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Elevated occupational transportation fatalities among older workers in Oregon: An empirical investigation

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ABSTRACT

Older workers have an elevated risk of being killed on the job, and transportation incidents involving vehicles or mobile machinery are especially deadly for this group. The present study was designed to address the research gap in understanding contributing factors to these incidents and recommend evidence-based guidelines for interventions. We gathered and analyzed data from several sources, including the Oregon Fatality Assessment and Control Evaluation program, the Oregon Workers' Compensation system, the Census of Fatal Occupational Injuries, the Bureau of Labor Statistics, and peer reviewed research literatures. Rates and rate ratios (RR) were used to evaluate excess risk among groups. The results of this study show that older workers in Oregon have an elevated risk of fatality both in all events (RR = 3.0, 95% CI 2.2–4.0) and transportation events (RR = 3.6, 95% CI 2.4–5.4). Additional analyses and extant literature supports our hypotheses that multiple risk factors contribute to the phenomenon, including (a) hazard exposure, (b) organization of work, (c) physical fragility, and (d) normative cognitive, sensory, and psychomotor changes that occur with age. The evidence-based framework proposed may provide valuable guidance for developing safety interventions that protect older workers.

1. Introduction

Older workers are at increased risk of being killed on the job. Although older workers are injured less often than younger workers, the injuries they experience are more severe, and include more fatalities (Kisner and Pratt, 1999; Grandjean et al., 2006). In 2010, workers 65 years and older had a rate of 104.3 work-related illnesses or injuries per 10,000 full-time workers, compared to a rate of 117.9 for all workers (Bureau of Labor Statistics, 2010b). However, when an older worker is injured, severity is greater based on lost workdays. In 2010, workers aged 65 years and older had a median of 16 lost workdays per injury or illness, as opposed to 8 lost workdays for all workers combined (Bureau of Labor Statistics, 2010a). Injuries to older workers are also more likely to be fatal. In 2010 the rate of fatal occupational injuries of workers over age 65 (11.9 per 100,000 FTEs) was over three times as high as the fatality rate for all workers (3.6 per 100,000 FTES) (Bureau of Labor Statistics, 2012b). The elevated risk of severe and fatal injuries to older workers is a socially important public health problem because the number of older Americans is growing rapidly as the baby boomer generation ages (those born in the years between 1946 and 1964). In addition, many Americans are remaining in the workforce beyond the standard retirement age of 65 (Popkin et al., 2008; Silverstein, 2008). Current economic conditions may drive retirement age even later for workers who experienced significant depreciation in retirement funds and/or home values (Association of Occupational and Environmental Clinics (AOEC) and the Society of Occupational and Environmental Health (SOEH), 2009). According to the Bureau of Labor Statistics (BLS), there are currently more than 5.5 million people 65 years and older in the workforce, or around 3.6% of the workforce. By 2016, this percentage is expected to rise to 6.1% of the total labor force, or an increase of over 80% (Bureau of Labor Statistics, 2008b).

Protecting older workers from transportation-related injuries and fatalities is a particular social priority. Roadway crashes are the leading cause of death in the workplace (Pratt, 2003), but they are particularly deadly for older workers. Between 2003 and 2008, workers 65 years and older had an occupational highway transportation fatality rate ratio of 3.77 compared to workers age 16–24 years old (Myers et al., 2011). Tiesman et al. (2011) found that older workers ≥65 years had the highest fatality rate due to occupational traumatic brain injury, and motor vehicle crashes accounted for 26% of all occupational traumatic brain injury fatalities in that age

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group. In addition, male workers had a significantly greater risk of occupational TBI than women. These data are consistent with findings of Janicek, who argued that the greatest need for occupational fatality prevention interventions was among older male workers in transportation and agricultural occupations (Janicak, 2003).

While the literature shows an elevated risk of transportation-related occupational fatalities among older workers, there is a pressing need to identify contributing factors that may be addressed with interventions. For example, one potential contributing factor is normative changes in cognitive, psychomotor, and vision abilities that occur with age. Occupational driving and the operation of mobile machinery require abilities that notably depreciate with aging, such as vision, reaction time, and cognitive executive function (Dawson et al., 2010). Researchers have also investigated other factors that may contribute to increased risk, such as marital status (e.g., never married) or occupational status (e.g., lone worker occupations) (Whitlock et al., 2004; Olson et al., 2009). However, such social factors may not be easily amenable to intervention. In general, there is a lack of systematic research investigating potential causes of this social problem that can be manipulated to reduce risk. This research gap is a barrier to creating effective interventions to reduce transportation-related fatalities among workers 65 years and older.

The current project was designed to address the research gap and provide evidence-based guidance for interventions. Our goals were to (1) to characterize the at-risk population and levels of excess risk through descriptive data analysis, rates, and rate ratios and (2) evaluate the evidence for potential explanations for increased fatality risk among older workers in transportation events. Our hypotheses are that four factors may each partially explain increased risk of transportation-related occupational fatalities among workers 65 years and older are:

1. *Hazard exposure*: Older male workers have higher levels of employment in hazardous transportation occupations.
2. *Organization of work*: Differences between small and large employers in safety management programs and work organization for older employees.
3. *Physical fragility*: Physical vulnerabilities and disease conditions that increase with age.
4. *Cognitive, sensory, and psychomotor changes*: Normative changes in cognition, sensory, and psychomotor abilities with age.

2. Methods

To test our hypotheses we gathered and analyzed data from several sources, including the Oregon Fatality Assessment and Control Evaluation program, the Oregon Workers' Compensation system, the national Census of Fatal Occupational Injuries, the Bureau of Labor Statistics, and peer reviewed research literatures. Due to the exploratory and qualitative nature of most of our questions, we did not conduct meta-analyses or select pre-established empirical criteria for accepting or rejecting hypotheses. Instead, our aim was to consider empirical evidence to test each factor for inclusion in our conceptual model for explaining elevated risk, and then qualitatively evaluate whether the balance of evidence suggested no support, some support, or strong support for the proposed model.

2.1. Data

2.1.1. Oregon occupational fatalities

Deaths from traumatic work-related fatalities that occurred between 2003 and 2009 in Oregon were identified through the Oregon Fatality Assessment and Control Evaluation (OR-FACE) program. FACE is a collaborative program between states and the National Institute for Occupational Safety and Health (NIOSH). The OR-FACE program was established in 2003 and conducts surveillance, investigation, assessment, and outreach related to preventing traumatic occupational fatalities in Oregon. Certain types of fatalities, even if they occur at work, are outside the scope of the OR-FACE program, and are therefore not included in the datasets used for the current study. Such excluded fatalities include deaths of institutionalized persons, fatal heart attacks and strokes (unless causally related to a traumatic injury or exposure), fatal events that occur during a person's recreational activities that are not required by an employer, and fatal events that occur during a person's commute to or from work. OR-FACE receives notifications of traumatic occupational fatalities from a variety of sources, including death certificates, news media, and Oregon Occupational Safety and Health Division (OR-OSHA). Historically the OR-FACE program has operated special emphasis programs of prevention research and outreach for high-risk populations, such as loggers. The topic of the current manuscript is one such special emphasis program.

2.1.2. Denominator data

To calculate fatality rates, the number of workers was estimated from the Bureau of Labor Statistics' Current Population Survey (CPS). The CPS is a monthly survey of about 60,000 occupied households (civilian, non-institutionalized). To be eligible to participate in the CPS, individuals must be 15 years of age or older and not in the Armed Forces. The CPS provides data on labor force status (employment, unemployment, and not-in-labor force) as well as the demographic characteristics of workers and non-workers (U.S. Census Bureau, 2006). Fatality rates calculated for this analysis excluded anyone younger than 15 years, since they are out of the scope of the survey.

2.1.3. Oregon Workers' Compensation

Oregon law requires employers to provide workers' compensation insurance for their employees, with some exceptions (e.g. sole proprietors). Claims that result or will likely result in three or more days of regularly scheduled work, hospitalization, or possibility of permanent disability (e.g., disabling claims) must be reported to the Department of Consumer and Business Services, which administers laws in workers' compensation, occupational safety and health, insurance, and other areas. Data include information needed to administer claims, such as source and nature of injury, injury event, occupation, employer information, employee demographics, hospitalization status, and claim status. In addition, a separate file containing claim costs for resolved accepted, disabling claims was used to assess days of time lost from work. This information excludes current death or permanent total disability benefits.

2.1.4. National fatality data

Data from the Census of Fatal Occupational Injuries (CFOI) were used to estimate national work-related deaths. CFOI tracks all fatal occupational injuries that occur within a state's boundaries. A fatal work-related injury is defined as a fatality to a non-institutionalized person, working at the time of the incident, and on the physical premises of the employer. Inclusion criteria for CFOI and FACE are similar (Hammond et al., 2012).

2.1.5. Peer-reviewed research literatures

Research literatures were systematically reviewed to gather evidence for hypotheses beyond what was available in Oregon FACE and Workers' Compensation databases. Search strategies differed by keyword but limits remained the same throughout each search. Databases searched included PubMed, Psych Info, Science Direct, Academic, Search Premier, Ovid, and Google Scholar. Priority was

Table 1
Age, sex and Hispanic ethnicity status, all work-related fatalities ≥15 years, OR-FACE, 2003–2009.

	Workers[a]	Number of deaths	Rate per 100,000	RR (95% CI)
Gender				
Female	5,749,057	31	0.5	1.0
Male	6,635,513	441	6.6	**12.3 (8.6–17.7)**
Age (years)				
15–19	477,299	17	3.6	0.9 (0.6–1.5)
20–24	1,127,880	40	3.5	0.9 (0.7–1.3)
25–34	2,832,798	58	2.0	**0.5 (0.4–0.7)**
35–44	2,828,264	92	3.3	0.9 (0.7–1.1)
45–54	2,855,070	135	4.7	1.2 (1.0–1.5)
55–64	1,836,496	81	4.4	1.2 (0.9–1.5)
65+	426,763	49	11.5	**3.0 (2.2–4.0)**
All ages	12,384,570	472	2.8	1.0
Hispanic				
No	11,334,341	432	3.8	1.0
Yes	1,050,230	40	3.8	1.0 (0.7–1.4)
Total	12,384,570	472	3.8	

Note: Boldface denotes significance at $\alpha = 0.05$ level.
[a] Worker denominator from Current Population Survey, summed for 2003–2009.

given to US studies due to differences in safety regulations across countries.

2.2. Variable definitions

Within OR-FACE fatal occupational incidents are reviewed and coded for industry (North American Industrial Classification System, NAICS), occupation (Standard Occupation Coding, SOC), and event (Occupational Injury and Illness Classification System, OIICS), as well as time, place, and demographic characteristics (e.g., age, gender, race, day of week, and time of incident). For current analyses, transportation events were selected by limiting the event code to "4" which is the major division for transportation incidents. This category includes fatalities from all modes of transportation, including vehicle-related incidents on and off public highways, pedestrian fatalities, and vehicle-occupant crashes (Bureau of Labor Statistics, 2007). Thus, transportation-related incidents in the current analyses involve workers from a range of different occupations and industries who were killed in many different types of events, such as motor vehicle crashes, pedestrians struck by motor vehicles or mobile machinery, and mobile machinery rollovers and collisions (e.g., fork lifts, tractors, bull dozers).

2.3. Statistical analysis

Occupational fatality rates were calculated by dividing the total number of fatalities between 2003 and 2009 and dividing by the estimated number of workers during the same period and then standardized to represent the number of fatalities per 100,000 full time workers. Because denominator data did not include individuals younger than 15, these individuals are not represented in rate calculations. Gender and age-specific fatality rate comparisons were quantified using rate ratios (RR) and tested for significance using 95% confidence intervals (CI). Poisson regression was used to assess trends in all fatalities and transportation fatalities over the seven-year time period. Data were analyzed in 2011–2012 using SAS, version 9.2.

3. Results

3.1. Purpose 1: characterizing the population at-risk and magnitude of increased risk

3.1.1. All traumatic occupational fatalities in Oregon

The first step in characterizing our population at risk was accomplished through an analysis of all occupational fatalities in the OR-FACE dataset. Between 2003 and 2009, there were 475 total occupational fatalities recorded by OR-FACE. By industry, most fatalities occurred in the transportation sector (14.7%), followed by forestry/logging (12.8%) and construction (12.4%). By occupation, most fatalities occurred in transportation occupations (21.9%), followed by construction (12.2%) and farming/ranching (8.8%) (data not shown).The age of victims ranged from 12 to 88 years, with an average age of 45 (SD = 15). Most deaths were among males (443, 93.3%) aged 45–54 years (135, 28.4%) due to transportation events (219, 46.1%). Events were distributed fairly evenly throughout the year, with slightly more events occurring in summer relative to other seasons (148, 31.2%). Where time of incident was known ($n = 409$), the majority occurred during hours of 8 a.m. to 5 p.m. (285, 69.7%) (data on other time categories not shown). In workers 15 years and older ($n = 472$) the overall fatality rate was 3.8 per 100,000 workers (Table 1). Men had a significantly higher risk of fatality than did women (RR = 12.3, 95% CI 8.6–17.7). Workers 65 years and older had the highest fatality rate (11.5 per 100,000), and their RR compared to the overall rate was 3.0 (95% CI, 2.2–4.0). There was no elevated risk for workers of Hispanic ethnicity. Occupational rates by year ranged from 4.4 per 100,000 in 2003 to 3.6 per 100,000 in 2009. Overall, the fatality rate declined by 3.1% during the seven-year period of interest ($p = .09$) (year-by-year data not shown).

After observing an increased risk of fatal injury among workers 65 and older, we investigated the most common fatal events across six different age intervals. Table 2 presents the number and percent of traumatic occupational fatalities by age group and event leading to injury. As noted above, nearly half ($n = 219$, 46%) of fatalities were due to transportation events involving a motor vehicle or mobile machinery, with an additional 23% due to contact with objects and equipment ($n = 108$). For all age groups, transportation events constituted the largest proportion of the total (range 39–55%). For workers 65 years and older, 55% of fatal events were transportation-related.

3.1.2. Transportation-related occupational fatalities in Oregon

After investigating patterns in fatality rates for the full OR-FACE dataset, we investigated counts and risk across age intervals for transportation-related events specifically. There were 219 occupational transportation fatalities identified in workers 15 years and older between 2003 and 2009. By industry, most fatalities occurred in the transportation sector (24.7%), followed by forestry/logging (14.2%) and agriculture (8.2%). By occupation, most fatalities occurred in transportation occupations (39.3%), followed by construction, farming/ranching, and fishing (all 6.8%) (data not

Table 2
Number and percentage of occupational fatalities by age group and event leading to fatality, Oregon FACE, 2003–2009, *n* (%).

Age (years)	Contact with objects and equipment	Falls	Transportation	Violence	Other[a]	Total
12–19	1 (5)	1 (5)	11 (55)	3 (15)	4 (20)	20 (4)
20–24	7 (18)	1 (2)	22 (55)	2 (5)	8 (20)	40 (8)
25–34	13 (22)	3 (5)	32 (55)	3 (5)	7 (12)	58 (12)
35–44	19 (21)	14 (15)	42 (46)	7 (8)	10 (11)	92 (19)
45–54	33 (24)	18 (13)	53 (39)	17 (13)	14 (10)	135 (28)
55–64	25 (31)	6 (7)	32 (40)	10 (12)	8 (10)	81 (17)
65+	10 (20)	5 (10)	27 (55)	5 (10)	2 (4)	49 (10)
Total	108 (23)	48 (10)	219 (46)	47 (10)	53 (11)	475 (100)

[a] Other includes exposure to harmful substances, fire/explosion, and overexertion.

Table 3
Age, sex and Hispanic ethnicity status, fatalities ≥15 years where event = transportation, Oregon FACE, 2003–2009.

	Workers[a]	Number of deaths	Rate per 100,000	RR (95% CI)
Gender				
Female	5,749,057	11	0.2	1.0
Male	6,635,513	207	3.1	**16.3 (8.9–29.9)**
Age (years)				
15–19	477,299	10	2.1	1.2 (0.6–2.2)
20–24	1,127,880	22	1.9	1.1 (0.7–1.7)
25–34	2,832,798	32	1.1	0.6 (0.4–0.9)
35–44	2,828,264	42	1.5	0.8 (0.6–1.2)
45–54	2,855,070	53	1.9	1.1 (0.8–1.4)
55–64	1,836,496	32	1.7	1.0 (0.7–1.4)
65+	426,763	27	6.3	**3.6 (2.4–5.4)**
All ages	12,384,570	218	1.8	1.0
Hispanic				
No	11,334,341	202	1.8	1.0
Yes	1,050,230	16	1.5	0.9 (0.5–1.4)
Total	12,384,570	218	1.8	

Note: Boldface denotes significance at $\alpha = 0.05$ level.
[a] Worker denominator from Current Population Survey, summed for 2003–2009.

shown).The overall transportation-related fatality rate was 1.8 per 100,000. Males were at much higher risk than females (RR = 16.3, 95% CI 8.9–29.9). As with total fatalities, the oldest workers had the highest rate (6.3 per 100,000) of transportation-related fatalities, and the rate ratio for these workers compared to the overall rate was significantly elevated (RR = 3.6, 95% CI 2.4–5.4). Workers with Hispanic ethnicity had a non-significant decrease in risk compared to all others (RR = 0.9, 95% CI 0.5–1.4) (Table 3). Rates of transportation fatality by year ranged from 2.1 per 100,000 in 2003 to 1.8 per 100,000 in 2009; the overall decline for the period was 4.0% but was non-significant ($p = .50$) (Fig. 1).

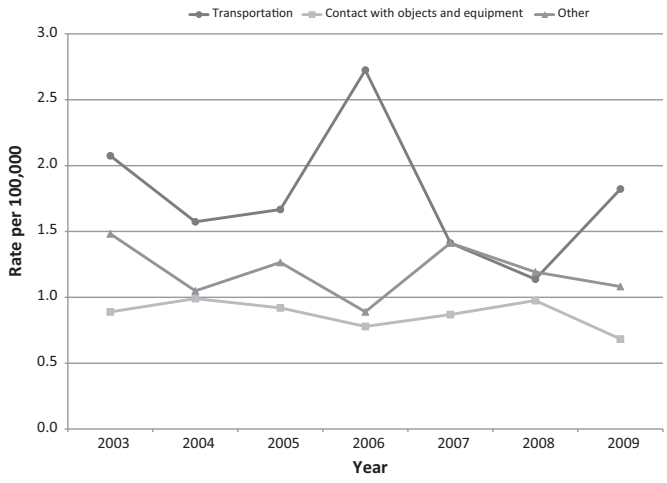

Fig. 1. Occupational traumatic fatality rates by year and event type, Oregon FACE, 2003–2009.

3.2. Purpose 2: investigation of potential explanatory factors for increased risk

3.2.1. Hazard exposure

The first hypothesis we considered was that elevated risk among male workers 65 years and older is due in part to employment levels in occupations with high exposure levels to transportation hazards. In other words, elevated transportation deaths in this age group may be partly a function of older males' having elevated rates of employment in dangerous transportation and material moving occupations. While this pattern of employment (high proportion of older males) may also apply to occupations such as agriculture where workers operate farming vehicles and machinery, workers in transportation and material moving occupations arguably have the highest exposure levels to vehicle and mobile machinery hazards. Previous research on employment levels and employment projections for older male workers provides a degree of support for this explanatory factor. Richardson and Schulman (1994) concluded that high rates of fatal injuries among older workers appeared to be related to their levels of employment in certain high-risk occupations and industries. In a paper that reported employment projections for the time period analyzed in the current project (2003–2009), older male workers in transportation and material moving occupations had among the highest projected growth rate (Committee on the Health and Safety Needs of Older Workers, 2004). To further test this hypothesis we computed fatality rates per 100,000 male workers for both the US and Oregon for only transportation and material moving (TMM) occupations. This analysis explicitly tests whether an elevated risk for older workers remains present when only male workers in the hazardous TMM occupations are studied in both state and national datasets. If the computed occupational fatality rate ratios for male workers 65 years and older in these targeted analyses were smaller than the

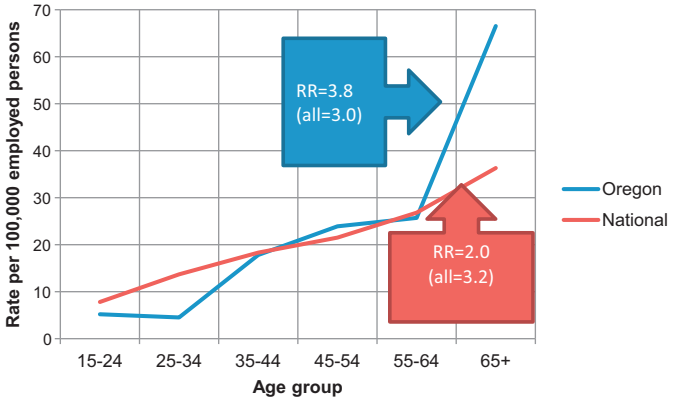

Fig. 2. Fatality rates for males employed in transportation and material moving occupations, 2003–2009.

rate ratios for all workers, it would support the notion that age does not explain all of the variance in elevated risk. In other words, if age was the sole or dominant contributing factor to elevated risk, the rate ratio for males 65 and older in hazardous TMM occupations would be roughly the same as the rate ratio for the general population of workers. Conversely, if the rate ratio for male workers 65 and older in TMM occupations was attenuated relative to the rate ratios for the general population of workers, this would suggest that the risk of fatality has a stronger association with exposure (employment) rather than age, at least within the TMM group.

Results showed that at the national level, the rate ratio for occupational fatalities among male workers ≥65 years in the TMM sector remained significantly elevated, but reduced in magnitude relative to the overall elevated risk for all US workers (all occupations, both sexes) who were ≥65 years of age (RR = 3.2 for all National workers over 65). More specifically, the National fatality rate ratio computed only for male TMM workers 65 and older compared to the average rate for all ages was 2.0 (95% CI 1.8–2.1) (Fig. 2). At the state level within Oregon, the fatality rate ratio computed only for male TMM workers ≥65 years was significant and actually increased in magnitude relative to the overall elevated risk for all Oregon workers (all occupations, both sexes) who were ≥65 years of age (RR = 3.0 for all Oregon workers over 65). More specifically, the Oregon fatality rate ratio for male TMM workers 65 and older compared to the average rate for all ages was 3.6 (95% CI 2.4–5.4) (Fig. 2). These findings at the National and State levels provide mixed support for the hazard exposure hypothesis.

3.2.2. Organization of work

The second hypothesis we considered was that elevated risk of fatality among male workers 65 years and older is due in part to organization of work factors. The way work is organized at small employers is likely to differ from the way work is organized at larger employers. In particular, we hypothesized that organization of work factors at smaller employers, such as job roles for older workers and safety management processes, contribute to elevated transportation fatality risk for older workers. To assess this hypothesis, we analyzed employer size for workers killed in transportation events in Oregon 2003–2009. Next, we reviewed the research literature for evidence of how employer size is related to organizational safety processes, and for data on changing job roles with age.

Older workers killed in transportation-related events in Oregon were predominantly employed in small organizations. Just over half of the victims were either self-employed or worked for an organization with fewer than 10 employees. The remaining fatalities occurred in organizations with fewer than 100 employees (Table 4). If occupational safety processes or job roles vary by employer size,

Table 4
Number and percentage of transportation and material moving fatalities by employer size for males ≥65 years, Oregon FACE, 2003–2009, *n* (%).

Employer size	Fatality *n* (%)
1 (self-employed)	6 (35)
2–9	3 (18)
10–19	2 (12)
20–49	1 (6)
50–99	3 (18)
Unknown	2 (12)
Total	17 (100)

Note: Employer size data gathered from Oregon Labor Market Information System Employer Database and manta.com.

employment data for Oregon fatalities suggest that organization of work factors at smaller employers may be contributing to elevated fatality risk among workers 65 years and older.

A literature search for differences in occupational safety programs between small and large employers was combined with selected occupational keywords and keyword combinations (e.g., occupational safety and small businesses, safety training and small businesses). Search strategies differed by keyword but limits remained the same throughout each search. Databases that focus on social and health sciences and engineering were systematically searched, using the same keywords and limits for each database. Databases included PubMed, Psych Info, Science Direct, Academic, Search Premier, Ovid, and Google Scholar. Priority was given to US studies due to differences in safety regulations across countries. Our review of relevant papers produced by our search revealed meaningful differences in the organization of work across small and larger employers. First, small businesses (between 2 and 200 employees) employ higher proportions of workers over age 65 years relative to larger businesses (Stokols et al., 2001). Two plausible explanations for this finding are that small businesses either attract and hire more older workers than larger businesses, or that smaller employers encourage or facilitate a later retirement age. Safety program investments are also associated with employer size. Based on a new analysis of two national historical surveys, Lentz et al. found that smaller employer size was associated with a decreased likelihood that the organization (a) employed full time staff for injury and illness prevention, (b) held regularly scheduled formal safety training, (c) operated a monitoring program for physical environmental factors, or (d) utilized safety consultants (Lentz et al., 2001). To illustrate the magnitude of differences observed, fewer than 10% of smallest organizations (<50 employees) included a full time staff member focused on injury and illness prevention, while the overwhelming majority of organizations with 500 or more employees had full time illness and injury prevention staff.

While we did not find any studies that explicitly described differences in job roles for older workers in small vs. large organizations, such differences are plausible because small employers must accomplish all business functions with fewer people. For example, in larger organizations there is greater opportunity for specialization in job roles and harder distinctions are drawn between management and labor. In contrast, individuals in small organizations would be more likely to wear many hats and perform generalized rather than specialized work, such as an older small business owner who occasionally performs front line production or service work in addition to his management duties. An example would be an aging owner of a small family farm who continues to occasionally operate tractors and other mobile machinery. In contrast to the small family farm, an employee in a large agribusiness company might be less likely to continue direct farming as he ages due to formal promotion into specialized management or administrative roles. In additional to higher levels of exposure to front line tasks among older workers in small organizations, the *occasional*

Table 5
Summary of hospitalization status, Oregon Workers' Compensation disabling claims, by event type, 2003–2009.

	Age group (*N*, %)			
	<65 years	≥65 years	Total	*p*-Value
All events				
Hospitalization status[a]				<.0001
Yes	5242 (4.1%)	238 (9.6)	5480 (4.2)	
No	123,139 (95.9)	2253 (90.4)	125,392 (95.8)	
Total	128,381 (100.0)	2491 (100.0)	130,872 (100.0)	
Transportation events				
Hospitalization status[b]				<.0001
Yes	614 (10.8)	31 (24.2)	645 (11.1)	
No	5079 (89.2)	97 (75.8)	5176 (88.9)	
Total	5693 (100.0)	128 (100.0)	5821 (100.0)	

[a] Excluded 22,287 claims with unknown hospitalization status.
[b] Excluded 924 claims with unknown hospitalization status.

nature of such front line work could be a relevant additional risk factor, because operational skills may deteriorate or become less fluent with infrequent practice.

Specific fatal case studies in Oregon illustrate the potential confluence of organization of work factors on hazard exposure for older workers in small businesses. For example, consider the case of an 80-year old land and farm owner who was killed when the tractor he was operating rolled over. In that case (1) the victim was a small farm owner who was working beyond the normal retirement age (smaller businesses employ more workers over 65 than larger businesses); (2) the tractor he was operating did not have a rollover cage (lower levels of safety investment by smaller businesses); and (3) although the victim was the farm owner, he continued to perform front line production work (a mixed job role combining management and front line labor).

3.2.3. Physical fragility

The third hypothesis we assessed is the role that physical fragility and disease conditions that increase with age play on the increased risk of transportation-related injuries. Age influences a person's susceptibility to disease conditions; disease incidence generally increases with increasing age, although the two should not be considered synonymous (Shock et al., 1984; Schulte et al., 2012). Further, older workers are more likely to suffer from chronic health conditions, and the conditions most common in these workers are often more disabling, more expensive, and more difficult to treat than those found in younger workers (Hymel et al., 2011; Summer et al., 1999). To assess the physical fragility factor, we used disabling workers' compensation claims to examine hospitalization status for injured claimants as well as days of time lost from work. If older workers are more likely to be hospitalized (as a proxy for more severe injuries) and more likely to have more missed workdays, then this would support the inclusion of the physical fragility factor in our conceptual model of elevated risk.

3.2.3.1. Hospitalization status as a proxy for injury severity. For all claims in Oregon accepted as disabling with known hospitalization status and age (n = 130,872) during the time period of this analysis, the mean claimant age was 40.7 years (standard deviation 12.5). Using hospitalization status as a proxy for injury severity, older workers ≥65 years were more than twice as likely to be hospitalized compared to younger workers (9.5% vs. 4.1%, X-square 182.3, $p < .0001$). When limited to only transportation events where claimant age and hospitalization are valid (n = 5693), this difference was more pronounced (24.2% vs. 10.8%, X-square 22.9, $p < .0001$) (Table 5).

3.2.3.2. Days of time loss. For claims resolved during the time period of this analysis (n = 148,380) there was a median of 21 lost workdays (mean = 65) of temporary disability days paid. Workers 65 years and older were more likely than younger workers to have greater than the median number of temporary disability days paid (57.6% vs. 48.7%, X-square 83.2, $p < .00001$).

3.2.4. Cognitive, sensory, and psychomotor changes

The fourth hypothesis assessed was that increased transportation fatalities among older workers are due to cognitive, sensory, and psychomotor abilities that decrease with age; these normative declines may impact older workers' ability to safely fulfill work demands with vehicles or mobile machinery. We are unable to directly evaluate this factor with current data sources in Oregon. Therefore, we reviewed relevant literature for supporting or refuting evidence. We note at the outset of this discussion that most research literature on this topic relates to motor vehicle operation, and that such findings may or may not generalize to the operation of mobile machinery such as tractors and front end loaders by older workers.

The systematic literature search utilized PubMed, PsycInfo, and Medline databases. Search terms were generated in the following six categories and implemented in the same fashion across each database: aging, cognition, driving, transportation occupations, sensory abilities, and fatality and injury risk. In addition to the examination of these search results, reviews of reference lists and preexisting knowledge of relevant articles further guided the literature reviewed.

3.2.4.1. Age-related sensory declines and motor vehicle operation. On average, as adults age they experience increased difficulty performing under hazardous driving situations due to reduced visual acuity and contrast sensitivity (Mcgwin et al., 2000). Vision impairment affects approximately 8% of the US population over 60 (Vitale et al., 2006), and many vision-related disorders are common at later age, including cataracts, glaucoma, and macular degeneration. Cataracts are the most common vision impairment past age 60, with age-related lens opacities affecting over half of adults aged 65–74 and up to 80% of adults aged 75–85 in one sample (Kahn et al., 1977; Sperduto and Seigel, 1980; Klein et al., 1992). The risk for glaucoma increases after age 40, with screening visits suggested every one to two years after age 65 (Rosenberg and Sperazza, 2008). Age-related macular degeneration affects 13.4% of individuals over 60 (Klein et al., 2011) and will likely increase 50% in prevalence by 2020 due to increases in this age demographic in the US (Friedman et al., 2004).

Among older adults, vision impairments adversely influence driving performance. When compared to older adults without cataracts, those with cataracts experience a higher at-fault crash risk and reduced confidence in their driving skills (Owsley et al., 1999). Glaucoma can cause moderate to severe visual field

Table 6
Summary of older age group differences in average person miles traveled, U.S. Department of Transportation National Household Travel Survey,[a] 2009.

Age	Persons (in thousands)	Person miles (in millions)	Average person miles traveled	Percent decrease
60–64	9575	167,014	17,442	
65–69	4325	63,775	14,744	15.5
70–74	2109	27,832	13,199	10.5
75–79	1020	12,936	12,685	3.9
80–84	406	4262	10,494	17.3
85+	175	1186	6785	35.4

[a] Data were obtained with the Data Extraction Tool, total travel by survey year and person attributes. Numbers are for employed drivers.

impairments, shown to result in increased likelihood of motor vehicle collisions (Mcgwin et al., 2005). Even mild glaucoma cases can impair the detection of peripheral hazards (Haymes et al., 2008). Limited research has been conducted on macular degeneration and crash risk or driving performance, however, the reduced visual acuity resulting from the atrophy of rods has been associated with difficulties when driving at night (Owsley and Mcgwin, 2008).

In addition to vision, hearing capabilities are related to worker safety, and transportation equipment operators experience an elevated risk for hearing loss compared to other working groups (Tak and Calvert, 2008). Age-related hearing loss affects 23% of adults aged 65–75 years of age and 40% of adults older than 75 years (Seidman et al., 2002). Moderate to severe hearing impairment can result in poorer driving outcomes in the presence of distracters (Hickson et al., 2010). Although a link between driving safety and hearing loss is probable, no research has elucidated this link among older transportation workers.

3.2.4.2. Cognitive and psychomotor changes at later age and driving ability. Although many cognitive abilities relate to driving, those most predictive of driving outcomes appear to be attention and visuospatial abilities (Reger et al., 2004). Both these cognitive abilities can be deconstructed into more specific components. Various components of attention (e.g., selective, divided, visual) and visual–spatial and perceptual abilities (e.g., perceptual speed, mental flexibility) are associated with crash risk or driving performance among older adults (Anstey et al., 2005). Many psychomotor abilities also relate to driving, such as limb coordination, range of motion, and reaction time. Moreover, when relevant, commercial motor vehicle operation involves greater psychomotor demand than conventional vehicle operation, considering the frequent shifting required of standard transmissions and the movement required to examine larger viewing angles (Llaneras et al., 1998). Considering the psychomotor changes of later age (Era et al., 2011), some particular aspects of driving or vehicle operation may become challenging for older workers. On particular dimension of vehicle operation that is critically important to safety is the ability to detect and react to an unexpected change in conditions. Speed and reaction time closely relate to driving outcomes (Anstey et al., 2005), as safe motor vehicle operations requires a quick response to such unexpected hazards.

Given that normative changes in cognitive, sensory, and psychomotor domains relate to safe vehicle operation, it would be desirable to establish when such changes reach a threshold that may require workplace accommodation and/or intervention. However, there is limited consensus regarding the age at which declines begin or accelerate. Many researchers suggest the onset occurs around the 50s to 70s, while others have estimated declines beginning as early as the 20s and 30s across cognitive domains (Salthouse, 2009). Psychomotor declines also begin early in aging, but accelerate after age 70 (Era et al., 2011). Similarly, reaction times and processing speeds slow throughout the aging process, resulting in progressively more delayed responses and cognitions at later age (Fozard et al., 1994; Salthouse, 1996). Nonetheless, tailored working conditions and demands may facilitate safe employment into later age if age-related sensory and cognitive declines are considered and accommodated in job and vehicle design (Popkin et al., 2008).

3.2.4.3. Cognitive and sensory changes at later age and driving cessation. Cognitive performances (specifically processing speed) and vision problems have longitudinally predicted voluntary driving cessation among older adults (Freeman et al., 2005; Edwards et al., 2008); however, an appropriate cognitive or sensory age threshold for prescribed abilities testing and driving cessation remains uncertain. Although global cognition can predict risk for unsafe driving, many older adults with severe cognitive impairment (i.e., dementia) can pass on-road driving tests (Iverson et al., 2010). Contrarily, many older drivers cite vision problems as a primary reason for self-initiated driving cessation (Dellinger et al., 2001; Ragland et al., 2004). Such age-related concerns likely account for the gradual decrease in driving miles with age among older adults. The aging population has resulted in an increased numbers of older drivers, but older drivers have historically driven less than younger drivers (Eberhard, 2008). According to the U.S. Department of Transportation National Household Travel Survey, consistent decreases in miles traveled per employed person begin at ages 65–69 years and continue to drop for all sequential five-year age groups (Table 6) (U.S. Department of Transportation and Federal Highway Administration, 2011). These data imply increasingly reduced driving among Americans as they age, resulting from many potential factors.

Many states have implemented specific provisions on license renewal for older drivers; however, limited research has verified the safety benefits of age-based licensing restrictions (Morrisey and Grabowski, 2005). Premature driving cessation unnecessarily restricts older adults who do not have driving problems, while tailoring driving conditions based on individual-specific driving errors improves the safety and maintains the independence of older drivers (Freund and Petrakos, 2008). The exact threshold for appropriate driving cessation likely depends on many factors, including driving conditions, the vehicle operated, and most importantly the individual (e.g., age, cognition, driving experience, etc.). It is possible that many of these exogenous variables can be manipulated in a workplace to encourage safe driving or machinery operation at later age.

4. Discussion

Elevated risk of transportation-related fatalities among older workers is a socially important problem. Identifying specific factors that contribute to this elevated risk is essential for prescribing effective interventions. In the current project we first characterized the at-risk population and levels of excess risk through descriptive data analyses. Next, we investigated four hypotheses that may explain excess risk, including: (1) hazard exposure, (2) organization of work, (3) physical fragility, and (4) normative age-related changes in cognitive, sensory, and psychomotor function. In the following sections we review the weight of evidence for each hypothesis,

identify gaps in knowledge for future research, and suggest potential intervention strategies in each area.

4.1. Discussion of the population at-risk

Consistent with the conclusions of prior researchers (Janicak, 2003), our descriptive analyses suggest that occupational fatality prevention interventions are needed for older male workers in transportation-related occupations. We observed increased risk for occupational mortality among men across all events and in transportation related events. The finding of excess risk among men has been shown previously (Bureau of Labor Statistics, 2008a). Tiesman et al. calculated a rate ratio of occupational traumatic brain injury of 15.0 for men vs. women. For transportation events, our rate ratio of 16.3 for men vs. women is consistent with that prior finding. National data from 2010 show that relative to their hours worked, men have a disproportionate share of fatal work injuries (92%) (Bureau of Labor Statistics, 2012a). The finding of an increased risk of occupational mortality by age group is also supported by previous studies (Tiesman et al., 2011; Kisner and Pratt, 1999; Bureau of Labor Statistics, 2012b). For transportation events, the fatality rate among workers older than 65 years was more than 3 times greater than the overall rate (Table 3). We did not find an elevated risk of occupational fatality overall or for transportation events for workers of Hispanic origin, even though evidence suggests that Hispanics are at increased risk of occupational fatalities (Richardson, 2005; Center for Construction Research and Training, 2008; Mcgreevy et al., 2010). It may be that excess fatality risk among Hispanics is limited to certain industries or occupations, however, data coding practices may have affected our ability to correctly detect an effect. The numerator data in our current analyses did not distinguish between race and ethnicity. Someone could be coded as white or Hispanic, but not both. However, the denominator data (CPS) had separate race and ethnicity variables. This coding artifact could have underrepresented occupational fatality cases for this group. Moreover, although the CPS is thought to be an unbiased and valuable source of data (Richardson et al., 2004), it is possible that CPS estimates for a subgroup in a smaller state, such as workers of Hispanic origin in Oregon, may not be sufficiently sensitive (Hammond et al., 2012) Further work on harmonizing coding systems for race and ethnicity, as well as exploring other data sources with demographic and economic measures, is warranted.

Overall fatality rates in Oregon declined over the time period of interest, which is consistent with national trends. The national fatality rate decreased from 4.2 per 100,000 FTE in 2006 to 3.6 per 100,000 FTE in 2010 (Bureau of Labor Statistics, 2008a). We do note that despite the downward trend in Oregon, there was a noted increase in the number of transportation related events in 2006 (Fig. 1). However, this one-year increase is probably explained by an increase in events in which multiple workers were killed, elevating the rate. Although we did not specifically examine yearly rates by age group, there were 7 incidents in 2006 where between two and four individuals were killed ($n = 19$, data not shown). Of these 19 deaths, five were in individuals 55 years or older (26.3%) and two were in individuals 65 years or older (10.5%). Our data show that overall, transportation events constitute the largest proportion of event type for all age groups (Table 2). Interventions to reduce transportation fatalities in older workers are important, given the current societal and economic trend of increased numbers of older workers in today's workforce (Schulte et al., 2012).

4.2. Hazard exposure

Our hypothesis that higher risk of transportation related fatalities among older workers is partially explained by increased employment in hazardous jobs received some support in the current analysis. Using national data, the rate ratio for male transportation and material moving (TMM) occupations in workers aged 65 years and older compared to the overall rate for all age groups was 2.0 (Table 4). This value is significantly elevated, but still smaller than the rate ratio of 3.2 for all workers 65 and older regardless of occupation (Table 1). The rate ratio comparing older workers to the average rate for male TMM workers in all age intervals was 3.8 (95% CI 2.3–6.3) (Table 5)). As with the national data, the Oregon effect size for risk remains elevated after using sex and occupation-specific employment data. However, the Oregon effect for males in transportation events was actually larger than the rate ratio of 3.0 for workers 65 years and older in all sectors (Table 1). These findings indicate that the risk of fatal occupational injury remains elevated after using sex and occupation-specific employment levels, indicating that levels of employment in hazardous occupations do not fully explain the excess risk of fatality in older workers.

Our findings on hazard exposure are consistent with the existing literature. Although some researchers have shown that older workers are at higher risk due to their overrepresentation in certain high-risk industries and occupations, such as agriculture (Kisner and Pratt, 1997; Myers et al., 1999), other multivariate analysis has shown that 80% of the variance in occupational fatalities was related to age, even using occupation and industry as covariates in the model (Mitchell, 1988). However, the latter study was based only on data from nine states, which did not include Oregon. Regardless of the reason for elevated risk, potential interventions to reduce hazard exposure for older workers in high-risk occupations should be explored and include continued improvement of engineering controls in general to make vehicles and mobile machinery safer.

4.3. Organization of work

Our hypothesis that increased risk of fatal injuries among older workers is partially due to variations in organization of work factors was suggested by the current analysis of employer size and supported by our review of the literature. More than half of the fatalities in workers 65 years and older in Oregon were employed by small organizations with fewer than 10 employees. This finding is consistent with previous work that demonstrated that workplace fatality rates are highest in smaller establishments (Mendeloff et al., 2006). However, small numbers of overall fatalities in older workers limits our ability to make broad generalizations about this hypothesis and its effect on risk of fatal injuries. Smaller workplaces are less regulated and less likely to have sufficient resources to do effective training and design. Therefore, finding ways to disseminate relevant information to smaller businesses will continue to be an important avenue to address (Committee on the Health and Safety Needs of Older Workers, 2004). In 2009, Oregon OSHA revised its rules on safety committees. The new rules require *all* employers to regularly convene either a safety committee or a safety meeting (Oregon OSHA, 2009). It is possible that this new regulation will have a positive effect on small businesses involved in transportation.

Other interventions to reduce hazards posed by the organization of work at small employers include improvements or increased availability of investments in safety programs, such as premium discounts by insurance providers dependent on the quality of safety and maintenance programs or collective enterprises where small employers pool resources to improve safety and health programs (such as the Owner-Operator Independent Drivers Association). Older workers represent a highly valuable human resource in organizations given their significant knowledge and experience. Therefore, interventions must include engineering accommodations that make vehicles and machines safer for

older workers. It is also worth considering promotion of qualified older workers into supervisory roles and away from line work to take advantage of experience while protecting against hazard exposure.

An analysis by the Rand Corporation demonstrated a higher fatality rate among small establishments compared to larger ones. For example, in the transportation and public utilities sector, establishments with 1–19 workers had a fatality rate that was over 6 times higher than establishments with greater than 1000 employees and 2 times higher than those in establishments with 20–49 employees. Further, fatalities linked to OSHA violations at small employers occur at a higher rate than at larger businesses. They also found evidence that the positive effect of OSHA inspections is greater at smaller establishments (Mendeloff et al., 2006). Thus, increased compliance inspections by OSHA might improve employee safety. However, the scope of OSHA might not cover risks addressed in this analysis, such as heavy truck operations covered by the Federal Motor Carrier Safety Administration. Oregon OSHA administers a program that might help small employers in transportation improve safety without requiring significant resources. The Safety and Health Achievement Recognition Program (SHARP) provides incentives for Oregon employers to implement or improve safety and health programs, and work with their employees to find and correct hazards. The program is offered at no cost to employers, and involves a comprehensive workplace inspection. Issues uncovered by the inspection are exempt from compliance enforcement, so the risk to employers is minimal (Oregon OSHA).

4.4. Physical fragility

Our hypothesis that physical fragility is a significant contributing to increased risk for fatal transportation-related injury was strongly supported by evidence from Oregon disabling workers' compensation claims statistics. If we generalize from non-fatal injury statistics, the evidence suggests that traumas that severely injure younger workers may kill older workers. Older workers were statistically more likely to require hospitalization due to their injuries than younger workers. In addition, older workers had a significantly higher median days of temporary disability paid to them. This evidence supports the idea that physical fragility and disease conditions due to age influence the risk of fatalities to older workers. In our view, research in this area suggests that among older workers there is a premium importance of purchasing protective features in vehicles, such as rollover cages, and promoting the use of personal protective equipment such as safety belts. Emergency procedures and injury response plans for severe events may also be critical for workers in this age group.

Our findings regarding physical fragility were also supported by the relevant research literature. Compared to younger workers, older workers experience lower overall occurrences of work-related injury and illness. However, they tend to experience higher fatality rates and more severe injuries (Mitchell, 1988; Committee on the Health and Safety Needs of Older Workers, 2004; Rogers and Wiatrowski, 2005; Bureau of Labor Statistics, 2011). Other research using workers' compensation data has shown that the incidence of lost-work time claims increases with increasing age, as well as the time off per work claim (Berecki-Gisolf et al., 2012). Older workers are more likely than their younger counterparts to have chronic illnesses or disorders that involve medical costs and health insurance claims, and to need some accommodation in their working conditions in order to maintain a safe working environment (Committee on the Health and Safety Needs of Older Workers, 2004). However, work can contribute both to physical and mental health. Gallo et al. (2000) analyzed data from the Health and Retirement Survey, and found that involuntary job loss was negatively and significantly associated with physical functioning and mental health. On the other hand, there is a selection effect ("healthy worker effect") when examining the morbidity and mortality of workers compared to the general population. It could be that workers in poorer health left the workforce before they became "older workers." Previous studies have shown that age-related declines in health do contribute to early removal from the workforce (Strijk et al., 2012). Mohren and colleagues showed that age is related to the need for recovery time, although this was not seen for the oldest employees. This finding can be explained by the healthy worker effect, where the oldest workers are the healthiest due to a drop-out of chronically ill employees (Mohren et al., 2010).

Physical fragility is also affected by workers' access to healthcare to identify and treat health conditions. Most working age Americans receive their health insurance coverage as part of an employer's compensation package. In 2005, 80.4% of adult full-time workers in private businesses were offered coverage at a primary job, compared to 84.1% in 2001. This percentage varied across industries, from a high of 91.6% in both mining and manufacturing to a low of 45.8% in agriculture, forestry, fishing, and hunting (Claxton et al., 2010). However, close to one-third of workers older than 55 years do not have health insurance provided by their employers (Committee on the Health and Safety Needs of Older Workers 2004). Since chronic conditions increase with age, this creates a situation where lack of health insurance may impact the ability of these workers to remain in the workforce. Some employers continue to offer health insurance to workers after they leave the workforce, although many of them require retired workers to pay for some of the cost of these plans. The need to attract and sustain an experienced, productive workforce may create incentives for employers to support expanded health interventions and insurance coverage. As noted by the National Research Council:

> "Private health insurance also plays a hidden role: It creates incentives for some workers to stay at their jobs due to the lack of insurance coverage if they were to exit, and it creates incentives for employers to terminate older workers who may add substantially to the cost of employer-based group health plans."

Interventions that specifically address the physical fragility factor among older workers could be addressed through health promotion activities. For example, Strijk and colleagues evaluated a worksite vitality intervention among older hospital workers (45 years and up) using a randomized controlled trial design. The intervention consisted of a weekly exercise program (weekly yoga session, weekly workout session, and weekly unsupervised aerobic exercising), free fruit, and three visits to a personal vitality coach. They found effects for those workers in the intervention group for sports activities and fruit intake, and a lower need for recovery compared to the control group (Strijk et al., 2012). The Oregon Healthy Workforce Center (ORhwc), and other National Centers of Excellence in Total Worker Health that are funded by the National Institute for Occupational Safety and Health, may be uniquely positioned to generate and evaluate these types of interventions. The ORhwc and other Centers in the Total Worker Health (TWH) program adopt the strategy of integrating occupational health protection (safety and injury prevention) with health promotion (disease prevention and wellness) to advance overall or "total" health of workers. An example of an integrated Total Worker Health intervention created in Oregon is the SHIFT program for commercial truck drivers, which addresses eating, exercise, sleep, and safety. The intervention, which includes a weight loss competition, computer-based training, and health coaching on cell phones, produced simultaneous improvements in health behaviors, body weight, and driving safety (Olson et al., 2009).

4.5. Cognitive, sensory, and psychomotor changes

Evidence that cognitive, sensory, and psychomotor decline are significant contributors to increased risk for fatal transportation events also has relatively strong support. Identifying age thresholds where declines accelerate on average in the population, such as past the age of 70 for certain psychomotor changes, should continue to be a research and intervention priority. Despite the predictive power of age for safety outcomes within the population, each older worker experiences age-normative declines in a unique way; age cannot predict cognitive levels across all individuals and cognitive declines do not solely determine driving outcome. Into later age, cognitive abilities remain malleable, even to the extent that older adults can outperform young adults if they continue to practice and train their cognitive abilities (Salthouse et al., 2006). In fact, significant life experience and job-related knowledge and skills may protect older worker safety in many settings (Farrow and Reynolds, 2012). Some skill decline may be due to infrequency of practice rather than age. In addition, operational performance decrements in the workplace among older workers may in some instances be attributable to the organization of work and practice opportunities rather than age. Older workers may operate machinery less often, especially when employed within a small business where occasional operation of machinery is common, so skills loss may be attributable to reduced exposure to practice of needed skills. For these several reasons described above, as well as the fact that workers in this area are earning a living by operating vehicles, suggests that driving cessation should be approached as an intervention strategy only with caution and in response to specific circumstances where empirical evidence is compelling and strong. Effective compensatory and training-based interventions have both ameliorated cognitive declines and enhanced older drivers' ability to continue driving safely into later age (Llaneras et al., 1998). In addition, reasonable accommodations (e.g., text and visual display size, volume of hazard alert controls in vehicles) may have significant positive impact on older workers' ability to maintain safe operation of vehicles.

5. Conclusion

Workers who are 65 years or older are at increased risk of fatal occupational injuries. In Oregon, nearly half of the workers over the age of 65 who were killed were injured in transportation-related events. Investigating potential causes of elevated risk of death among older workers in transportation events is a socially important problem due to the increasing number of older employees in the workforce. The current project proposed and evaluated four hypotheses that may each partially explain elevated fatality risk in this population. The hazard exposure hypothesis received only some support as an explanatory variable. At the national level, the fatality RR for older workers reduced when male employment in TMM industry was controlled for, which provides marginal support that the effect is smaller when employment in hazardous occupations is taken into account. In Oregon analyses, however, the fatality RR for older workers actually increased after controlling for male TMM employment levels. The organization of work hypothesis received strong support in our literature review, and was suggested by our data findings, although overall small numbers of fatalities in older workers limit our ability to make broad generalizations. However, over half of Oregon workers killed in transportation-related events were self-employed or employed by organizations with 10 or fewer employees. Previous research indicates that smaller businesses employ higher numbers of older workers and have lower levels of safety investments and resources. Our physical fragility hypothesis received strong support from analyses of Oregon disabling workers' compensation claims, with older workers being more likely to be hospitalized for work-related injuries, and also requiring more lost work days per injury relative to their younger counterparts. And finally, the hypothesis of age related cognitive, sensory, and psychomotor changes also received strong support from the existing research literature. While it is clear that normative declines in certain abilities are associated with reduced driving performance and increased crash risk, the multi-factorial nature of the problem, and the fact that many older workers rely on vehicle operation to make a living, encourages an equally multi-faceted and accommodating approach to selecting interventions rather than a simplistic focus on driving cessation. While older workers are at increased risk of occupational fatalities, older workers are actually injured less often than their younger counterparts, and represent a valuable human resource that may be leveraged to maximize the quality of safety programs and outcomes in any organization. In this regard, we believe that the proposed transportation fatality risk factors for older workers may be a valuable generative guide for developing accommodating and adaptive interventions that protect this growing workplace demographic from being killed on the job.

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