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April 2019

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1 Introduction

It is generally agreed that "new" employees are likely to experience more injuries than those who have been on the job for some time. As Jimmy W. Hinze indicated in his classic 1997 text on construction safety:

> "One of the basic tenets of worker safety is that new workers pose a high safety risk."[1]

Or, as reported more recently and in more detail in *Safety and Health* magazine (June 2016):

> "Employees in their first month on the job have more than 3 times the risk for a lost time injury than workers who have been at their job for more than a year, according to research from the Toronto-based Institute for Work and Health."[2]

While the basic point regarding inflated risk for new workers is common in the safety literature, the character of the resulting injuries is seldom considered. This document attempts to fill that gap. Although limited in geographical extent to Tennessee and in temporal scope to 2014 and 2015, this case study examines injury issues including Type, Cause, Body Part, and severity as well as examining the role of employer establishment size.

1.1 Additional Data Source for Injury Surveillance

New injury surveillance data based on workers' compensation (WC) records has resulted from an initiative of the National Institute of Occupational Safety and Health (NIOSH) to provide statistical information regarding workplace injuries that may supplement the Survey of Occupational Injuries and Illnesses (SOII) information currently assembled by the Bureau of Labor Statistics (BLS).

For several years, NIOSH has awarded a number of grants to a few states to encourage exploration of workers' compensation records in those states. In the summer of 2016 such a grant was awarded to the Construction Industry Research and Policy Center (CIRPC) at the University of Tennessee. This resulted in an agreement with the Tennessee Bureau of Workers' Compensation to make the individual reports of workers' compensation claims, called "First Report of Injury" (FROI) available (subject to agreed upon confidentiality concerns).[3]

While WC data is available for all industries in Tennessee (about 100,000 observations per year), our research focused only on construction (about 4,500 cases per year) and for the years 2014 and 2015. While we believe the detail provided for this one industry and time period is revealing, a number of limitations should be noted:

- Tenure distribution of non-injured employees is unknown, therefore rate denominators can not be calculated to compare groups.
- About 25 percent of the tenure observations are missing.
- Limited information is available on injury seriousness and none on "days away from work."

[1] Jimmy W. Hinze, Construction Safety. Prentice-Hall, Upper Saddle River, 1997, p. 208.
[2] http://safetyandhealthmagazine.com/articles/14053-new-workers-higher-risk.
[3] In addition to Tennessee, states receiving such grants include California, Massachusetts, Michigan, and Ohio.

- The WC data provide no information on worker training.
- The analysis is limited to one industry (construction) and one state (Tennessee) and may not reflect the situation in other industries or geographies.
- Tenure is defined here as time worked with a particular employer, not time in a particular job, in a craft or occupation or in an industry.
- Workers' compensation data received contained injuries to both males and females. There was reason to believe that the female injury data was not accurately reflected in the employment data. For that reason no separate analysis by gender has been undertaken. It does appear, however, that approximately ten percent of the reported injuries were suffered by women, a figure similar to the percentage of females in the construction labor force.

1.2 The Tenure Picture

Perhaps it may be helpful to begin examination of tenure with a national overview of workplace tenure in general and in construction in particular. The BLS publishes a report on employee tenure every two years based on supplementary questions in the Current Population Survey (CPS)[4]The report, covers several demographic characteristics such as age, sex, industry, occupation, and ethnicity as well as providing a time perspective.

As shown in Table 1 for all national industries in alternate years since 2006, average tenure has varied from 3.6 years to a high of 4.2 years. A similar picture is reflected in the construction industry data. The variations noted appear to be related to cyclical factors in employment which have a greater impact on construction than on the economy as a whole.

Table 1: Median Years of Tenure, Current Employer, U.S. Wage and Salary Workers, Selected Years*

	2006	**2008**	**2010**	**2012**	**2014**	**2016**
Private Industries	3.6	3.6	4.0	4.2	4.1	3.7
Private Construction Industry	3.0	3.5	4.2	4.3	3.9	4.0

*Bureau of Labor Statistics. Employer Tenure in 2016. USDL 16-1857. Table 5. Figures are for January.

Table 2 focuses on tenure in construction alone and provides a comparison of the national data for 2016 with this study-related observation for 2014-15 in Tennessee. We need to make clear that this is not an apples-to-apples comparison since the national data covers employment in the entire construction industry while the Tennessee data refers only to the portion of the population that experienced injury.

Shown here for various time periods is the percentage distribution of employment continuity. It should be clear from examination of either series, short-term tenure with a given employer tends to be the rule; long-term tenure is less common. Of particular note, however, is the dominant role played by short-term tenure in Tennessee construction. Nearly one-third (30.1 percent) of injuries

[4]Bureau of Labor Statistics, Employee Tenure in 2016, USDL 16-1867. More recent data can be accessed in Employee Tenure in 2018, USDL 18-1500 which is based on the January 2018 CPS survey.

Table 2: Tenure in Construction: National vs. Tennessee, Percentage Distribution

	U.S. 2016* percent	**TN 2014-15** percent**
$<$ 6 months	13.6	30.1
7-12 months	10.4	14.4
Subtotal $\leq$ 12 months	**24.0**	**44.5**
13-23 months	5.9	15.2
2 years	5.4	8.1
Subtotal $\leq$ 3 years	**35.3**	**67.8**
3 years	11.1	–
4 years	7.4	–
Subtotal $\leq$ 5 years	**53.8**	**76.2**
5 years	8.0	–
6 years	3.7	–
7-9 years	8.6	–
Subtotal $\leq$ 10 years	**74.1**	**86.5**
10-14 years	11.8	–
15-19 years	6.4	–
Subtotal $\leq$ 20 years	**92.3**	**95.2**
20-24 years	3.5	–
25+ years	4.4	–
Total	**100.0**	**100.0**

*Includes both sexes, 16 and over. Bureau of Labor Statistics. Employer Tenure in 2016. Table 5a. (Table 5a is an unpublished table provided by Mr. Steven Hipple of the Bureau of Labor Statistics, November 2017.)

** Based on Tennessee workers' compensation injuries where tenure was known (7,904 injuries out of a total of all injuries of 9,031). No allowance was made for more than one injury to an employee during the period because injured employees were not uniquely identifiable.

Note that table totals within this document do not necessarily total 100.0 percent because of rounding error.

involved those with 6 months or less experience and 44.5 percent involved those with 12 months or less attachment to a given employer. Table 3 summarizes the contrast between the national data and the Tennessee data. For tenure of less than three years, the Tennessee experience nearly doubles the national average whereas for a ten year or greater period the national figures are approximately twice those for Tennessee.

Table 3: Summary of National and Tennessee Data*

	U.S. 2016 percent	**TN 2014-15 percent**
$<$ 3 years	35.3	67.8
$>$ 9 years	25.9	13.5

*Source: Table 2

2 The Tennessee Case: Injury Patterns

Details from the workers' compensation database allows for analyses of a variety of injury characteristics such as:

- Type (Nature) of injury
- Cause of injury
- Body part injured
- Type of treatment
- Industry involved (at three-digit level)

In conjunction with data from employment statistics it is possible to consider firm size and other employment characteristics. First, however, consider injury patterns and their relation to tenure.

In the analysis to follow of the Type, Cause, and Body Part revealed in the workers' compensation records for Tennessee we focus on the top ten injury categories in each case for the known tenure among the total injury population. These are then compared to the incidence of those same injuries among those with known tenure during the first year of employment.

2.1 Type (Nature) of Injury

Table 4 shows the top ten injuries by Type recorded for 2014 and 2015 combined. For each of these injuries we first show the injury count and proportion in the entire construction sector for whom there is tenure information. We also show the count and proportion for the population with one year or less of tenure. A final column shows the relationship between the total of each injury Type and the proportion of each attributed to those with one year or less tenure.

Altogether there were 53 injury Types reported, but the 6,119 top ten injuries amounted to nearly 90 (88.6) percent of all injuries recorded. A similar percentage (89.9 percent) of injuries were

Table 4: Top Ten Injuries in Construction by Type (Nature), Tennessee 2014-15. By Total and First Year Tenure*

Type (Nature)	**Total**		**0-12 Months**		
	Count	**Proportion 1**	**Count**	**Proportion 2**	**Ratio 2/1**
Strain	1,938	0.317	773	0.293	0.92
Laceration	1,015	0.166	454	0172	1.04
Contusion	823	0.134	354	0.134	1.00
All Other Specific, NOC	593	0.097	268	0.102	1.05
Sprain	538	0.088	255	0.097	1.10
Fracture	439	0.072	190	0.072	1.00
Foreign Body	299	0.049	135	0.051	1.04
Puncture	198	0.032	97	0.037	1.16
Multiple Physical	163	0.027	70	0.027	1.00
Burn	113	0.018	44	0.017	0.94
Total Top Ten	**6,119**	**1.000**	**2,640**	**1.000**	
Grand Total All	**6,904**		**2,937**		
Top Ten/Grand Total		**0.886**		**0.899**	

The figures relate only to the injuries for which tenure was reported (6,904 of 9,031 or 76.45 percent of the injuries in this case).

reported for those with one year or less tenure. Three of these, strain (31.7 percent), laceration (16.6 percent), and contusion (13.4 percent) accounted for just over sixty percent of the total (61.7 percent) and just under sixty percent of the injuries of those with tenure of one year of less (59.9 percent).

The last column of Table 4 shows the "one year tenure" proportions relative to the total injury proportion. Since these proportions vary from a low of 0.92 to a high of 1.16, we do not know if the Type (nature) of injury proportions varies significantly between short (tenure of 1 year of less) and long-tenured employees. A more formal approach to these relationships as well as those dealing with Cause and Body Part will be found in the Statistical Appendix A.[5] This appendix contains chi square goodness-of-fit tests for three groups of long-tenured employees (i.e. 6+ years, 10+ years, and 20+ years). As a result of these tests, we reject ($p < 0.01$) the null hypothesis of a good fit between the short-tenure distribution of injuries and the long-tenured distributions in each of the three groups for Type.

2.2 Cause of Injury

It appears that the Causes of injury are more diverse than the Types of injury. First, the detailed surveillance data list some 72 injury Cause categories compared to 53 injury Types. Furthermore, the top ten individual Causes account for just over 50 (52.1) percent of the total tenure injuries as shown in Table 5 rather than the nearly 90 percent in the case of injury Types. Note that while "strain" appears in both the Type list and the Cause list, we differentiate between them. The former is an overexertion and the latter can be defined as an overstretching of some part of the musculature.

Once again, as in the case of injury Types, we examine the relationship of injuries to those with one year or less of tenure to the overall pattern of injuries among the total known tenure population. In this case the proportions vary from a low 0.88 to a high of 1.17, a range not dissimilar to that found for injury Types. We again find the chi square tests cause rejection ($p < 0.01$) of the null hypothesis of a good fit between the Cause distributions of three long-tenured groups and those with tenure of one year or less.

2.3 Body Part Injured

Injuries are reported to some 53 Body Parts, with the top ten accounting for over 62 percent (62.7 percent) of the total injuries. The "lower back area" with 658 injuries and 15.2 percent of the top ten injury categories leads the group with fingers (14.8 percent), shoulder (14.8 percent), and hand (11.0 percent) all following with over ten percent each in top ten frequency. These data are shown in Table 6 along with the analogous proportions for those with less than one year tenure. As before, the last column shows the tenure Body Part proportions relative to their total tenure frequency. Again, the proportions fall in the relatively narrow range of 0.95 to 1.07.

[5] Also indicated in Appendix A is the IAIABC listing of the individual injuries that make up each of the categories discussed.

Table 5: Top Ten Injuries in Construction by Cause, Tennessee 2014-15. By Total and First Year Tenure

Cause	**Total**		**0-12 Months**		
	Count	**Proportion 1**	**Count**	**Proportion 2**	**Ratio 2/1**
Object Being Lifted/Handled	541	0.150	264	0.176	1.17
Strain or Injury By, NOC	525	0.146	198	0.132	0.90
Lifting	498	0.138	189	0.126	0.91
Pushing, Pulling	328	0.091	132	0.088	0.97
Other, Misc., NOC	313	0.087	141	0.094	1.08
Falling or Flying Object	310	0.086	144	0.096	1.12
Fall Slip, Trip	308	0.086	114	0.076	0.88
Foreign Matter (Body) in Eye	281	0.078	121	0.081	1.04
Cut, Puncture, Scrape	266	0.074	103	0.069	0.93
Fall from Different Level	229	0.064	97	0.065	1.02
Total Top Ten	**3,599**	**1.000**	**1,503**	**1.000**	
Grand Total All	**6,904**		**2,937**		
Top Ten/Grand Total		**0.521**		**0.512**	

Table 6: Top Ten Injuries in Construction by Body Part, Tennessee 2014-15. By Total and First Year Tenure

Body Part	**Total**		**0-12 Months**		
	Count	**Proportion 1**	**Count**	**Proportion 2**	**Ratio 2/1**
Lower Back Area (muscles)	658	0.152	269	0.144	0.95
Finger(s)	642	0.148	285	0.153	1.03
Shoulder	510	0.118	203	0.109	0.92
Hand	477	0.110	211	0.113	1.03
Knee	474	0.110	207	0.111	1.01
Eyes	399	0.092	176	0.094	1.02
Multiple Body Parts	371	0.086	155	0.083	0.97
Foot	271	0.063	120	0.064	1.02
Ankle	263	0.061	121	0.065	1.07
Lower Arm	261	0.060	119	0.064	1.07
Total Top Ten	**4,326**	**1.000**	**1,866**	**1.000**	
Grand Total All	**6,904**		**2,937**		
Top Ten/Grand Total		**0.627**		**0.635**	

2.4 Summary Relationships

Based on the chi square tests of Statistical Appendix A, we reject the null hypotheses that the proportions of injuries (with respect to Type, Cause, and Body Part dimensions) between long-tenured employees fit the distribution of the more limited population of those with 12 months or less tenure. Table A1 provides the results for chi square tests with one test for each dimension - tenure group pair. In each case, the top ten elements occurring elements were determined. Then the number of claims for each of the three tenure group categories was tested against the corresponding proportion of claims for the 0-1 year tenure group. In each of the nine instances, the $p-value < 0.01$. Therefore, in each instance we reject the null hypothesis that the data are consistent with the specified distribution.

2.5 Type of Treatment

In addition to interest in the details of injury characteristics, it is important to know about the seriousness of the reported injuries. Unfortunately, we do not have any direct measure of seriousness, but the workers' compensation data does contain treatment information Such information as is available is broken down into six categories as follows:

- 0 = No medical treatment
- 1 = Minor on-site remedies by employer
- 2 = Minor clinic/hospital remedies and diagnostic tests
- 3 = Emergency evaluation, diagnostic tests, and medical procedures
- 4 = Hospitalizations greater than 24 hours
- 5 = Future major medical/lost time anticipated

In 2014-15, 82 percent of the injuries fell into these categories (7,425 of the total of 9,031 cases). No treatment information was given for 1,606 cases. The percentage distribution of treatment is shown in Table 7. If we assume that the injuries for which treatment is not reported are proportional, the estimated percentage distribution of all cases is also shown in Table 7. While recognizing the limitations of such an effort, we have categorized these treatment categories into levels of seriousness as follows:

- Minor (categories 0 and 1)
- Moderate (category 2)
- Serious (categories 3, 4, and 5)

Using these definitions, nearly 30 percent of the injuries fall into the "minor" category, 57 percent are in the "moderate" category, and 13 percent are "serious" as shown in the group totals in Table 7. Note that in the latter category, "serious", most treatments (11.56 percent) involve "emergency evaluation, diagnostic tests, and medical procedures" and only about 1.5 percent are in what would appear to be the most serious treatment categories (4 and 5). Of course these seriousness categories are subjective and other approaches are possible. Despite the caveat, it is notable that with the

definitions proposed nearly one-third of the cases appear to be minor and relatively few appear to be most serious (96 cases in category 4; 24 cases in category 5).

Table 7: Percentage Distribution of Treatment, 2014-15

Treatment Category	**Percent of Total**	**Group Total - Percent**
0 - None	12.79	
1 - Minor, On Site	16.65	
Subtotal		**29.44**
2 - Minor, Clinic	57.39	
Subtotal		**57.39**
3 - Emergency Evaluation	11.56	
4 - Hospitalization	1.29	
5 - Future Major Medical	0.32	
Subtotal		**13.17**
Total All	**100.00**	**100.00**

Relating injury seriousness to tenure reveals that, except for tenure years 1 and 2, minor injuries tend to fall as tenure increases. Again, with the exception of years 1 and 2 when reductions in moderate injuries are offset by an increase in minor injuries, moderate injuries tend to increase somewhat as tenure increases. For the most part, serious injuries appear to account for between 11 and 15 percent of injuries and, except for the 6-9 year period, tend to be relatively stable. These results are shown in Table 8.

Table 8: Tenure and Injury Seriousness, 2014-15

Tenure Period	**Degree of Injury**		
	0,1 Minor Percent	**2 Moderate Percent**	**3,4,5 Serious Percent**
0-6 months	22.86	62.44	14.70
7-12 months	24.33	61.10	14.57
1 year	38.75	49.44	11.80
2 years	38.38	49.74	11.88
3-5 years	18.86	67.48	13.66
6-9 years	15.30	67.63	17.07
10-19 years	15.69	69.80	14.51
$>$ 19 years	22.41	66.55	11.03
All years	**29.44**	**57.39**	**13.17**

If the definition of "moderate seriousness" is altered to include treatment 3 (thus removing it from the definition of "serious" as well) the results by tenure grouping as summarized above do not change substantially except that approximately 10 percent of injuries are shifted from the serious to moderate category, leaving only 1 to 2 percent as "serious".

2.6 Injuries, Age, and Tenure

Injuries can also be related to the age of the employee. Table 9 provides a summary of this information showing the distribution of injuries across the spectrum of seriousness by age bracket. Generally speaking, minor injuries tend to fall with age at the expense of moderate injuries. Serious injuries, as defined, tend to be remarkably stable relative to age.

Table 9: Injury Seriousness by Age, 2014-15**

Age*	**Minor**	**Moderate**	**Serious**
< 18	52.38	47.62	0.00
18-21	31.89	54.53	13.58
22-25	44.51	44.96	10.54
26-29	37.62	49.75	12.62
30-39	30.18	55.64	14.18
40-49	25.76	60.33	13.91
> 49	18.88	68.09	13.03
Grand Total	**29.44**	**57.39**	**13.17**

Notes:
*Only 23 injuries were reported in the < 18 category and only 5 reported missing age information
**Based on treatment categories: 0-1 = minor; 2 = moderate; 3-4-5 serious

Of perhaps greater importance is the relationship between age and tenure as reflected in the portion of injuries sustained by those with one year or less tenure and all others with tenure. Table 10 shows raw numbers and percentages of injuries experienced by those with short-term tenure. (one year or less) and the remainder of the tenure groups. It is noteworthy that among the youngest group (16-19 years), 86 percent of those with short tenure reported injury. Clearly in each successive age group the proportion of those with short tenure plays a notably diminished role.

A factor mitigating the concern with the relative importance of injury among the younger population with limited tenure is the fact that the younger age groups involve a relatively smaller portion of the worker injuries. Of the 6,888 total of injuries in Table 10, nearly 60 percent involve those in the age groups of 35 and above.

3 The Tennessee Case: Firm Size and Injury Patterns

3.1 Firm Size and Employment

In Section 2, injury data for 2014 and 2015 was reported on a combined basis. In this section dealing with firm size, due to data limitations, the data relate to 2015 alone.

According to information reported in the Quarterly Census of Employment and Wages (QCEW)

Table 10: Injury, Age, and Tenure: Percentage Distribution

Age Group	**$\leq$ 1 year**	**$>$ 1 year**	**Total**	**Percent $\leq$ 1 year**
16-19	138	22	160	86.25
20-24	529	318	847	62.46
25-34	908	940	1,848	49.13
35-44	677	974	1,651	41.01
45-54	504	979	1,483	33.99
55-64	218	565	783	27.84
65-84	28	88	116	24.14
Total	**3,002**	**3,886**	**6,888**	**43.58**

construction employment in Tennessee averaged 112,795 in 2015.[6,7] Unfortunately, a breakdown of the total by firm size is not available. However using the workers' compensation information along with unemployment insurance data it is possible to determine firm size and a number of other employment characteristics for the subset of 73,147 in the workers' compensation database.

For nine employment size groups, Table 11 shows a number of variables:

- Number of firms
- Employment
- Average employment
- Percent distribution of employment
- Percent distribution of firms

Table 11: Construction Firm Size and Employment, Tennessee 2015

Firm Size Employees	**Number of Firms**	**Employment**	**Average Employment**	**Percent of Employment**	**Percent of Firms**
0-4	249	604	2.43	0.83	14.95
5-9	276	1,890	6.85	2.58	16.58
10-19	370	5,239	14.16	7.16	22.22
20-49	460	14,215	30.90	19.43	27.63
50-99	174	11,650	66.95	15.93	10.45
100-249	101	15,416	152.63	21.08	6.07
250-499	13	4,155	319.62	5.68	0.78
500-999	14	8,832	630.86	12.07	0.84
1000+	8	11,146	1,393.25	15.24	0.48
Total	**1,665**	**73,147**	**43.93**	**100.00**	**100.00**

*Based on Unemployment Insurance data for those reporting workers' compensation claims

[6]For the year 2015, for example, employment in these firms experiencing a workers' compensation injury is reported to be 73,147 out of estimated total construction employment of 112,795 (64.8 percent).

[7]QCEW(2016). http://data.BLS.gov/cew/doc/access/cvs_data_slices.htm. June 28, 2016.

As one might expect, the smallest firms, (those employing four or fewer), account for less than one percent of employment but nearly 15 percent of the firms. The largest firms account for less than half a percent of firms, but over 15 percent of employment. For the 1,665 firms in the sample, the median size is about 18 employees and average employment per firm is approximately 44.

3.2 Firm Size and Injuries

For 2015, Table 12 shows the percent distribution of firms along with the percentage distribution of injuries. In this case injuries are recorded both as "known" and "total". Known injuries are those where tenure is also known. Total injuries include both those with known and unknown associated tenure. The smaller firms (under 20 employees) account for over 50 percent of the firms, but are associated with approximately 23 to 27 percent of injuries (depending on known vs total designation). On the other hand, those firms with 50 or more employees make up less than 19 percent of firms but account for over 50 percent of injuries.

Table 12: Injury, Firm Size, and Tenure: Percentage Distribution*

Firm Size Employees	**Percent of Firms**	**Known Injuries***	**Total Injuries****	**Percent of Known Injuries**	**Percent of Total Injuries**
0-4	14.95	185	296	5.3	6.8
5-9	16.58	211	329	6.0	7.5
10-19	22.22	402	567	11.5	12.9
20-49	27.63	769	951	21.9	21.7
50-99	10.45	427	528	12.2	12.0
100-249	6.07	1,210	1,367	34.5	31.2
250-499	0.78	125	129	3.6	2.9
500-999	0.84	93	119	2.6	2.7
1000+	0.48	86	99	2.5	2.3
Total		**3,508**	**4,385**	**100.0**	**100.0**

*Injured - Tenure known

**Injured - Tenure known and unknown

It should be remembered that the employment data reported here is based on the subset of employees (73,147) in the workers' compensation database rather than the total construction employment (estimated to average 112,795) for 2015. Ideally we would like to also know the number of firms in each size category without injuries and the number of employees in the firms.

3.3 Firm Size, Injury and Tenure

Of the 4,385 injuries in the 2015 data, the firms reporting these injuries had 73,147 employees. Of these reported injuries, 3,508 had associated tenure information.

The relationship between firm size and tenure can be considered from a number of points of view. Two that will be examined here are:

1. Relative to employment, and
2. Relative to tenure status

Table 13 compares employment by firm size to the injury total for each size class. For example, the smallest size class (0-4 employees) reported 296 injuries and an estimated 604 employees. Thus it appears that during 2015 some 49 percent of workers experienced some recordable injury. As firm size increases it is clear that the percentage of injuries to employment falls monotonically and rather dramatically (except for the 100-249 category) so that for the very largest firms (1000+ employees) less than one percent reported injury. In general terms, then, one is much less likely to experience a workplace injury working for a larger firm. Also of interest in the context of this investigation is the role played by firm size coupled with tenure. In Table 14 we show the proportion of injuries in each size class incurred by those with one year or less tenure. These data are based on known tenure only,[8]

Table 13: Firm size, Employment and Injury; 2015

Firm Size	**Total Injuries***	**Total Employment**	**Injuries as a Percent of Employment**
0-4	296	604	49.0
5-9	329	1,890	17.4
10-19	567	5,239	10.8
20-49	951	14,215	6.7
50-99	528	11,650	4.5
100-249	1,367	15,416	8.9
250-499	129	4,155	3.1
500-999	119	8,832	1.3
1000+	99	11,146	0.9
Total	**4,385**	**73,147**	**6.0**

*Includes injuries to those reporting tenure and those for whom no tenure information was available.

As one might expect, based on earlier analysis, a very significant proportion of the 2015 reported injuries occur in the first year of tenure, amounting to 44.8 percent on an overall basis. For the very small firms (0-4 employees) a majority of the injuries take place among those with one year of less tenure. It is notable, however that injuries in the first year of tenure are surprisingly common

[8]While these figures relate to known tenure data, we have no reason to believe that the "unknown injuries" are not distributed as are the "known injuries". Thus the proportions would be unchanged if the calculations were made based on the assumption that unknown injuries were distributed as were the known injuries.

Table 14: Known One-Year Tenure Injuries as a Proportion of Total Known Tenure Injuries: By Size Class of Employer, 2015

Firm Size	**$\leq$ 1 year**	**Total Injuries***	**Injuries as a Percent of Total**
0-4	95	185	51.4
5-9	101	211	47.9
10-19	178	402	44.3
20-49	339	769	44.1
50-99	193	427	45.2
100-249	463	1210	38.3
250-499	88	125	70.4
500-999	37	93	39.8
1000+	76	86	88.4
Total	**1,570**	**3,508**	**44.8**

*Includes only injuries to those reporting tenure.

among all firm sizes. Indeed, the lowest percentage is 38.3 for the 100-249 employees group while most of the other size groups experienced an impact in the 40 percent range. The two outliers are the 250-499 and 1000+ size classes at 70.4 and 88.4 percent respectively. It is not clear why these latter deviations from the overall pattern exist.

4 Generalization of the Results

It is reasonable to ask how representative the findings reported here are since they relate to a single state (Tennessee), a single industry (construction), and a brief time period (2014-15). Fortunately two additional states (Ohio and Washington) have provided construction industry tenure results which can be compared with the Tennessee results. In addition we can report limited tenure data for other industrial sectors in Tennessee and a breakdown for the three-digit NAICS categories comprising the construction industry in Tennessee.

4.1 Comparison by State

Several other states have undertaken workers' compensation surveillance activities similar to the Tennessee NIOSH study which gave rise to this study. Two of the jurisdictions have, in response to our request, provided data relative to tenure in construction for the years 2014 and 2015 which can be compared with the Tennessee data. Table 15 shows the three state results.[9] For the 6 month or less tenure period Tennessee workers' compensation injuries amounted to 30.1 percent

[9]We are indebted to Steven J. Nabor of the Ohio Bureau of Workers' Compensation and Darrin Adams of the Washington State Department of Labor and Industry for their prompt response to our request for comparable information from their states.

while for Washington (WA) the percentage was 31.7 while Ohio (OH) reported 33.59 percent. On a full year basis the percentages are: TN, 44.5 percent; WA, 47.5 percent; OH, 45.62 percent. For a two year period or less the figures are even closer: TN, 59.7 percent; WA, 60.8 percent; OH, 58.69 percent.

Table 15: Tenure Results by State, Construction 2014-15

Tenure Period	**Tennessee Percent**	**Washington Percent**	**Ohio Percent**
$0 \leq 6$ months	30.1	31.7	33.59
6 months ≤ 1 year	14.4	15.8	12.03
$1 \leq 2$ years	15.2	13.3	13.07
$2 \leq 3$ years	8.1	7.6	7.01
$3 \leq 5$ years	8.4	7.8	8.15
$5 \leq 10$ years	10.3	12.0	9.47
$10 \leq 15$ years	5.0	5.7	6.34
$15 \leq 20$ years	3.7	3.0	4.44
20+ years	4.8	3.0	5.90

4.2 Comparison by Industry Sector

The NIOSH funded study involved workers' compensation injuries in all sectors of the Tennessee economy and as a result we can report first year tenure findings for all industries, not just construction. As can be seen from Table 16, the proportions vary from a low of 7 percent for Utilities (NAICS 22) to 69 percent for Administration and Support and Waste Management and Remediation Services (NAICS 56). While not placing too much emphasis on the numbers reported since tenure was not the focus of inquiry in other than construction it is probably safe to conclude that it is not unlikely that a disproportionate share of injuries in virtually all industries are associated with short-term tenure.

4.3 Comparison by Industry Sector, Construction

The table that follows show injuries for two tenure periods (0-12 months and more than 1 year) and for the three-digit NAICS construction categories:

- 236 Construction of Buildings
- 237 Heavy and Civil Engineering
- 238 Specialty Trade Contractors

Note that of the largest number of injuries (3622 out of a total of 6904) for which we have tenure data, more than half (52.5 percent) were in the Specialty Trade sector. About one third involved Construction of Buildings (32.5 percent) and the remaining 15.0 percent , Heavy and Civil Engineering.

Table 16: Injury Proportion in First Year Employment, Tennessee 2014-15

NAICS Sector	**Description**	**Proportion of Injuries in First Year - Percent**
11	Agriculture, Forestry, Fishing, & Hunting	49
21	Mining	27
22	Utilities	7
23	**Construction**	**45**
31-33	Manufacturing	31
42	Wholesale Trade	34
44-45	Retail Trade	36
48-49	Transportation & Warehousing	40
51	Information	28
52	Finance & Insurance	19
53	Real Estate & Rental & Leasing	41
54	Professional, Scientific, & Technical Services	37
55	Management of Companies & Enterprises	36
56	Admin & Support & Waste Management	69
61	Educational Services	21
62	Health Care & Social Assistance	34
71	Arts, Entertainment, & Recreation	56
72	Accommodation & Food Services	51
81	Other Services	41

As far as timing is concerned, "short-tenure" injuries were most likely to take place in Construction of Buildings (1090 out of 2246 or 48.5 percent), with short-tenure injuries slightly less likely in Specialty Trades (1555 out of 3622 or 42.9 percent) and longer-tenure injuries (666 out of 1036 or 64.3 percent) most likely in Heavy and Civil Engineering.

Table 17: Injuries, Tenure and NAICS Sector, 2015*

Tenure Period	**Section 236 Construction of Buildings**	**Section 237 Heavy and Civil Engineering**	**Section 238 Specialty Trade Contactors**	**Total**
$0 \leq 12$ months	1090	370	1555	3015
More than 12 months	1156	666	2067	3889
Total	**2,246**	**1,036**	**3,622**	**6,904**

*For those injuries for which tenure is known.

5 Summary and Recommendations

5.1 Summary of Findings

- Access to workers' compensation insurance records at the state level combined with employment information from federal insurance records provide an important supplement to other statistical sources such as the BLS Survey of Occupational Injuries and Illnesses (SOII) for data on employment related injuries.
- Employee tenure with the employer plays an important role in explaining construction industry injuries. In Tennessee, for 2014-15 some 44.5 percent of reported injuries were sustained by workers with tenure of one year or less.
- The three most common Types of injuries (strain, laceration, and contusion) account for 62 percent of the top ten Types of injuries. The top ten make up nearly 90 percent of all injuries by Type.
- In terms of Cause, the top three items: object being lifted, strain, and lifting are responsible for over 43 percent of the top ten Causes. The top ten represent over half (52.1 percent) of injuries among the 72 Causes listed.
- Injuries to the lower back, fingers, and shoulder are the three Body Parts most impacted amounting to 41.8 percent of the top ten. The top ten in turn represents 62.7 percent of the grand total of 53 body parts affected.
- Chi square tests fail to show the data for longer-tenure injuries (in terms of Type ($p < 0.01$), Cause ($p < 0.01$) or Body Part ($p < 0.01$)) are consistent with the corresponding distributions for early tenure injuries.
- In an attempt to measure injury severity, medical responses have been classified as: minor, moderate, and serious. As related to tenure periods, minor injuries tend to fall in the mid-

to-upper twenties in percentage, moderate injuries to range around sixty percent, and serious injuries to fall in the mid-to-lower teen range.

- In terms of firm size, the median firm employees about 18 workers, but average employment is 44. For 2015, some 1,665 firms employed 73,147 workers who reported injuries. The size class 20-49 firms contained the largest number of firms: 490.
- At the three-digit NAICS level the largest number of injuries, more than half, occur among Specialty Trade Contractors (NAICS 238). NAICS 236 (Construction of Buildings) accounts for about one-third of injuries with NAICS 237 (Heavy and Civil Engineering Construction) a distant third.
- Across Tennessee injury proportions in first year employment vary from a high of 69 percent (NAICS 56) to a low of 7 percent (NAICS 22). Note that Construction (NAICS 23), the industry examined in detail for this study experienced an injury proportion above the average for all Tennessee industries.
- Firm size plays a significant role in the incidence of injury. The smallest firms (0-4 employees) reported injury to nearly half (49 percent) of employees during 2015. For firms with a greater number of employees, for example those with 100-249 workers the percentage of those with injuries falls to less than 10 percent (8.9).
- Overall, during 2015, approximately 45 percent of injuries affected those with one year or less of tenure; thus it follows that 55 percent of injuries were experienced by those with more than one year of tenure. This indicates that regardless of firm size the early months of employment are critical in terms of safety.
- One-year tenure results for Ohio (46 percent) and Washington (48 percent) are remarkably similar to those reported for Tennessee for 2014 and 2015 at 45 percent. This is suggestive that other findings reported here may also be mirrored elsewhere and are not necessarily unique.

5.2 Recommendations

- Insights into workers health and safety is enhanced by addition of workers' compensation surveillance records. In this report we have examined only a small fraction of the data available for Tennessee and additional work across industries and occupations is needed.
- Other aspects of injury related to construction in Tennessee such as relationship to gender remain to be explored.
- Based on the findings presented here, the importance of new employee "on-boarding" or orientation cannot be over emphasized.
- Content of the on-boarding should include recognition of the results of the injury analysis presented here. New workers are exposed to the same injury factors as all employees. Although not explored here, it may be important to recognize the role and issues played by temporary workers.

- The role played by smaller firms may require special attention. These firms may lack the resources internally, required for adequate training. Creative approaches may be required to meet perceived needs. While total employment in these firms may be minimal, the size of the injury impact is great. OSHA's Susan Harwood Targeted Topic Training grants are an example of the type program that could fill a need. OSHA'S relationship with SCORE and the development of an online webinar aimed at small businesses may be helpful in reaching small firms.
- The identification of specific injuries may suggest areas in addition to training where employer action may bring benefits. For example, strains were the leading Type of injury. Work modifications by employer should be considered where possible to reduce strains on the bodies of workers.
- Upper extremities as a group (e.g. finger(s), shoulder(s) , hand(s), etc.) were the most frequently injured Body Parts. Employers should consider how different methods/tools and more effective personal protective equipment (e.g. proper gloves) could help reduce finger and hand injuries.
- If workers' compensation records are to play a continuing and increasing role in injury surveillance, consideration should be given to modification of the "First Report of Injury" (FROI) to provide additional research-focused information.
- Longer tenured workers have the same injury Causes and Types as shorter tenured workers; therefore safety training for "new" workers can also be used as refresher training for experienced workers.

References

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Appendices

Appendix A Statistical Appendix

A.1 Chi Square Tests

A more structured approach to the comparisons shown of short-term tenure (one year or less) and long-term tenure in Section 2 above for Type, Cause, and Body Part of injury is presented here.

Null hypothesis Ho: For other tenure periods considered, the data in the top ten categories are consistent with the distribution of the short-term tenure group.

We used the chi square test for goodness-of-fit using the proportions for the 0-1 year period found in Tables 4, 5, and 6 with the claim counts for the three tenure periods (i.e. 6+ years, 10+ years, and 20+ years). Table A1 indicates a $p - value < 0.01$ and the null is rejected for the three individual periods in every dimension. However, using the same test on the total population, we fail to reject the null at the 5 percent significance level. This last result seems reasonable given that 45 percent of the total injuries come from the 0-1 year period.

Table A1: Chi Square Tests (Goodness-of-Fit) p-values

Dimension	**Six + Years**	**Ten + Years**	**Twenty + Years**	**Total Population**
Type	< 0.01	< 0.01	< 0.01	0.18
Cause	< 0.01	< 0.01	< 0.01	0.08
Body Part	< 0.01	< 0.01	< 0.01	0.93

A.2 IAIABC List of Categories

Table A2: IAIABC List of Categories*

Type	Cause	Body Part
Aids	Abnormal Air Pressure	Abdomen Including Groin
All Other Cumulative Injury, NOC	Absorption, Ingestion or Inhalation, NOC	Ankle
All Other Occupational Disease Injury, NOC	Animal or Insect	Body as a Whole
All Other Specific Injuries, NOC	Broken Glass	Body Sys & Mult Body Sys
Amputation	Caught In, Under, or Between, NOC	Brain
Angina Pectoris	Chemicals	Buttocks
Asbestosis	Cold Objects or Substances	Chest
Asphyxiation	Collapsing Materials (Slides of Earth) ˗ either man made or natural	Disc - Neck
Black Lung	Collision or Sideswipe with Another Vehicle ˗ both vehicles in motion	Disc - Trunk
Burn	Collision with a Fixed Object ˗ standing vehicle or stationary object	Ear(s)
Cancer	Contact With, NOC	Elbow
Carpal Tunnel Syndrome	Continual Noise	Eye(s)
Concussion	Crash of Airplane	Facial Bones
Contagious Disease	Crash of Rail Vehicle	Finger(s)
Contusion	Crash of Water Vehicle	Foot
Crushing	Cumulative, NOC ˗ all other	Great Toe
Dermatitis	Cut, Puncture, Scrape, NOC	Hand
Dislocation	Dust, Gases, Fumes or Vapors	Head - Soft Tissue
Dust Disease, NOC	Electrical Current	Heart
Electric Shock	Explosion or Flare Back	Hip
Enucleation	Fall, Slip, Trip, NOC	Insuff. Info to Pro. Iden.Uncl
Foreign Body	Falling or Flying Object	Internal Organs
Fracture	Fellow Worker, Patient	Knee
Freezing	Fire or Flame	Lower Arm
Hearing Loss or Impairment	Foreign Matter (Body) in Eye(s)	Lower Back Area (Muscles)
Heat Prostration	From Different Level (Elevation) ˗ off ˗ either man made or natural	Lower Leg
Hepatitis C	From Ladder or Scaffolding	Lumbas/Sacral Vertebrae
Hernia	From Liquid or Grease Spills	Lungs
Infection	Hand Tool or Machine in Use	Mouth

Inflammation	Hand Tool, Utensil; Not Powered	Multiple Body Parts
Laceration	Holding or Carrying	Multiple Injuries to Head
Loss of Hearing	Hot Object or Substances	Miltiple Lower Extremities
Mental Disorder	Into Openings ˍ shafts, excavations, floor openings, etc.	Multiple Neck Injury
Mental Stress	Jumping	Multiple Trunk
Multiple Injuries (Physical and Psychological)	Lifting	Multiple Upper Extremities
Multiple Physical Injuries Only	Machine or Machinery	Neck - Soft Tissue
Myocardial Infarction	Motor Vehicle	No Physical Injury
No Physical Injury	Motor Vehicle, NOC	Nose
Poisoning - Chemical,(other than metals)	Moving Part of Machine	Pelvis
Poisoning - General	Moving Parts of Machine	Sacrum and Coccyx
Poisoning - Metal	Object Being Lifted or Handled (cut, puncture, scrape)	Shoulder(s)
Puncture	Object Being Lifted or Handled (striking, stepping on)	Skull
Radiation	Object Being Lifted or Handled (struck, injured)	Spinal Cord - Neck
Respiratory Disorders	Object Handled	Spinal Cord - Trunk
Rupture	Object Handled by Others	Teeth
Severance	On Ice or Snow	Thumb
Silicosis	On Same Level	Toe(s)
Sprain	On Stairs	Upper Arm
Strain	Other ˍ Miscellaneous, NOC	Upper Back Area
Syncope	Other Than Physical Cause of Injury	Upper Leg
Vascular	Person in Act of a Crime ˍ robbery or criminal assault	Vertebrae
VDT - Related Diseases	Powered Hand Tool, Appliance	Wrist
Vision Loss	Pushing or Pulling	Wrist(s) & Hand(s)
	Radiation	
	Reaching	
	Repetitive Motion ˍ callous, blister, etc.	
	Repetitive Motion ˍ carpal tunnel syndrome	
	Rubbed or Abraded, NOC	
	Sanding, Scraping, Cleaning Operation	
	Slipped, Did Not Fall	
	Stationary Object	
	Steam or Hot Fluids	
	Stepping on Sharp Object	
	Strain or Injury By, NOC	

	Striking Against or Stepping On, NOC
	Struck or Injured, NOC ˍ includes kicked, stabbed, bit, etc.
	Temperature Extremes
	Twisting
	Using Tool or Machinery
	Vehicle Upset ˍ overturned or jackknifed
	Welding Operations
	Wielding or Throwing

*Source: International Association of Industrial Accident Boards and Commissions (IAIABC)

Appendix B Exploring Regression Analyses

Regression analysis for these data to quantify likelihood of injury was not attempted because there is no information available for uninjured employees (i.e. no variation in 'Injured' status- the desired response variable). Regression was explored to try and establish other relationships within the data. For example, might predictor variables say anything about the type of injury sustained? If so, this would be advantageous in structuring targeted safety training. The following is a brief summary of the exploration followed and the results obtained.

1. The variable 'Cause Code' was assigned as the response variable. Cause Code was defined as a categorical (nominal) variable from 1 to 10 based on the type of injury.
2. Based on available information, explanatory variables were chosen as Gender, Age, Tenure, and NAICS classification code. Two additional categorical variables were created based on Tenure. The first, Tenure equal to six months or less (Yes/No) and the second being Tenure equal to twelve months or less (Yes/No).
3. The initial data set provided was edited to exclude rows missing any of the explanatory variables. In addition, rows were removed where the age of the injured employee indicated a minor (less than 18 years old) or an elderly employee (80 years old or older).
4. A number of different logistic regressions were performed on the data set using combinations of Tenure, Age and Gender. While the results of the regression models proved to be statistically significant, they were not practically significant, as the R-Square value for the regressions were less than 0.01.
5. Another attempt was made using data on males only. Again, the regression models proved to be statistically significant, but not practically significant, as the R-Square value for the regressions were less than 0.01.
6. The 'Male Only' data set was then further divided using NAICS code and the results were similar to those above.
7. Finally, a negative binomial regression model was investigated because of over-dispersion within the response variable. However, much like the logistic regression, the models produced had no practical significance. In summary, our exploratory analysis could not produce a model with any predictive power based upon the available data.

Explanatory variables were:

- Gender (Categorical) -gender of the injured employee
- Age (Quantitative) -the age in years of the injured employee
- Tenure (Quantitative) -the length of time with the employer
- Tenure_6MOS (Categorical) -indication if the employee was in their first 6 months of employment
- Tenure_12MOS (Categorical) -indication if the employee was in their first 12 months of employment

- NAICS Code (Categorical) -classification to an industry according to the primary business activity of employer

The initial data set provided was manipulated to drop rows with missing data for any of the explanatory variables. In addition, rows were removed where the age of the injured employee indicated a minor (less than 18 years old) or relatively older employee (80 years old or older). Rows with missing data were dropped as were rows with Age < 18 and Age > 80.

Logistic regression was the model of choice.

Full Data Set

- Cause Code regressed on Gender + Tenure + Age
- Cause Code regressed on Gender + Tenure_6MOS + Age
- Cause Code regressed on Gender + Tenure_12MOS + Age

Males Only

- Cause Code regressed on Tenure_6MOS + Age
- Cause Code regressed on Tenure_12MOS + Age

NAICS 236 only, NAICS 237 only, and NAICS 238 only

- Cause Code regressed on Tenure_6MOS + Age
- Cause Code regressed on Tenure_12MOS + Age
- Cause Code regressed on Age + LN(Tenure) + Age*LN(Tenure)

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