

**BRIEF REPORT**

# Workplace injury rates and firm-level turnover in Montana's oil and gas industry

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**Abstract****Background:** Do workers follow their self-interest by minimizing injury risk in their employment decision? If so, employers could use injury reduction as a recruitment and retention strategy. This study explores whether injury incidence is associated with turnover in Montana's Oil and Gas industry.**Methods:** A panel data set of Unemployment Insurance and Workers' Compensation administrative records from 2010 to 2015 was used to model the relationship between turnover and injury claim rates at the firm level.**Results:** Total turnover and injury rates were found to be positively related while injury rates and separation rates had no such association. Quarters in which the employer experienced a severe injury had a 3.3 percentage point increase in separation rates.**Discussion:** The findings suggest that injured workers contribute to increased turnover, but coworker turnover does not increase with increased injury rates in the firm. Secondary findings suggest a relationship between recent hires and increased injury rates, although further investigation is required.**KEYWORDS**

business turnover, oil and gas, workplace injuries

## 1 | BACKGROUND

Expansion of the Oil and Gas industry created conditions for the "Bakken boom" in North Dakota and Montana. Increased employment in fracking jobs was followed by increased research into the associated occupational exposures and hazards. Workers in hydraulic fracturing used in oil and gas development are exposed to health risks<sup>1</sup> including exposures to dangerous levels of silica<sup>2,3</sup> or other chemicals.<sup>4</sup> While research has begun to provide knowledge of the occupational risks of fracking, more is needed to clarify the impacts and benefits of safety interventions and safety culture for businesses.<sup>4</sup> This study seeks to fill a gap in the research by studying whether firms with higher rates of injuries have increased employee turnover. The relationship is studied using Unemployment Insurance tax records and Workers' Compensation injury reporting data in Montana's Oil and Gas industry. A positive relationship between injury rates and turnover would imply that employers

can find turnover reduction benefits through investments in safety. In Montana, where labor is in short supply, reduced turnover could be a valuable incentive for businesses and critical insight for state policymakers advocating for improvements in the state's injury rates.

### 1.1 | Previous Research

A 2009 review found mixed results on the consistency and quality of economic analyses of occupational health and safety interventions.<sup>5</sup> Studies of the healthcare and beverage manufacturing industries have shown that safe workplaces decrease turnover and reduce workers' compensation costs<sup>6-8</sup> while another of the transportation industry found that structural incentives, such as rewards for greater delivery speed, diminish the influence of workplace hazards on workers' separation intentions.<sup>9</sup> Thus, while the relationship between safety and turnover appears subject to industry-specific incentive

structures, broader research suggests a safer work environment can reduce turnover by improving employee satisfaction.<sup>10</sup>

Employers face significant costs from greater turnover through recruitment, training, and lost productivity. To an extent, employers can benefit from turnover through reduced future costs,<sup>11</sup> however, employers generally find cost savings by restraining turnover.<sup>12,13</sup> To restrain turnover, employers can turn to compensation to influence their employees' decision to stay in a job.<sup>14,15</sup> However, compensation can only be increased to a certain point before limiting profitability. Injury reduction in the workplace could be a factor helping reduce turnover as well. For workers, the adverse impact of occupational injuries on future earnings could potentially be greater than that of being laid off for a temporary period.<sup>16,17</sup> Safety in the workplace is largely influenced by management<sup>18</sup> and research suggests that the influence of managers on their employees in the workplace plays a larger role in overall occupational safety than federal regulations through the OSHA.<sup>19</sup>

This study aimed to measure the association between workplace injury rates and firm-level turnover in Montana's Oil and Gas industry. The purpose was to explore whether a work environment that reduces injury risk could be a potential tool for worker retention.

## 2 | METHODS

### 2.1 | Data

Leverage for workers is important for employees to be able to influence employer behavior.<sup>20</sup> To capture a moment when such leverage was present, this study analyzes Montana's Oil and Gas industry during the Bakken boom, from 2010–2015. This time and location were characterized by high demand for workers, with limited supply, presenting a moment when workers had security to move between employers according to their preferences. Administrative data from the state of Montana's Unemployment Insurance and Workers' Compensation agencies were used to create a longitudinal panel of employment and injury claim records and investigate whether employer turnover was positively associated with injury rates. All data used in this study were obtained with the approval of the related state agencies.

Unemployment Insurance administrative records of all covered employers from Montana's Oil and Gas industry over 2010–2015 formed the study sample. These records are used as the basis for the Quarterly Census of Employment and Wages (QCEW) and are considered a census of wage-paying employment in the industry. Counts of employment, hires, and separations, as well as worker wages, industry, and location for each employer are determined from the Unemployment Insurance wage records. To narrow the study to Oil and Gas industry employers, the analysis used businesses classified in one of the following 2012 North American Industry Classification System industries: 211111 – Crude Petroleum and Natural Gas Extraction; 211112 – Natural Gas Liquid Extraction; 213111 – Drilling Oil and Gas Wells; 213112 – Support

Activities for Oil and Gas Operations; 237120 – Oil and Gas Pipeline and Related Structures Construction; 486110 – Pipeline Transportation of Crude Oil; and 486210 – Pipeline Transportation of Natural Gas. Observations of business-level employment and wages are quarterly with enterprise businesses consisting of multiple locations considered one business. The result is a longitudinal panel of quarterly observations by firm. Small employers with less than five employees were dropped from the study sample to exclude pass-through entities, trusts using wages as a vehicle for annual disbursements, and other small businesses with unreliable records. Calculation of hires and separations compare adjacent quarterly records to determine which employees are new hires and which separate during the quarter. Employers without the full panel of observations had their first and/or last quarter dropped, due to the lack of data available to determine hires or separations and to avoid conflating business closures or startups with operational turnover. The resulting data set provides an unbalanced panel of 296 employers with between 4 and 24 observations apiece for a total of 4766 observations.

Employer-level injury counts were added to the panel using Workers' Compensation claims. Counts of First Reports of Injury and Subsequent Reports of Injury, from here on referred to as initial injury reports and subsequent injury reports, provided a data set of injury claims filed for each employer. Initial reports provided characteristic injury information, such as when the injury occurred and the type of injury while subsequent injury reports provided data for more severe injury claims such as whether those claims led to missed time at work. As such, injuries that required filing of subsequent injury reports were used as a proxy for the occurrence of severe injuries. Workers' Compensation claims data provide reasonable estimates of injuries at each employer because of mandatory claim reporting to the Montana Workers' Compensation Agency. In addition, Workers' Compensation data cover contingent worker relationships,<sup>21</sup> contains details on work-related injuries that are not found in other occupational health data systems, and have been shown in Washington state to provide better reporting than the Bureau of Labor Statistics' Survey of Occupational Injuries and Illnesses.<sup>22,23</sup>

In this study, data from Unemployment Insurance and Workers' Compensation were matched using employer identification numbers and counts of all claims, total initial injury reports, and counts of severe claims (total subsequent injury reports) were summed by quarter. Of the 296 employers from the oil and gas industries identified in the Unemployment Insurance file, 176 were found to have at least one Workers' Compensation injury claim between 2010 and 2015 while injuries were present in 788 of the 4766 employer-quarter observations.

Using the Unemployment Insurance employment data, two measures of turnover were developed. Total turnover is the total change of a business' employees divided by average employment for the quarter. More specifically, the total number of new hires (employees not used the quarter before the reference quarter) and separations (employees whose employment ended during the

reference quarter) was divided by the average of 3 monthly snapshots of the number of employees working at the business. In the context of the relationship being measured, changes in the total turnover measure include changes in the firm's ability to retain employees as well as hire new ones. A second turnover measure, a separation rate, was also calculated to isolate the employee retention effect while modeling. The separation rate was defined as total separations divided by the monthly average number of employees. Average quarterly turnover in the study sample was 0.61 (61%; Table 1), implying that the majority of an employer's jobs have new or departing workers each quarter. Average quarterly separations made up about half of the turnover, at about 0.31 (31%), with nearly a third of a firm's workers departing each quarter.

Injury rates were modeled two ways, as a total injury rate and as an indicator of severe injury incidence, to provide a more robust understanding of the relationships modeled. The total rate of injuries was calculated as the number of first reports of injury for the business in a quarter divided by that quarter's average employment. The average quarterly injury rate was 0.01 (1%), implying a rate of one injury per 100 quarterly employees. Most Montana Oil and Gas industry firms are small employers, averaging nearly 26 employees per firm, so no injuries were reported in over 80% of quarterly observations. Total injury rates based only on initial claim filings

include nonsevere injuries that are reported out of caution, thus leading to more variation in a business's discretion in reporting.

In contrast, reporting of more severe injuries is more consistent, making it desirable to also model the relationship using subsequent injury reports to corroborate any results found from total injury rates. Severe injuries are rarer than injury claims in general; among the 4766 observed employer-quarter pairs, only 316 experienced an injury that led to lost work time. Therefore, an indicator of the presence of a severe injury for the employer in the given quarter was used. Summary statistics of variables included in modeling are in Table 1. The data used to construct measures of turnover and injuries do not account for hours worked due to their unavailability in the administrative data used. However, the measures do provide comparability in that each is an employer's actual rate of worker turnover and separation compared with the actual rate of reported injuries with the same denominator.

Changes in economic conditions that impact the demand for labor and turnover were included in the models using unemployment rates and prices of oil and natural gas. Nonseasonally adjusted unemployment rates for Montana come from the U.S. Bureau of Labor Statistics' Local Area Unemployment Statistics program and West Texas Crude Oil Futures Prices and Henry Hub Natural Gas Futures Prices from the Energy Information Administration. Unemployment rates and oil and gas prices were averaged quarterly.

**TABLE 1** Summary statistics of model variables

Statistic	Definition (units)	Mean	Standard deviation	Range
Firm turnover rate	Turnover rate (Hires+Separations) / Avg. # Employees <sup>1</sup>	0.61	1.02	0.0-20.5
Firm separation rate	Rate of separations (Separations / Avg. # Employees <sup>1</sup> )	0.31	0.59	0.0-11.0
Firm injury rate	Rate of injury reports (Injury Reports / Avg. # Employees <sup>1</sup> )	0.01	0.05	0.0-1.0
Firm severe injury indicator	Incidence of a severe injury (Indicator)	0.07	0.25	0.0-1.0
Average worker wage	Average wages earned per employee (USD)	18,143	14,033	188-374,539
Employment	Avg. # Employees <sup>1</sup>	25.68	46.21	1-536
unemployment rate	Average Monthly Montana Unemployment Rate (%)	5.69	1.30	3.63-8.40
Natural gas price	Average Henry Hub Gas Price (USD)	3.79	0.72	2.47-5.11
Crude oil price	Average West Texas crude price (USD)	85.64	17.52	44.93-104.11
Quarter	Quarter of observation, for seasonality (Indicator)	-	-	0.0-1.0

<sup>1</sup>average number of employees

## 2.2 | Model Form

Turnover can originate from either firm or worker decision making. For the employer, job creation and destruction are largely determined by the age, size, and type of firm,<sup>24</sup> as well as availability of labor and demand for the firm's product.<sup>25</sup> Turnover originating from worker behavior, on the other hand, is largely motivated by compensation<sup>14</sup> and job satisfaction.<sup>10</sup> This study explored the hypothesis that workplace safety is also a factor in voluntary turnover by modeling the relationship between turnover and injury rates in the firm while controlling for firm characteristics, labor availability, and product demand.

Three models were developed using alternative methods of measuring turnover and injury rates. Total turnover, which includes hires and separations, was modeled as a function of total injury claim rates. After that, the dependent variable was changed to the separation rate to capture the injury rate's effect on worker departures alone. Finally, in lieu of the injury rate, an indicator of presence of at least one severe injury is included in the model, to determine whether the impact on worker separations is different depending on the severity of injuries that occur. Firm characteristics included in the model were firm size and average worker wage. Labor availability was proxied using the Montana unemployment rate, and demand effects were included using oil and natural gas prices. Seasonal patterns in turnover were captured using a categorical variable for the quarter of the record that was modeled using a dummy variable for each quarter (with the first quarter excluded). The first quarter covered January through March, the second April through June, the third July through September, and the fourth October through December.

Using F- and Hausman tests, specifications including employer fixed effects, time fixed effects, two-way effects, and random effects were compared to identify the appropriate model form. F-tests found no significant improvement to the models by adding time or two-way effects to an employer fixed effects model. A Hausman test found employer fixed effects to provide better fit over random effects estimation. As such, employer fixed effects modeling was found to be the best form for analyzing the unbalanced panel data. The models were estimated with a log-log transformation to balance model variables of different ranges (ie turnover rate and average wages) and for the transformation's desirability for interpretation. Tests were applied to check for heteroscedasticity, serial correlation, and cross-sectional dependence. A Breusch-Pagan test found heteroscedasticity present in model residuals while Pesaran's Cross-section Dependence test<sup>26</sup> and a Breusch-Pagan Lagrange Multiplier test confirmed the presence of cross-sectional dependence. The serial correlation was identified using a Breusch-Godfrey test while a Durbin-Watson test confirmed the result. The error variance issues identified through the preceding tests can be accounted for using robust standard errors.<sup>27</sup> The Driscoll and Kraay nonparametric covariance matrix<sup>28</sup> was used to generate standard errors robust to cross-sectional dependence and heteroscedasticity. In addition, the Arellano method<sup>29</sup> for standard error estimation produced estimates

robust to heteroscedasticity and serial correlation. The robust standard errors using the Driscoll and Kraay estimation methods are presented with the model results.

## 2.3 | Institution and ethics approval and informed consent

All data used in this research were obtained with approval from the Montana Department of Labor and Industry. No ethics review and approval or informed consent were required for this research because the research was performed on non-personally identifiable administrative data from government programs at the Montana Department of Labor and Industry.

## 3 | RESULTS

The employer fixed effects model of the injury claim rate on total turnover (model 1, Table 2), found a statistically significant positive relationship between total injury rate and turnover rates for employers. The relationship remained significant under robust standard error estimation. The log-log transformation of the data is interpreted as a doubling of the untransformed injury rate for the quarter being associated with an average 0.256 (26%) increase in the turnover rate for that quarter, all else constant. The average quarterly injury claim rate for employers was only 1% with the turnover rate averaging 61% (Table 1), such that a doubling of the injury rate would be associated with 15% ( $0.256 \times 0.61$ ) increase in turnover. For the average-sized firm (26 employees), this is an increase in turnover greater than one worker. Other than the injury rate, the only factor with a statistically significant relationship with a total turnover that holds under robust standard error estimation was seasonality, with turnover at the highest in the second quarter (spring/early summer) and the lowest in the first quarter (winter) (Table 2).

The second model isolates the impact of injury rates on worker departures by modeling separation rates as a function of the total injury rate (model 2, Table 2). Unlike the model of total turnover, no statistically significant relationship between the separation rate and injury claim rate was found. The separation rate is a portion of total turnover, with hires removed. Observing the results of the two models together suggests that the injury rate has a relationship with the hire rate, but not the separation rate. The separation rate shows a statistically significant seasonal pattern, with the separation rate being highest in the fourth quarter, and lower in the first and third quarters. Further, as the unemployment rate increases, the separation rate is found to decrease. Large employers are found to have lower separation rates while employers with higher average wages are found to have a higher separation rate.

In the third model (Table 2), the presence of a severe injury was modeled as a regressor of separation rates. This shows the employer fixed effects model of the presence of a severe injury, included as a dummy variable in the model, regressed on separation rates. The

**TABLE 2** Log-Log models of injury rates and turnover

Dependent Variable <sup>a</sup>	Model 1 Turnover Rate	Model 2 Separation Rate	Model 3 Separation Rate
	(Driscoll-Kraay Robust standard error)		
Log injury rate	0.256*** (0.092)	0.104 (0.078)	
Severe injury indicator			0.033*** (0.010)
Log average worker wages	0.037 (0.023)	0.052** (0.021)	0.052** (0.021)
Log average employment	-0.017 (0.012)	-0.026*** (0.009)	-0.027*** (0.009)
Log unemployment rate	0.023 (0.029)	-0.043** (0.020)	-0.043** (0.021)
Log gas price	0.022 (0.021)	-0.0001 (0.014)	-0.001 (0.014)
Log oil price	0.018 (0.015)	-0.012 (0.012)	-0.012 (0.012)
Quarter 2	0.065*** (0.006)	0.025*** (0.006)	0.025*** (0.006)
Quarter 3	0.046*** (0.013)	0.012 (0.010)	0.012 (0.010)
Quarter 4	0.041*** (0.008)	0.034*** (0.008)	0.034*** (0.008)
Observations	4766	4766	4766

\* $P < 0.1$ ,\*\* $P < 0.05$ ,\*\*\* $P < 0.01$ <sup>a</sup>See Table 1 for units.

model found a statistically significant effect of, on average, a 3.3 percentage point increase in the separation rate during quarters where a severe injury occurred. For the average employer (26 employees), the increase in the separation rate translates to less than one worker separated.

## 4 | DISCUSSION

This study set out to determine whether injury rates in a business have a relationship with worker turnover in Montana's Oil and Gas industry. Injury rates were found to have a significant positive relationship with total turnover, such that a 1% increase in the injury rate was associated with a 15% increase in turnover for the average employer. This effect was large enough to imply that the associated change in turnover went beyond workers who were directly injured. In contrast to this finding, no statistically significant relationship was found between the total injury rate and separation rate, suggesting

that the relationship is not due to workers leaving an employer with high injury rates. Instead, increases in the rates of hires could be associated with increases in the rates of injuries due to new workers being more likely to get hurt on the job.<sup>30-32</sup> However, this relationship would require further exploration. The finding does put into doubt whether workers respond to work environments with high injury rates with more separations. Further evidence of that is the relatively small impact of severe injuries on turnover, influencing less than one worker separation for an employer of average size. The small effect likely reflects the probability of an injured worker separating from their employer after a severe injury as opposed to other coworkers departing following a colleague's injury.

The use of an employer fixed-effects model assumed fixed organizational factors that would affect turnover are constant across the firm and over the full-time period of the panel. However, management factors that could have varied between work groups within a firm would be measured as the same across the entire firm. The data used in this study does not allow any more specific measurement of within-employer factors making this a limiting factor of the study, because preferably workgroup-specific management effects would be controlled for. In addition, the inclusion of injury claim rates and wages as predictors of turnover may introduce collinearity between the two factors because wages can be used to compensate for injury risk in the workplace. This could have contributed to the lack of significant findings in the relationship between turnover and injury rates.

The impact of severe injuries on separation rates suggests that reductions in turnover can be achieved by improving safety practices and reducing severe injury incidence. However, it is important to note that the finding only pertains to the Oil and Gas industry, from 2010 to 2015, and is not a universal finding. Similar examinations of other industries may yield different results. Factors leading to the lack of a stronger finding may have been the national economic conditions after the 2008 financial crisis, which led to worker migration to the region and potentially reduced worker concern with workplace safety, and inconsistencies in Workers' Compensation claim reporting. The finding that higher wages were associated with higher separation rates even was unexpected because, to a point, higher compensation should dampen turnover. However, during the Bakken boom, low unemployment rates provided an environment for potential "bidding wars" where employers competitively increased pay as separation rates increased, thus cyclically increasing turnover. Alternatively, the Bakken region is between North Dakota and Montana (though primarily in ND), and wage record patterns resulting from firms moving across state lines could have influenced the turnover measure in the data. Interestingly, there was not a significant relationship between turnover and oil prices. Montana's oil producers were resilient to oil price drops,<sup>33</sup> potentially explaining the lack of a significant effect.

The results of the study point to future directions of research using Workers' Compensation and Unemployment Insurance administrative data. The findings suggest there is an association between hiring rates and injury rates, which could be further explored to

determine value in increased safety training to reduce injuries among new hires. Additionally, the long-term employment impacts of injuries on workers, evidenced by the association of severe injury and worker separations, merits a closer look. While the study focused specifically on turnover and injury rates of employers in the Oil and Gas industry, the administrative data sources would allow for expanding the scope to additional industries while examining individual worker turnover following injury incidence would expand the findings to provide insight into coworker actions following injuries on the job.

## AUTHOR CONTRIBUTIONS

This project was carried out largely by Christopher Bradley, who designed the layout for the panel data set created for the research, created the Unemployment Insurance portion of the data set and merged those records to the Workers' Compensation data, executed statistical analysis, and drafted and finalized the submitted brief report. Julia Brennan provided expertise on the Workers' Compensation claims portion of the data set, prepared the data for analysis by producing the extract of Workers' Compensation data, and consulted on how the data could be used in the analysis. Barbara Wagner assisted in the conception and design of the study, as well as revisions, and final approval of the report. All authors agree to be accountable for any matters that arise after completion of the work and resolution of any questions that arise.

## CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests.

## DISCLOSURE BY AJIM EDITOR OF RECORD

Rodney Ehrlich declares that he has no competing or conflicts of interest in the review and publication decision regarding this article.

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