogeneity	140	1) -0.006** 2) 0.001*	probability of inspection reduces frequency and increases severity	Medium
Lanoie and Stréliski (26) Quebec 1983-1990 industry	general deterrence-- number of inspections per 1000 full-time employees	1) frequency: log of probability ratios based on the injury rate; 2) severity: log of average number of days lost due to a workplace accident; 3) frequency: log of probability ratios based on the permanent impairments rate;	aggregate cross-sectional, time series, Generalized least squares regression with correction for heteroskedasticity and autocorrelation	i) 224 (full sample) ii) 120 (sample subset: 15 high risk industries)	1) i) -0.004*** ii) -0.006*** 2) i) 0.002*** ii) 5) 0.002*** 3) i) 0.002 ii) 0.001	probability of inspection reduces frequency and increases severity	Medium

***significant at 1%
** significant at 5%
* significant at 10%

(continued)

Table 5: Summary of high and intermediate quality studies examining the effect of OHS inspections on illness and injury outcomes

Author & year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
McCaffrey (41) United States 1976-1978 firm	Feature A) dummy variable indicating early inspection in the year, i.e., March or April vs. November or December of 1976; Feature B) dummy variable indicating early inspection in the year, i.e., March or April vs. November or December of 1977; Feature C) dummy variable indicating early inspection in the year, i.e., March or April vs. November or December of 1978.	1) frequency: lost workday injury rate for the year 1976; 2) frequency: lost workday injury rate for the year 1977; 3) frequency: lost workday injury rate for the year 1978.	panel micro data Ordinary least squares regression (not explicitly stated)	i) 1990 ii) 1846 iii) 1801 iv) 1373 v) 1231	i) 0.25-- feature A with outcome 1; ii) -0.21 -- feature B with outcome 2; iii) -0.24-- feature C with outcome 3; iv) 0.2 -- feature B with outcome 1; v) -0.08-- feature C with outcome 2.	no evidence that inspections reduce frequency	Medium
Ruser (42) United States 1979-1984 firm	no feature directly included in model but separate regressions run for inspected and uninspected firms and analyzed the unexplained variance	frequency: lost workday injuries per 100 full-time workers, including lost-time and restricted workday activity claims	panel micro data Negative binomial regression model	15690	none to report: high unexplained injury rates tend to decline even without inspections, particularly for smaller firms, suggesting that OSHA inspections may be more effective if targeted to larger firms with high unexplained injury rates	no evidence that inspections decrease frequency	Medium
Smitha et al. (16) United States 1992-1997 industry at state level	number of OSHA inspections per year	frequency: case rate of days away from work, or days of restricted work activity, or both, not including fatalities	aggregate cross-sectional, time series, Poisson regression model	3286	1) 0.0275*** (complete model) 2) 0.0290***(reduced model)	probability of inspection increases frequency and increases severity	Medium
Viscusi (43) United States 1972-1975 industry	number of OSHA inspections per 100,000 workers at time: Feature A: t Feature B: t-1 Feature C: t-2 Feature D: t-3	frequency: log of probability ratio based on injury rate including injuries and illness	aggregate cross-sectional, time series, Ordinary least squares with lagged injury rate variable estimated using two-stage least squares	205	Feature A) -1.415 Feature B) -0.288 Feature C) 0.735 Feature D) 1.652	no evidence that probability of inspection reduces frequency	Medium
Viscusi (44) United States 1973-1983 industry	frequency of OSHA inspections per production worker in: Feature A: t Feature B: t-1	1) frequency: log of probability ratio based on overall injury and illness rate; 2) frequency: log of probability ratio based on lost workday injury and illness rate; 3) severity: total number of days lost due to injury and illness per 100 workers.	aggregate cross-sectional, time series, Ordinary least squares with testing for endogeneity	220	Feature A 1) 12.4* 2) 9.61 3) 6.069 Feature B 1) -12.8* 2) -16.637** 3) -25.862***	probability of inspection reduces frequency and severity- - impact with a lag	Medium

***significant at 1%
** significant at 5%
* significant at 10%

Table 6: Summary of high and intermediate quality studies examining the effect of citations and penalties on illness and injury outcomes

Author, year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
Gray and Mendeloff (32) United States 1979-1985 1987-1991 1992-1998 firm	specific deterrence-- inspections with penalties in period Feature A: t Feature B: t-1 Feature C: t-2 Feature D: t-3	frequency: log of change in total number of lost workday injuries	panel micro data Ordinary least squares with testing for autocorrelation	i) 27368 (1979-1985 equation) ii) 32765 (1987-1991 equation) iii) 25603 (1992-1998 equation)	Feature A i) -0.058 ***; ii) 0.004; iii) -0.002 Feature B i) -0.046 ***; ii) -0.036 ***; iii) 0.01 Feature C i) -0.048 ***; ii) -0.016; iii) -0.016 Feature D i) -0.005; i) -0.046 ***; iii) -0.006	inspections with penalties have both an immediate and lagged impact on lost workdays in the earlier time period, but less-to-no impact in the more recent time periods	High
Gray and Scholz (45) United States 1983-1985 firm	Feature A: general deterrence-- percentage change in expected penalties in year: a) t b) t-1 c) t-2 Feature B: specific deterrence-- dummy variable indicating an inspection with penalty occurred in year: a) t b) t-1 c) t-2 d) t-3	frequency: percentage change in lost workday injury rate	panel micro data Maximum likelihood regression with autoregressive error structure	1) 5352 2) 15672 3) 6368	Feature A Small firms a) -1.39 ***; b) -0.63 ***; c) -0.44 ** Medium firms a) -0.77 ***; b) -0.21 **; c) -0.32 *** Large firms a) -0.59 ***; b) -0.12; c) -0.38 *** Feature B Small firms a) -0.05; b) -0.11**; c) -0.14 **; d) 0.02 Medium firms a) -0.05 ***; b) -0.06 ***; c) -0.03; d) 0.01 Large firms a) 0; b) 0; c) -0.02; d) 0	an increase in the probability of penalty has an immediate and lagged impact on injury frequency an actual inpsection with penalty has an immediate and lagged impact on injury frequency for small and medium sized firms	High

***significant at 1%
** significant at 5%
* significant at 10%

(continued)

Table 6: Summary of high and intermediate quality studies examining the effect of citations and penalties on illness and injury outcomes

Author, year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
Gray and Scholz (11) United States 1982-1985 firm	specific deterrence-- dummy variable indicating inspection that imposed a penalty in year: Feature A: t Feature B: t-1 Feature C: t-2 Feature D: t-3	1) frequency: percent change in lost workday injuries 2) severity: percent change in total lost workdays	panel micro data Regressions based on the Chamberlain method which accounts for heterogeneity among plants due to omitted variables, serial correlation in the dependent variables and endogeneity of inspections	27368	Feature A 1) -0.0583 ***; 2) -0.0243 Feature B 1) -0.0664 ***; 2) -0.0788 *** Feature C 1) -0.0656 ***; 2) -0.0828 *** Feature D 1) -0.0361 ***; D2) -0.0113 ***	inspections with penalties have an immediate and lagged impact on injury frequency and severity	High
Scholz and Gray (34) United States 1979-1985 firm	Feature A: general deterrence — percentage change in predicted penalty in year: a) t b) t-1 c) t-2 Feature B: specific deterrence — inspections with penalties in year: a) t b) t-1 c) t-2 d) t-3	1) frequency: percentage change in lost workday injuries; 2) severity: percentage change in lost workdays	panel micro data Generalized least squares with autoregressive errors	27368	Feature A Outcome 1 a) -0.897 ***; b) -0.294 ***; c) -0.381 *** Outcome 2 a) -0.446 ***; b) -0.14; c) -0.28 *** Feature B Outcome 1 a) -0.036 **; b) -0.049 ***; c) -0.043 ***; d) -0.006 Outcome 2 a) -0.001; b) -0.058 ***; c) -0.043 **; d) -0.006	an increase in the predicted penalty in the current and previous years increases the frequency of lost workday injuries an increase in inspections with penalties in the current and previous years increases the number of lost workdays	High
Scholz and Gray (13) United States 1979-1988 firm	Feature A: specific deterrence-- log of complaint inspections with penalty for year: a) t-1 b) t-2 Feature B: specific deterrence-- log of regular inspections with penalties for year: a) t-1 b) t-2	frequency: log change in injuries	panel micro data GLS: calculated using MLE includes autoregressive lags	27368	Feature A a) -0.019; b) -0.027 Feature B a) -0.069 ***; b) -0.057 ***	an increase in inspections with penalties in the current and previous year increases the number of injuries	High

***significant at 1%
** significant at 5%
* significant at 10%

(continued)

Table 6: Summary of high and intermediate quality studies examining the effect of citations and penalties on illness and injury outcomes

Author, year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	High Quality
Bartel and Thomas (10) United States 1972-1978 industry	general deterrence-- change in the log of industry penalty rate	severity: log of lost workdays rate	aggregate cross-sectional, time series Two stage non-linear least squares regession	2772	0.051	changes in the industry penalty rate do not have an impact on injury severity	Medium
Bartel and Thomas (46) United States 1974-1978 industry	general deterrence-- penalties per inspection divided by employees per firm--measure of violations per employee	severity: log of lost workdays rate	aggregate cross-sectional, time series Two stage least squares regression	Sample size not provided	0.093	violations per employee does not have a significant impact on injury severity	Medium
Guo (38) United States 1986-1991 firm	specific deterrence-- inspection with penalty in year Feature A: t Feature B: t-1 Feature C: t-2 Feature D: t-3	1) frequency: percentage change in lost workday injuries; 2) severity: percentage change in number of lost workdays.	panel micro data Maximum likelihood regression	242	Feature A 1) 0; 2) -0.02 Feature B 1) -0.04; 2) -0.17 Feature C 1) -0.04; 2) 0.12 Feature D 1) -0.02; 2) 0.03	inspections with penalties do not have an immediate or lagged impact on injury frequency or severity	Medium
Kim (39) United States 1976-1988 industry at state level	Feature A: general deterrence-- number of serious violations per 1,000 manufacturing workers Feature B: general deterrence-- number of non-serious violations per 1000 manufacturing workers Feature C: general deterrence-- number of serious penalties per 1,000 manufacturing workers Feature D: general deterrence-- number of non-serious penalties per 1,000 manufacturing workers	1) frequency: total injury rate per 1,000 manufacturing employees; 2) frequency: serious injury rate per 1,000 manufacturing employees; 3) frequency: nonfatal injury rate per 1,000 manufacturing employees.	aggregate cross-sectional, time series Two equation regression model with total inspections as the dependent variable of the second regression, testing for under-identification, autocorrelation and heteroskedasticity	585	Feature A 1) -0.104 ***; 2) 0.277 *** Feature B 1) 0.035 ***; 2) 0.004 *** Feature C 1) 0.004 ***; 2) 0.012 *** Feature D 1) 0.018 ***; 3) 0.01 ***	violations and penalties have an unclear relationship with the frequency of different types of injuries, i.e., in one case they reduce frequency and in others they increase it	Medium

***significant at 1%
** significant at 5%
* significant at 10%

(continued)

Table 6: Summary of high and intermediate quality studies examining the effect of citations and penalties on illness and injury outcomes

Author, year, jurisdiction, sample period, unit of analysis	Feature info	Outcome details	Data type and statistical methodology	Sample size	Feature effect size (by outcome)	Interpretation of results	Quality
Lanoie (40) Quebec 1983-1987 industry	general deterrence-- number of penalties imposed for infractions in previous year divided by 1,000 full-time employees	1) frequency: log of probability ratios based on the rate of injury, including diseases, and only including injuries with at least one lost workday; 2) severity: log of average number of workdays lost per injury, including only injuries with at least one lost workday, and fatalities and permanent disabilities assigned a duration of 6,000 days	aggregate cross-sectional, time series Ordinary least squares with adjustment for heteroskedasticity, testing for serial correlations, and testing for endogeneity	140	1) 0.002 2) -0.007	no evidence that an increased probability of penalty decreases frequency or severity	Medium
Lanoie and Stréliski (26) Quebec 1983-1990 industry	general deterrence-- number of penalties per 1,000 full-time employees	1) frequency: log of probability ratios based on the injury rate; 2) severity: log of average number of days lost due to a workplace accident; 3) frequency: log of probability ratios based on the permanent impairments rate;	aggregate cross-sectional, time series Generalized least squares regression with correction for heteroskedasticity and autocorrelation	i) 224 (full sample) ii) 120 (sample subset - 15 high risk industries)	Outcome 1 i) 0; ii) -0.002 Outcome 2 i) 0.004; ii) -0.003 Outcome 3 i) 0.007; ii) 0.006	no evidence that an increased probability of penalty decreases frequency	Medium
Robertson and Keeve (47) New York, Wisconsin Connecticut 1975-1976 firm	Feature A: specific deterrence-- dummy variable indicating OSHA citation during or just prior to the year Feature B: specific deterrence-- dummy variable indicating OSHA citation in the previous year Feature C: specific deterrence-- dummy variable indicating OSHA citation two years prior	1) frequency: number of subjective injuries (all injuries) at the plant level in time period t 2) frequency: number of objective injuries (all injuries) at the plant level in time period t 3) frequency: number of subjective injuries (lost-time injuries) at the plant level in time period t 4) frequency: number of objective injuries (lost-time injuries) at the plant level in time period t 5) frequency: change in days lost (1976 minus 1975) for injury in the jth industry of the ith state	panel micro data Instrumental variables: did not describe it as such, but estimated the number of injuries expected above or below those expected from exposure alone, using the regression results at the individual level	1-4) 24 5) 3340	Feature A 1) -4.33 2) -31.48*** 3) -9.91* 4) -13.68*** Feature B 1) 10.61 2) -1.63 3) -7.61 4) -5.2 Feature C 1) -3.14 2) 0.72 3) 1.9 4) -4.7	an OSHA citation during or immediately before the beginning of the year decreases the incidence of injuries	Medium

***significant at 1%
** significant at 5%
* significant at 10%