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The Role of Age on the Cause, Type,

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## Abstract

As older workers continue to delay retirement, understanding the health and safety needs of an aging workforce will be critical over the next twenty years. The goal of the project was to determine the impact of age on workers in the construction industry as age relates to selected



## Background

The number of workers in the workforce who are 55 and older will increase by nearly 50% from 2004 to 2014. The proportion of workers 55 and over relative to all workers is also growing, from 11.9% in 1994, 15.6% in 2004, to an expected 21.2% in 2014 (Toossi, 2005).

are no published studies specifically investigating aging trends among a large cohort of workers in the construction trade that report on the nature, cause, and costs of work-related injuries. The proposed study was the first comprehensive effort to identify aging related trends associated with compensation claim variables of injury nature, cause and costs.

## Methods

### Population studied

The dataset represented workers' compensation claims filed by construction workers in the state of Colorado between the June 30, 1998 and June 30, 2008. Because claims are "open" for some period of time following the initial injury, a 24-month claim period was chosen to use for the analysis of cost data. The 24-month period has been used in previous workers' compensation cost studies and represents a time frame with very little additional costs (<1%) after that period (personal communication with actuarial at Pinnacol, 2010). The dataset represented approximately 80% of all construction companies for the state of Colorado. The remaining 20% of construction companies include self-insured companies, companies who



Percent (%) of claims

Age When Injured

**Figure 1.** Age distribution at time of injury

*Note.* Average age: 35, SD: 11, Median Age: 33, IQR: 26-43, Range: 19-99,  
Total number for claims: 107,064

### Statistical analysis approach

The outcomes (cost, injury/illness cause and nature) and dependent (age) variables were evaluated in terms of their distribution and completeness. The dependent versus the outcome variables were plotted to identify outliers and trends in the data. Categorical and ordinal variables were derived where appropriate. The categories of the cause and nature of injury variables were collapsed in order to group the least frequently occurring categories. Thus, illnesses were not specifically studied within this project as all of them were collapsed into “other” categories. Cost variables were log-transformed for all statistical analyses because the criteria for normality was not met. Cost variables were also adjusted for inflation to the year 2010 by using the Consumer Price Index.

The frequency and mean cost (total, medical and indemnity) of the injury’s or illness’s cause and nature by age group was determined. Pearson correlations and point-biserial correlations were ran to determine the strength of the relationship between dependent variable and outcome variables. Analyses of variance were used to evaluate differences in mean cost (total, medical and indemnity) of a claim across age groups. Multiple pairwise comparisons using a bonferroni adjusted alpha level of .003 per test (.05/15) was used to compare differences between age groups and the mean cost of a claim (total, medial and indemnity).

Linear regression analyses were conducted in order to explain the effect of age (years) on cost (total, medical and indemnity) and the interaction effects of age and injury/illness cause and nature on cost. The following procedures were used:

#### The effect of age (years) on cost

Each outcome variable (total cost, medical cost, and indemnity cost) was assessed in separate linear regression models for the explanatory variable age of claimant (years).

The interaction effects of age on the association of injury cause and nature on cost

The outcome variables were also assessed by separate linear regression models for the explanatory variables cause and nature of injury/illness and their interactions with age (years) (see Figure 2). For example, the linear regression model for total cost and cause was:

$$Y(\text{Total Cost}) = \beta_0 + \beta_1 * \text{Cause} + \beta_2 * \text{Age} + \beta_3 * \text{Cause} * \text{Age} + \epsilon$$

The interaction was first assessed by determining if the Type III SS test for unequal slopes was significant for the interaction coefficient. Once the interaction between the explanatory variable and age was found to be significant, the intercept term was excluded from the models (e.g., PROC GLM model option 'noint'). For example, the linear regression model for total cost and cause was:

$$Y(\text{Total Cost}) = \beta_1 * \text{Cause} + \beta_3 * \text{Cause} * \text{Age} + \epsilon$$

This allowed for the direct interpretations of the interaction beta estimates as the slopes for the individual regression lines for the explanatory variables and cost by age. They represented the percent increase in the cost of a claim for the category of cause or nature of injury for each year increase of age. For example, if the beta estimate for falls\*age in the above model was .0124, and it can be interpreted as a 1.24% increase in the cost of a claim for each year increase in age for a fall type of cause of injury.

A stepwise selection method was then used to eliminate any main effects and interaction terms that were not significant at the p<.0001 level. Forward and backward selection methods were then used to confirm the stepwise selection method results.

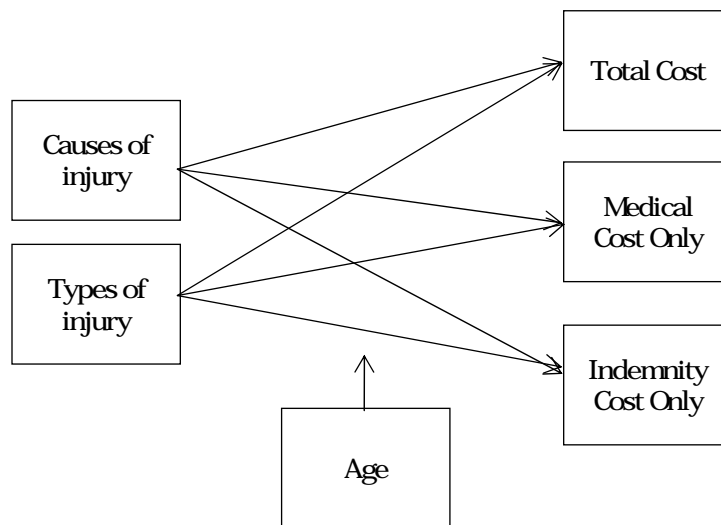


Figure 2. Diagram of relationships analyzed

## Results

Using workers' compensation claims data from Pinnacle Assurance, it was estimated that injured construction workers filed 111,057 claims during the ten-year period from June 30, 1998 and June 30, 2008. Of the 111,057 workers' compensation claims, those between the ages of 18 and 99 represented 107,064 claims. The mean age of a construction worker who filed a claim was 34 (SD=11) and nearly all injured workers who filed a claim were male (95%).

Age was evaluated as a continuous variable as well as a categorical variable with the age groups: 18-24 (n=21,733), 25-34 (n =36,018), 35-44 (n =27,092), 45-54 (n =16,360), 55-64 (n =5,259), 65+ (n =603).

The total cost of all 107,064 claims was \$936,450,233, with a mean of \$8,697 (SD= \$37,637) and median of \$573 (IQR= \$280 - \$2,022). The total medical costs for all claims was \$411,933,676, with a mean of \$3,816 and a median of \$528. The total indemnity costs for all claims was \$462,683,499, with a mean of \$4,306 and a median of \$0. Only 22.5% (n =25,007) of all claims filed during this time period incurred indemnity costs.

### Age differences in terms of cost (Specific Aim #1)

Pearson correlations revealed that there was a small but significant correlation between age when injured and total cost,  $r(107064)=.07$ ,  $p<.0001$ , medical costs,  $r(107064)=.05$ ,  $p<.0001$ , and indemnity costs,  $r(107064)=.10$ ,  $p<.0001$ . Indemnity expenses were more common among older workers. For example, 34% of workers 65 years or older incurred indemnity costs where as only 18% of workers 18-24 years of age incurred indemnity costs (see Figure 3). Older workers incurred costsdemnity

Figure 3. Claim type by age group

One-way analyses of variance (ANOVA) were conducted to evaluate the relationship between the age groups in terms of cost (total cost, medical costs and indemnity costs) of a

Strains were among the most common causes of injuries overall, but were ranked as the most frequent cause among the middle-aged groups (35-44, 45-54, 55-64). The distribution of types of strains did not vary greatly across all age groups except workers 65+ who experienced more strains from lifting and fewer strains from twisting compared to other age groups. Cuts, punctures and scrapes occurred more frequently among younger age groups. Causes classified as “miscellaneous” were more common among younger age groups and the most common cause type under this category was foreign body in eye. All other types of causes of injuries did not vary greatly among the different age groups. Small point-biserial correlations between age when injured and each cause of injuries were found to be significant. For example a positive point-biserial correlation was found between age when injured and fall, slip or trip ( $r_{pb}=.0699$ ,  $p<.0001$ ) and strain ( $r_{pb}=.0642$ ,  $p<.0001$ ) and a negative point-biserial correlation for cut, puncture or scrape ( $r_{pb}=-.0915$ ,  $p<.0001$ ).

**Table 4.** Distribution of cause of injury by age group

	Age group											
	Rank	18-24 <i>n</i> =21,733	Rank	25-34 <i>n</i> =36,018	Rank	35-44 <i>n</i> =27,092	Rank	45-54 <i>n</i> =16,360	Rank	55-64 <i>n</i> =5,259	Rank	65+ <i>n</i> =603
Strain	2	4,570 (21%)	1	9,555 (27%)	1	7,810 (29%)	1	5,039 (31%)	1	1,550 (30%)	2	150 (25%)
Striking against or												

M(ous) a ousken)5.25003( )-1123(1 )10 -126.7(255182131%)695( )]123(1 )10 -121) ouin,ate ee-161821%%) 110 -12%)21%] 2560 (21%)110 -12%

### The relationship between causes of injury and cost by age group (Specific Aim #2)

The most frequent causes of injuries were not necessarily the most costly. For example, motor vehicle accidents were the most costly, especially among older age groups (see Figure 4). When the motor vehicle category was broken down into the different types of accidents (e.g., with another vehicle, a rail vehicle, water vehicle, airplane or miscellaneous) a motor vehicle crash with another vehicle was the most common (56% of all motor vehicle causes). Repetitive motion injuries occurred least frequently overall, but were among the most costly for older age groups (65+).

For the most frequent causes of injuries, the older age groups incurred more costs than the younger age groups. For example, the mean total cost of a strain was \$12,787 (SD=\$24,259) among those 65 and older, but only \$4,995 (SD=\$15,925) among those between 18 and 24 years. Among the types of strains, objects being handled or lifted were most costly for workers ages 65 years and older, where as holding/carrying were most costly for workers ages 55-64, but there was little variation in cost by types of strains among workers 18 to 24 years of age (see Figure 7). A striking against or stepping on cause of injury cost more among older age groups, especially for workers 55-64 and 65 years and older.

Falls, slips and trips were the second most costly type of cause overall. Mean costs were higher for the oldest four age groups, compared to the two youngest age groups. Costs related to falls from a different level were the most different by age group, with increasing cost by increasing age group (see Figure 8).

Older workers incurred greater costs associated with indemnity costs than younger workers. Medical costs were generally greater among older workers but costs dropped slightly









**Table 5.** Results from linear regression models for the cost of a claim in relation to cause of injury and age of claimant

	Total cost <sup>†</sup>		Medical only cost <sup>†</sup>		Indemnity only cost <sup>†</sup>	
	Beta estimate (SE) <sup>a</sup>		Beta estimate (SE) <sup>a</sup>		Beta estimate (SE) <sup>a</sup>	
	p-value		p-value		p-value	
Burn or scald-heat or cold exposure-contact with*age <sup>b</sup>	-		-		-	
Caught in, under or between*age <sup>b</sup>	-		-		.02 (.004)	<i>p</i> <.0001
Cut, puncture or scrape*age <sup>b</sup>	-		-		-	
Fall, slip or trip*age <sup>b</sup>	.013 (.001)	<i>p</i> <.0001	.011 (.001)	<i>p</i> <.0001	.025 (.002)	<i>p</i> <.0001
Motor vehicle*age <sup>b</sup>	.024 (.004)	<i>p</i> <.0001	.018 (.004)	<i>p</i> <.0001	.043 (.006)	<i>p</i> <.0001
Strain*age <sup>b</sup>	.019 (.001)	<i>p</i> <.0001	.012 (.001)	<i>p</i> <.0001	.038 (.001)	<i>p</i> <.0001
Striking against or stepping on*age <sup>b</sup>	.013 (.001)	<i>p</i> <.0001	.008 (.001)	<i>p</i> <.0001	.025 (.002)	<i>p</i> <.0001
Repetitive motion*age <sup>b</sup>	.025 (.006)	<i>p</i> <.0001	-		.068 (.002)	<i>p</i> <.0001
Miscellaneous*age <sup>b</sup>	.009 (.001)	<i>p</i> <.0001	-		.023 (.000)	<i>p</i> <.0001

<sup>†</sup>Cost variables log-transformed

<sup>a</sup>Parameter estimates for each category of cause of injury modeled together. SE= standard error.

<sup>b</sup>Slope estimate for type of cause of injury and cost by age when injured (years)

- Not significant in the final model

**Table 6.** Distribution of nature of injury by age group

	Age group											
	Rank	18-24 n=21,733	Rank	25-34 n=36,018	Rank	35-44 n=27,092	Rank	45-54 n=16,360	Rank	55-64 n=5,259	Rank	65+ n=603
Strain	3	4,437 (20%)	1	9,501 (26%)	1	8,115 (30%)	1	5,052 (31%)	1	1,594 (30%)	2	156 (26%)
Contusion	1	4,608 (21%)	2	7,231 (20%)	2	5,646 (21%)	2	3,542 (22%)	2	1,215 (23%)	1	164 (27%)
Laceration	2	4,455 (21%)	3	6,331 (18%)	3	3,987 (14%)	3	1,977 (12%)	3	628 (12%)	3	70 (12%)
Foreign body	4	1,851 (8%)	4	2,932 (8%)	4	1,961 (7%)	5	1,041 (6%)	6	287 (5%)	8	25 (4%)
Sprain	6	1,206 (6%)	6	2,280 (6%)	5	1,931 (7%)	4	1,293 (8%)	4	409 (8%)	4	43 (7%)
Puncture	5	1,964 (9%)	5	2,517 (7%)	6	1,389 (5%)	8	694 (4%)	9	200 (4%)	9	23 (4%)
Other	7	933 (4%)	7	1,569 (4%)	7	1,313 (5%)	6	923 (6%)	5	322 (6%)	5	43 (7%)
All other	9	745 (3%)	8	1,300 (4%)	8	1,046 (4%)	7	701 (4%)	8	224 (4%)	7	28 (5%)
Fracture	8	763 (4%)	9	1,275 (4%)	9	932 (3%)	9	671 (4%)	7	236 (4%)	6	36 (6%)
Crushing	10	389 (2%)	10	552 (2%)	10	387 (1%)	10	256 (2%)	10	80 (2%)	10	10 (2%)
Burn	11	381 (2%)	11	526 (1%)	11	384 (1%)	11	210 (1%)	11	64 (1%)	11	5 (1%)

*Note.* “All other” was created by Pinnacol Assurance and includes everything that could not be categorized under their possibilities of nature of injury. “Other” was created for this study and includes all nature of injury possibilities that occurred less frequently (<1%).

### The relationship between nature of injury and cost by age group (Specific Aim #3)

The most frequently occurring injury natures were not the most costly. Fractures comprised between 4 and 6% of all natures of injuries, but were the most costly natures of injury across all age groups (see Figure 9). Natures of injuries classified as “all other” were also among the most costly across all age groups. Since natures of injuries classified as “all other” were originally coded as such, this nature of injury could not be broken down by type further. Natures of injuries classified as “other” were the third most costly. For the purposes of this study, the researcher created an “other” category in order to account for injury natures that occurred the least frequently (<1%). The specific natures of injuries that contributed to the cost of this “other” category were multiple injuries (M=\$57,909, SD=\$132,908), rupture (M=\$43,515, SD=\$56,096) and concussion (M=\$34,722, SD=\$142,520). The mean total cost increased by increasing age group for strains, contusions, sprains, all other, fractures and crushings. The remaining total costs by natures of injury did not demonstrate clear trends by age groups.

Older workers tended to incur greater costs than younger workers. Older workers incurred a greater amount of medical costs than younger workers (see Figure 10). For example, workers 65 years and older incurred a mean of \$20,272 (SD=\$38,878) medical costs whereas workers 18-24 years incurred a mean of \$11,649 (SD=\$30,732) medical costs for fracture injuries. Older workers also incurred more indemnity costs than younger workers (see Figure 11). For example, workers 65 years and older incurred a mean of \$10,201 (SD=\$30,770) indemnity costs whereas workers 18-24 years incurred a mean of \$2,100 (SD=\$10,000) indemnity costs.

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**Table 7.** Results from linear regression models for cost of a claim in relation to nature of injury and age of claimant

	Total cost <sup>†</sup>	Medical only cost <sup>†</sup>	Indemnity only cost <sup>†</sup>
	Beta estimate (SE) <sup>a</sup>	Beta estimate (SE) <sup>a</sup>	Beta estimate (SE) <sup>a</sup>
	p-value	p-value	p-value
All other*age <sup>b</sup>	.014 (.003)	-	.035 (.004)
	<i>p</i> <.0001		<i>p</i> <.0001





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## Appendix

**Table 1.** Cause of injury coding scheme

Code	Cause of injury	Code grouped	Cause of injury grouped
7	animal or insect	1	burn or scald – heat or cold exposure – contact with
1	burn - dust, gas, fume, vapor	2	caught in, under or between
1	burn - miscellaneous	3	cut, puncture or scrape
1	burn-acid chemicals	4	fall, slip or trip
1	burn-contact hot object	5	motor vehicle
1	burn-fire, flame	6	strain
1	burn-radiation	7	striking against or stepping on
1	burn-steam, hot fluids	8	repetitive motion
1	burn-temp. extremes	9	miscellaneous
1	burn-welding operations		
2	caught-machinery		
2	caught-object handled		
1	cold objects or substances		
2	collapsing materials (slides of earth)		
5	crash of rail vehicle		
5	crash of water vehicle		
9	cumulative (all other)		
3	cut - miscellaneous		
3	cut-broken glass		
3	cut-tool powered		
3	cut-tool, not powered		
1	electric shock-contact w/electric current		
1	explosion or flare back		
4	fall - miscellaneous		
4	fall - same level		
4	fall on ice or snow		
4	fall or slip from different level		
4	fall or slip from ladder or scaffolding		
4	fall or slip from liquid or grease spills		
4	fall, into opening		
4	fall, on stairs		
4	fall-slip, no fall		
9	foreign body in eye		
9	misc, other than physical cause of injury		
2	miscellaneous caught in or between		
5	miscellaneous motor vehicle		
6	miscellaneous strain or injury		
7	miscellaneous strike or injury		
7	miscellaneous striking against or stepping on		
5	mot. Veh-coll/fixd object		
5	motor veh-airplane crash		
5	motor veh-coll/vehicle		
5	motor vehicle-upset		
6	object being lifted or handled		

**Table 1. (Continued)**

Code	
9	other
8	repetitive motion
9	robbery or criminal assault
6	strain or injury by continual noise
6	strain or injury by twisting
6	strain-holding, carrying
6	strain-jumping
6	strain-lifting
6	strain-pushing, pulling
6	strain-reaching
6	strain-using tool/machine
7	strike-lifted object
7	strike-moving parts
7	strike-sanding, cleaning
7	strike-stationary object
7	strike-step, sharp object
7	struck by-falling object
7	struck by-lifted object
7	struck by-motor vehicle
7	struck by-moving parts
7	struck by-object by other
7	struck by-tool, machine
7	struck or injured by fellow worker, patient
6	strain or injury - miscellaneous

**Table 2.** Nature of injury coding scheme

Code	Nature	Code grouped	Nature grouped
1	a(i)(w w)4.9(o)4.3(r-.0006)8.t(r-).5(	i)4.2(n)4.6h015	Tc(st)3.9(ri)3.9(ke-l)3.9(i)3.9(f7(o-11467 .20.02re)v305

**Table 2. (Continued)**

Code	Nature
11	dislocation
11	dust disease noc
11	electric shock
11	enucleation
11	foreign body
22	fracture
11	freezing
11	hearing loss
11	heat prostration
11	hernia
11	herniated disc
11	infection
11	inflammation
30	laceration
11	mental stress
11	multiple physical injuries
11	MYOCARDIAL INFARCTION
11	no physical injury
11	poisoning--general
11	poisoning--general(not od or cumulative)
11	poisoning-chemical
11	poisoning-metal
11	poisoning-chemical
40	puncture
11	radiation
11	rapture
11	respiratory disorders (incl. asthma)
11	ruptured disc
11	severance
11	silicosis
47	sprain
48	strain
11	unclassified
11	vascular loss
11	vision loss
11	concussion
11	mental stress
11	rupture
11	mental disorder
11	multiple injuries both physical and
11	aids
11	VDT-RELATED DISEASE

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