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Effects of Residential Location and Work-Commuting on Long-Term Work Disability

Z. Joyce Fan · Michael P. Foley · Eddy Rauser · David K. Bonauto · Barbara A. Silverstein

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Abstract *Purpose* Little is known about the independent effect of workers' residential location and work-commuting on their long-term disability due to work-related injuries. We examined 149,110 incident claims while adjusting for multiple risk factors in a large, population-based sample of Washington State workers' compensation State Fund claims during 2002–2008. *Methods* Claimants' residential addresses were geocoded with census tract and aggregated into four category classification of the Rural Urban Commuting Area Codes (RUCAs) which takes into account for tract-level work-commuting. We used logistic regressions to assess the association between RUCAs and whether or not a person was off work for more than 180 days due to injury; Quantile regressions to predict various percentiles of cumulative lost workdays by RUCAs. *Results* Compared to those who live in the Urban Core, workers in other areas experienced longer average paid time loss days due to work-related injury. The association between residential location and long-term disability was significant, odds ratio (OR) 1.19 (95 % confidence interval (CI) 1.11–1.27) for residents of Small Town and Isolated Rural and OR 1.17 (95 % CI 1.12–1.22) for those of Sub Urban, and persisted after controlling for injury nature, socio-demographic, employment-related, and claim administrative characteristics. The impact of residential location and work-commuting elevated as the duration of disability increased. *Conclusions* This study shows that residential location and work-commuting has a significant and time-varying impact on duration of work disability. Workers living in Sub Urban and Small Town and Isolated Rural areas represent a particularly vulnerable group with respect to risk of long-term work disability.

Keywords Residential location · Work-commuting · RUCAs · Disability · Work-related injuries · Workers' compensation

Introduction

According to the US Bureau of Labor Statistics, the total number of nonfatal occupational injury and illness cases requiring days away from work to recuperate was 1,181,290 in 2011 [1]. The economic burden of work-related injury and illness is substantial. The national costs of occupational injury and illness among civilians in the United States were approximately $250 billion [2]. Workers' compensation covers less than 25 % of these costs, so all members of society share the burden. It's estimated that about 10 % of the US civilian having work disability at any one time [3]. Lengthy time-loss claims have detrimental effects for injured workers, employers and the workers' compensation system. Prolonged time-loss claims drive up workers' compensation rates for employers and increase the cost of operating the workers' compensation system. Even though a small percentage of work injury claims result in chronic disability, they account for the majority of costs [4, 5]. For example, a study in Washington State workers' compensation reported that approximately 5 % of cases of three surgical outcomes [carpal tunnel, lumbar fusion, and thoracic outlet] that had

Z. J. Fan (✉) · M. P. Foley · E. Rauser · D. K. Bonauto · B. A. Silverstein
Washington State Department of Labor and Industries, Safety and Health Assessment and Research for Prevention, PO Box 44330, Olympia, WA 98504-4330, USA
e-mail: fanj235@lni.wa.gov

accumulating 120 days of time loss accounted for 85 % of total expenditures [4]. Consequently, the social and economic impact of time away from work attributable to occupational injuries and illnesses is extensive [2, 3, 6].

Previous studies have identified multiple factors that predict the risk for and duration of long-term work disability including age [5, 7, 8], gender [5, 7], size of business [5, 7, 9], industry [7, 10–12], and claim administrative characteristics [5, 7, 8]. Many of these predictors are likely associated with the location of the worker's residence in an urban or rural setting. Rural residents experience greater rates of morbidity and mortality in comparison with their urban counterparts [13–15]. Rural workers are highly vulnerable to work injury and prolonged work absences, and experience high prevalence of risk factors for poor work disability outcomes [16–23]. The geographical variations of occupational injury/illness have been related to the differences in the economy, demographics, policy/culture/value, industry [24, 25], as well as health care access and care experiences [14, 22, 25, 26]. However, little is known about the extent to which worker's residential location is associated with long-term work disability.

A growing body of research also suggests that the impact of a given risk factor on the duration of work disability may change depending on how long the worker has been disabled [10, 27–30]. In particular, it is important to examine whether the effect of residential location and work-commuting varies across claims with different levels of cumulative lost workdays.

To help fill these gaps in knowledge, the current report presents the study that assessed the effect of workers' residential location and work-commuting on long-term disability of all work-related injury natures while adjusting for multiple risk factors in a large, population-based sample. Four category classifications of the Rural Urban Commuting Area Codes (RUCAs) [31, 32] were used as an indicator of residential location and work-commuting patterns. Better understanding of the geographic variability of long-term disability due to work injury will help policy makers and health care managers make informed decisions on targeting prevention efforts to the more vulnerable working population.

The objective of this study is to examine the relationship between workers' residential location and long-term disability, measured by paid time loss days. The research questions are: (1) Is there a difference in long-term disability of injured workers among Washington State workers' compensation State Fund compensable incident claims by RUCAs?; (2) Will the differences in RUCAs persist after adjusting for injury nature, socio-demographic, employment-related, and claim administrative characteristics?; and (3) Does the duration of cumulative lost workdays vary by RUCAs?

Methods

Data Description and Variable Definition

Study Participants and Claims Related

The Washington State Department of Labor and Industries (L&I) State Fund is the exclusive provider of workers' compensation insurance to WA employers, except those who are able to self-insure, self-employed, or those covered by alternative workers' compensation systems including federal government employees, longshoreman, railroad workers, and harbor workers. The L&I State Fund system covers approximately two-thirds of all employees and 99.5 % of all employers in the State of Washington [33]. Compensable claims are those where wage replacement for time loss was paid, a disability award was made, a fatality occurred or where the employer kept the disabled worker on salary. Wage replacement benefits due to loss to work time from an occupational injury occur after a 3-day waiting period following the injury day.

Most predictors examined in this study have previously been found to be associated with work-related disability [5, 7, 9–12, 34]. Claimant's individual data extracted from Washington State L&I claims databases includes socio-demographic characteristics (age at the date of injury, gender, marital status, number of dependents, annual wage, language preference for receiving communications from L&I), employment-related (length of employment, size of employer, industry and occupation), and self-reported height and weight for calculating body mass index (BMI).

The injury nature was categorized by combining injury types, body parts involved, and nature of the injury [35, 36]. Injuries that could not be grouped in the categories were included as others.

Claim administrative characteristics include claim filing and processing. Data regarding benefits were restricted to 3 years from date of injury to allow each claim to have a common period of maturity.

The study outcome was 180 days or more of cumulative compensated lost work days paid and was calculated on the basis of the total number of full days a person was off work due to an injury during the last 3 years [36].

Geocoding and Geographic Difference

We obtained census tract code for each claimant based on their residential street addresses in the State of Washington using Maptitude (v5.0). We replaced the missing residential addresses (4.4 %) with the correspondent mailing address and excluded 62,047 (5.5 %) invalid addresses that were not geocodable for the census tract codes. These geocoded data were aggregated into four area types by

linking the individual claimant's information with RUCAs four category classification: Urban Core, Sub Urban, Large Rural Town, and Small Town and Isolated Rural (Appendix Table 4; Appendix Fig. 3).

Study Population

This study consisted of 149,110 WA residents who were injured at work during 2002–2008 and had been receiving paid time loss as State Fund compensable claims for up to 3 years after the date of injury. Originally, 1,172,854 claims were extracted in April 2012 from L&I with date of injury in the period of January 1, 2002 and December 31, 2008. We excluded data from self-insured because work disability data were only available for State Fund claims. In order to include all incident claims, we kept the first claim if multiple claims (up to four) occurred for an individual during the 7-year period. After excluding claims resulting in a fatality, total permanent disability, loss of earning power, and those where an employer kept the injured worker on salary, the study profile represents 89 % of State Fund compensable claims during the same period. Figure 1 shows the number of claimants excluded from the study for various reasons.

Data Analyses

Descriptive statistics were used to summarize the claimants' distribution of socio-demographic and employment-related characteristics, injury nature, and claim administrative characteristics by RUCAs.

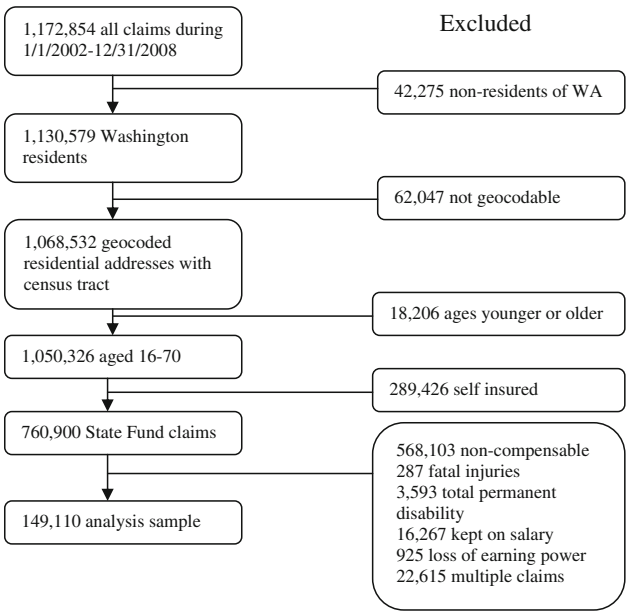

Fig. 1 Study profile, Washington state workers' compensation data 2002–2008

Logistic regressions were used to assess the bivariable association between worker's residential location and work-commuting (RUCAs) and whether or not a person was off work for more than 180 days due to injury. Next, separate multivariable models were constructed for each domain of variables (socio-demographic and employment-related characteristics, injury nature, and claim administrative characteristics) in order to identify the important variables within each domain that independently contribute to long-term disability due to injury. The final multivariable logistic regression models were constructed while simultaneously adjusting for the important variables as the results of the previous steps.

To investigate whether the effects of residential location and work-commuting on duration of work disability, we used quantile regression models to predict various percentile of cumulative lost workdays by RUCAs [37]. Quantile regression permits estimates of the magnitude of the effects as expressed in terms of the number of additional time lost days associated with a residential area compared with a reference group. Specifically, it estimates the difference in compensated lost workdays in Sub Urban, Large Town, and Small Town relative to that of the Urban Core. We specified quantile regressions from the 50th to 95th percentile, with a 5 % increment. The same predictors of disability were used in logistic and quantile regression.

Because of the large number of claims in this study, we evaluated the robustness of the findings as suggested by Cheadle [5]. An independent co-variable is considered robust and significant if, in each of the 7 years, it had a p value less than 0.01 and was within 25 % above or below the average coefficient for all years. All analyses were performed with SAS v9.2 (SAS Institute Inc., Cary, NC, USA).

Results

Descriptive and Bivariable Analyses

Long-term disability due to work injury varies by worker's residential location and work-commuting patterns (Table 1; Fig. 2). Of all Washington State Fund compensable incident claims due to non-fatal injury during 2002–2008, 20.3 % of claims resulted in being off work for greater than 180 days, ranges 19.6–21.8 % for Urban Core and Sub Urban residents, respectively. The average paid loss work days were 136 for those who live in Urban core, 23 days less than that of Sub urban (159 days, $p < 0.001$), 11 days less than that of Large Rural Town (147 days, $p < 0.001$), and 16 days less than that of Small Town and Isolated Rural (152 days, $p < 0.001$).

Bivariable logistic regression revealed that residential location and work-commuting is related to the likelihood of

Table 1 Geographic distribution of socio-demographics characteristics, injury nature, claim administrative characteristics, WA state fund compensable claims 2002–2008

	n	Sample (%)					Disability (%)				
		Overall	Urban Core	Sub Urban	Large Rural Town	Small Town Isolated Rural	Overall	Urban Core	Sub Urban	Large Rural Town	Small Town Isolated Rural
All	149,110		69.6	14.8	8.5	7.2	20.3	19.6	22.7	20.5	21.8
Age (years)											
16–34	55,754	37.4	38.8	33.6	35.9	32.8	28.8	29.9	25.2	30.2	25.3
34–54	74,962	50.3	49.3	53.4	50.8	52.5	59.2	58.4	62.0	59.1	59.7
55–70	18,394	12.3	11.8	13.1	13.3	14.7	12.0	11.7	12.8	10.7	15.0
Gender											
Female	47,396	31.8	32.3	30.4	31.3	30.4	35.8	35.7	34.9	36.6	38.0
Male	101,706	68.2	67.7	69.6	68.7	69.6	64.2	64.3	65.1	63.4	62.0
Body mass index											
<25	40,010	29.5	30.4	28.3	26.4	27.4	27.6	28.4	26.8	24.7	26.0
25–29.9	51,446	37.9	37.9	38.3	37.0	38.7	37.9	37.8	38.7	36.3	38.2
≥30	44,129	32.5	31.7	33.4	36.6	33.8	34.5	33.8	34.5	39.0	35.8
Annual income											
<25,000	61,606	41.3	41.5	35.0	45.1	48.2	37.6	36.8	32.3	45.0	48.0
25,000–50,000	68,021	45.6	45.7	48.3	43.4	42.1	46.2	47.1	47.9	41.5	40.7
≥50.1	19,483	13.1	12.8	16.7	11.5	9.7	16.1	16.1	19.8	13.5	11.3
Marriage status											
Not married	77,962	52.3	54.7	47.6	47.0	44.9	50.2	52.3	46.2	47.6	43.1
Married	71,148	47.7	45.3	52.4	53.0	55.1	49.8	47.7	53.8	52.4	56.9
Having children											
No	95,758	64.2	65.3	63.1	60.2	60.8	60.2	60.5	61.8	55.6	59.0
Yes	53,352	35.8	34.7	36.9	39.8	39.2	39.8	39.5	38.2	44.4	41.0
Language preference											
English	135,651	91.0	90.4	95.5	90.5	87.9	88.3	87.0	95.1	87.9	85.0
Spanish and other	13,459	9.0	9.6	4.5	9.5	12.1	11.7	13.0	4.9	12.1	15.0
Job tenure (year)											
<1	48,300	38.0	39.0	35.0	36.9	36.0	41.5	42.2	38.8	41.7	41.2
1–5	46,483	36.6	37.2	36.1	33.4	35.2	36.8	37.1	37.5	34.1	36.1
≥5	32,373	25.5	23.8	28.9	29.7	28.8	21.6	20.6	23.8	24.2	22.7
Company size, FTEs											
1–9	33,885	22.8	21.0	25.4	25.2	31.1	27.3	25.7	30.3	28.2	34.3
10–49	34,855	23.4	23.2	24.2	23.1	24.4	24.1	23.7	25.1	24.3	24.6
≥50	80,144	53.8	55.8	50.4	51.7	44.6	48.6	50.5	44.6	47.5	41.2
Industry											
Agriculture, forestry, fishing, and hunting	7,445	5.0	2.5	5.6	12.2	19.4	5.4	2.9	4.9	13.3	20.6
Mining and utility	935	0.6	0.3	0.8	1.7	1.9	0.4	0.2	0.6	0.9	1.0
Construction	28,267	19.0	19.1	22.5	14.7	14.9	23.6	24.3	26.8	17.8	17.7
Manufacturing	15,341	10.3	9.9	12.1	11.5	9.4	9.3	8.9	10.7	10.5	9.0
Wholesale and retail	24,328	16.3	17.1	15.5	13.3	14.4	15.4	16.1	14.8	12.6	13.5
Transportation and warehousing	7,979	5.4	5.6	4.7	5.2	4.0	5.5	5.6	5.5	6.0	4.3
Professional, scientific, technical service and management of companies and enterprises	2,837	1.9	2.1	1.8	1.3	1.2	1.9	2.1	1.8	1.3	1.2

Table 1 continued

	n	Sample (%)					Disability (%)				
		Overall	Urban Core	Sub Urban	Large Rural Town	Small Town Isolated Rural	Overall	Urban Core	Sub Urban	Large Rural Town	Small Town Isolated Rural
Administration and support, waste management and recreation services, education, health care, social assistant services	29,331	19.7	21.0	17.8	16.8	13.6	19.5	20.5	18.1	18.8	14.5
Arts, entertainment, recreation, accommodation, food services, and other services except for public administration	19,790	13.3	14.4	10.6	10.9	10.7	12.3	13.1	10.6	10.5	11.6
Public administration, real estate and finance	12,815	8.6	3.6	5.7	9.8	8.3	6.6	6.4	6.3	8.3	6.5
Occupation											
Management, business and financial operations	3,989	2.9	3.0	2.9	2.5	2.6	2.8	2.9	2.8	2.5	2.7
Professionals	7,780	5.7	6.1	5.5	4.4	3.7	5.0	5.4	4.8	3.3	3.5
Healthcare practitioners and technical support	9,395	6.9	6.5	7.1	9.4	7.4	6.3	5.9	6.3	9.3	6.2
Food preparation and serving related	8,024	5.9	6.4	4.9	4.7	4.5	5.9	6.4	5.4	4.4	4.6
Other service and sales	19,910	14.6	15.7	12.2	12.3	12.5	14.2	14.8	12.4	13.1	14.3
Office and administrative support	6,771	5.0	5.4	4.3	4.3	3.3	4.8	5.2	4.2	4.2	3.2
Farming, fishing, and forestry	5,707	4.2	2.0	4.7	10.5	16.6	4.7	2.3	4.3	12.0	17.7
Construction and extraction	25,256	18.6	18.6	21.6	15.2	15.8	22.6	23.4	24.9	17.6	17.0
Installation, maintenance, repair, and production	26,551	19.5	19.2	21.5	19.7	18.1	17.5	17.4	19.3	16.7	15.2
Transportation and material moving	22,717	16.7	17.1	15.3	16.9	15.5	16.2	16.3	15.6	16.8	15.7
Injury nature											
Back and neck	12,521	8.4	8.5	8.0	8.3	8.7	10.4	10.1	10.5	11.0	12.0
Back and neck MSDs	33,674	22.6	23.0	22.8	20.8	19.8	28.1	28.3	28.5	27.8	25.2
Contusion, cut and scratch	17,824	12.0	12.3	10.8	11.4	11.6	6.2	6.4	5.6	5.4	6.8
Fracture	14,918	10.0	10.0	9.6	10.6	10.1	9.7	9.9	8.3	10.6	9.7
Other	26,390	17.7	16.9	18.3	20.0	21.4	13.3	12.7	14.0	14.1	15.0
Spring and dislocation	22,428	15.0	15.0	15.2	14.9	15.1	14.1	14.2	14.0	14.1	14.1
Upper extremity MSDs	21,353	14.3	14.3	15.4	14.0	13.2	18.2	18.3	19.1	16.9	17.1
Injury to first medical visit, days											
0–3	97,536	68.7	69.1	67.0	69.0	68.2	63.3	64.0	60.4	63.8	63.3
4–10	22,543	15.9	16.0	15.8	15.5	15.5	15.5	15.3	16.1	15.9	15.5
≥11	21,797	15.4	14.9	17.2	15.5	16.3	21.2	20.7	23.5	20.3	21.2
Medical visit to claim receipt, days											
0–6	67,704	47.5	48.6	46.1	42.6	44.8	46.1	47.1	44.6	42.5	44.9
7–14	51,486	36.1	35.3	37.5	39.8	36.8	34.7	34.2	35.7	38.0	33.4
≥15	23,389	16.4	16.1	16.4	17.6	18.4	19.2	18.7	19.7	19.5	21.7
Claim receipt to time loss fund, days											
0–13	56,509	40.1	39.5	40.1	42.3	43.9	34.4	34.0	33.7	36.1	37.0
14–39	38,394	27.3	28.2	25.9	25.2	23.4	27.1	28.0	25.8	25.2	24.0
≥40	45,960	32.6	32.4	33.9	32.5	32.7	38.6	38.0	40.5	38.7	39.0

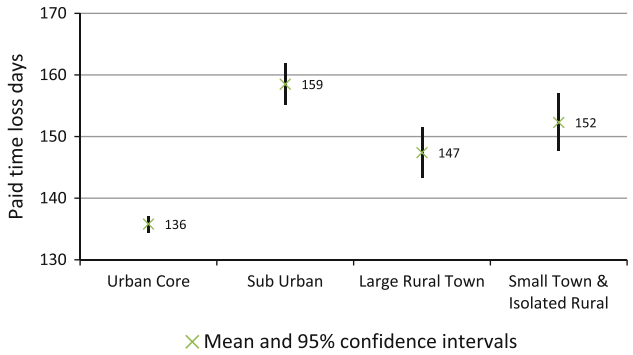

Fig. 2 Paid time loss days by residential location, WA L&I State Fund compensable claims 2002–2008. During 3 years period after an injury

being off work for more than 180 days, i.e., those who didn't live in Urban Core were more likely to have long-term disability after an injury. The crude effect of geographic difference shows that compared with Urban Core residents, the ORs of injury resulted in more than 180 days paid loss time were significant for Sub Urban (OR 1.20, 95 % CI 1.16–1.24, Table 2), Large Rural Town (OR 1.06, 95 % CI 1.01–1.11), and Small Town and Isolated Rural (OR 1.14, 95 % CI 1.09–1.20).

The geographic distribution of the study population and those with work disability are presented in Table 1. Most of the listed variables of claimants' socio-demographics, employment-related characteristics, injury nature, and claim administrative characteristics differ between urban and rural residency.

Multivariable Logistic Regression

The role of residential location and work-commuting to long-term disability is confirmed when all other variables are held constant (Table 2). The adjusted effect of RUCAs shows that compared with Urban Core residents, those living in other areas had significantly increased odds of having long-term disability, OR 1.19 (95 % CI 1.11–1.27) for Small Town and Isolated Rural, OR 1.17 (95 % CI 1.12–1.22) for Sub Urban, and OR 1.11 (95 % CI 1.05–1.18) for Large Rural Town.

Besides the difference in residential location and work-commuting, multivariable logistic regression results identified a list of variables from different domains that are responsible for most the variance explained (Table 2). The socio-demographic variables of older age (compared with 16–34), female gender, having children in household, preferred language of non-English, employment related variables of job tenure less than 1 year (compared with 5 or more years) and construction industry (compared with Administration and Finance/Real Estate) were significantly more like to have more than 6 months of disability (ORs > 1.5). Injuries involving neck or back, and upper extremity MSDs were significantly more likely to have more than 6 months of disability (ORs > 1.5). While the effects of time delays in the workers medical treatment and claims adjudication- delay in getting to a doctor, delay in receipt of the claim, and delay in the decision about whether the claim was allowable were significant, the postponement in getting to a doctor explains the most variance.

Multivariable Quantile Regression

The multivariable quantile regression results indicated that compared with the residents of Urban Core, the number of additional compensated lost workdays increased in other areas as the percent of cumulative lost workdays increased. The outcome measure for the 80th percentile of cumulative lost workdays is close to 180 days or 6 months (Table 3). Compared with Urban Core residents whose 80th percentile of compensated lost workdays was 176, workers in Sub Urban and Small Town and Isolated Rural had more than 30 days, and Large Rural Town had more than 20 days of additional lost workdays while adjusting for other important factors. The differences between Urban Core and other areas increased to more than 60 days at the 90th percentile (449 days or 15 months) and 70 days or more at the 95th percentile (802 days or 27 months).

Discussion

Using a large sample of all incident disability claims from the WA workers' compensation system, this study shows that residential location and work-commuting have a significant and time-varying impact on duration of work disability. Compared with those who live in Urban Core, workers in other areas experienced longer average paid time loss days due to injury. While other factors including injury nature, socio-demographic, employment-related, and claim administrative characteristics independently affect the long-term disability, the variation observed on these factors didn't eliminate the association between the geographic difference and long-term disability. Further, the impact of residential location increased as the duration of disability increased. The role of residential location and work-commuting to long-term disability due to work related injury is confirmed from these data.

The results of this study indicated that the rural-urban patterns of long-term disability are not always monotonic. Those who live in Sub Urban areas have higher odds of adverse outcome due to work injury than that of Large Rural Town. Large Rural Towns often have more in

Table 2 Logistic regression results

	Crude OR (95 % CI)	Adjusted OR (95 % CI)[a]
Rural urban commuting area (ref = urban core)		
Large Rural Town	1.06 (1.01–1.11)	1.11 (1.05–1.18)
Small Town/Isolated Rural	1.14 (1.09–1.20)	1.19 (1.11–1.27)
Sub Urban	1.20 (1.16–1.24)	1.17 (1.12–1.22)
Age (year) (ref = 16–34)		
35–54	1.69 (1.64–1.74)	1.71 (1.65–1.78)
55–70	1.33 (1.27–1.39)	1.72 (1.62–1.82)
Gender (ref = male)		
Female	1.25 (1.22–1.29)	1.52 (1.45–1.58)
Annual income (ref < 25,000)		
25,000–50,000	1.14 (1.11–1.17)	0.98 (0.94–1.01)
≥50,001	1.47 (1.42–1.53)	1.12 (1.08–1.16)
Having children (ref = no)		
Yes	1.24 (1.21–1.27)	1.77 (1.67–1.88)
Language preference (ref = English)		
Spanish and other	1.46 (1.41–1.52)	1.74 (1.63–1.85)
Job tenure (year) (ref ≥ 5)		
<1	1.37 (1.32–1.42)	1.77 (1.69–1.86)
1–5	1.24 (1.19–1.28)	1.38 (1.32–1.44)
Company size, FTEs (ref ≥ 50)		
1–9	1.44 (1.39–1.48)	1.42 (1.36–1.48)
10–49	1.18 (1.14–1.21)	1.18 (1.13–1.23)
Industry (ref = Public administration, real estate and finance)		
Administration and support, waste management and recreation services, education, health care, social assistant services	1.37 (1.30–1.45)	1.32 (1.23–1.43)
Agriculture, forestry, fishing, and hunting	1.55 (1.44–1.67)	1.43 (1.25–1.63)
Arts, entertainment, recreation, accommodation, food services, and other services except for public administration	1.27 (1.19–1.35)	1.34 (1.23–1.46)
Construction	1.85 (1.75–1.95)	1.64 (1.50–1.79)
Manufacturing	1.23 (1.16–1.31)	1.40 (1.28–1.52)
Mining and utility	0.80 (0.66–0.98)	0.73 (0.57–0.92)
Professional, scientific, technical service and management of companies and enterprises	1.37 (1.24–1.52)	1.33 (1.16–1.51)
Transportation and warehousing	1.45 (1.35–1.56)	1.40 (1.27–1.55)
Wholesale and retail	1.29 (1.22–1.36)	1.36 (1.26–1.47)
Occupation (ref = professionals)		
Construction and extraction	1.53 (1.44–1.63)	1.43 (1.29–1.59)
Farming, fishing, and forestry	1.35 (1.24–1.47)	1.46 (1.25–1.69)
Food preparation and serving related	1.20 (1.10–1.29)	1.27 (1.14–1.41)
Healthcare practitioners and technical support	1.06 (0.98–1.14)	1.07 (0.96–1.18)
Installation, maintenance, repair, and production	1.03 (0.97–1.11)	1.25 (1.14–1.37)
Management, business and financial operations	1.14 (1.03–1.25)	1.17 (1.04–1.33)
Office and administrative support	1.12 (1.03–1.22)	1.13 (1.01–1.25)
Other service and sales	1.14 (1.07–1.22)	1.23 (1.12–1.35)
Transportation and material moving	1.14 (1.06–1.22)	1.35 (1.23–1.49)
Injury nature (ref = other)		
Back and neck	1.87 (1.77–1.97)	1.89 (1.77–2.02)
Back and neck MSDs	1.88 (1.81–1.96)	1.98 (1.87–2.08)
Contusion, cut and scratch	0.65 (0.62–0.69)	0.69 (0.64–0.74)
Fracture	1.37 (1.30–1.44)	1.39 (1.29–1.49)
Spring and dislocation	1.32 (1.25–1.38)	1.31 (1.23–1.39)
Upper extremity MSDs	1.95 (1.86–2.04)	1.76 (1.66–1.87)
Injury to first medical visit, days (ref = 0–3)		
4–10	1.07 (1.04–1.11)	0.98 (0.94–1.03)
≥11	1.69 (1.63–1.75)	1.51 (1.45–1.58)
Medical visit to claim receipt, days (ref = 0–6)		
7–14	0.99 (0.96–1.01)	1.02 (0.99–1.06)
≥15	1.26 (1.22–1.31)	1.20 (1.15–1.26)
Claim receipt to time loss fund, days (ref = 0–13)		
14–39	1.20 (1.17–1.24)	1.27 (1.22–1.32)
≥40	1.51 (1.46–1.56)	1.44 (1.38–1.50)

[a] Adjusted for all variables simultaneously

common with metropolitan areas than they do with Small Town and Isolated Rural and Sub Urban. Rural location plays a major role in determining the nature and level of access to and provision of health services [14, 22, 25, 26]. It was reported that those with long-term illness and bad health status are much more likely to experience difficulty in their access to health facilities [38]. The concept of access is more complex than simple distance measures. They encompass a wider set of factors relating to behaviors and perception which related to a range of highly qualitative factors such as perceived service quality, opening hours and previous experience [39].

Moreover, geographic difference varies by type of industries and/or occupation in an area. In these data, more Construction workers are from Sub Urban and more Agricultural, Forestry, Fishing and Hunting industry workers are from Small Town and Isolated Rural areas. Work characteristics of Construction and Agricultural

Table 3 Quantile regression results[a]

Quantile	No. time loss days for Urban Core in 3-years	Additional no. of days in compensated lost workdays[b]					
		Sub Urban		Large Rural Town		Small Town and Isolated Rural	
		No. of days	(95 % CI)	No. of days	(95 % CI)	No. of days	(95 % CI)
50th	29	3.2	(2.0–4.4)	2.6	(1.1–4.1)	4.2	(2.5–6.0)
55th	38	4.2	(2.7–5.7)	3.2	(1.2–5.2)	5.9	(3.7–8.1)
60th	49	5.5	(3.6–7.5)	4.7	(2.2–7.2)	7.2	(4.4–10.0)
65th	65	7.6	(5.0–10.3)	6.7	(3.2–10.1)	11.4	(7.6–15.2)
70th	88	11.3	(7.8–14.8)	10.0	(5.4–14.5)	18.6	(13.6–23.7)
75th	121	19.7	(15.1–24.4)	13.3	(7.3–19.3)	25.7	(19.0–32.4)
80th	176	30.7	(23.9–37.5)	21.0	(12.2–29.8)	33.9	(24.2–43.7)
85th	267	48.0	(37.6–58.4)	34.7	(21.2–48.2)	44.1	(29.1–59.1)
90th	449	67.5	(51.1–83.8)	63.7	(42.5–84.9)	74.4	(50.8–97.9)
95th	802	70.2	(47.5–92.8)	76.3	(47.0–105.6)	75.5	(42.9–108.1)

[a] Adjusted for socio-demographic, employment-related, injury nature, and claim administrative characteristics

[b] Multivariable quantile regression for each percentile specified. Didn't show the results for other covariates

industries, such as heavy manual work, repetitive monotonous movements, and the high accident risk, are presumably related to a greater likelihood of long-term work disability [40, 41] and a higher risk for neck, back, and upper extremity musculoskeletal disorders [11, 12, 41, 42]. Nonetheless, the effect of geographic difference persisted after adjusting for industry and nature of injury.

While facing return to work can be difficult for all injured workers, these data suggest that workers who live in Sub Urban and Small Town and Isolated Rural have a heavier disability burden, especially when an extended duration of disability. This may in part be due to the disparities of providers and quality of care between rural and urban areas [22]. Numerous occupational health studies identify a connection between the duration of a worker's compensation claim and long-term loss of earning power [3, 4, 6, 43]. The longer injured workers remain off work, the harder it is for them to return to their original job and income. After 2 months off work, a worker who earns $2,513 a month would lose $994 while on time-loss [partial wage-replacement] benefits in Washington State [33]. Among various factors that affect return to work, an employer's offer of an accommodation to facilitate return to work has been identified consistently as protective against chronic work disability [8, 30, 44, 45]. For workers in Sub Urban and Small Town and Isolated Rural areas, limited appropriate alternative duties and resources to support injured workers could be potential barriers in their efforts to return to work. Further investigations into this geographic difference are warranted to help injured workers return to work safely and promptly.

The study findings also highlight the importance of other factors in work disability. Besides residential location, a number of important factors that have been found in previous studies were also confirmed to influence the duration of disability in this study. Among the most important and consistent were older age [5, 7, 8], female gender [5, 7], smaller firms [5, 7, 9], construction industry [7, 10–12], and delays in getting treatment and filing a claim [5, 7, 8]. While the persistent effect of residential location on duration of work disability is evident in this study, the effect is relatively small. When controlling for major risk determinants, the geographic difference may exacerbate the effects of socio-economic disadvantage, poorer service availability, more hazardous environmental, occupational and transportation conditions [14, 15].

Of many options of rural-urban definition [46], we chose RUCA because it takes into account both the size of settlement [census-tract data] and the functional relationships between places [tract-level work-commuting data] [31, 32, 46]. RUCA is the only system available at the census tract levels. Since census tract codes are the smallest geographic building block for which reliable commuting data are available, it is more precise than county- or Zip-code based alternatives [47]. The census tract code version of RUCA differentiates between rural portions of metropolitan counties and urban portions of non-metropolitan counties. While RUCA definition is a useful option for this study, the RUCA algorithm at the census tract level resulted in a misclassification for Asotin County. Even though it is classified as Urban Core, in reality, it is overwhelmingly rural. This misclassification could in theory underestimate the effect of geographic

difference. However, because the number of claims in Asotin county is small (0.21 % of all sample), it didn't affect the OR estimation in this study.

The comparison of work disability by residential location and work-commuting based on the count of incident claims from our study is a first step towards a deeper understanding of the complex process of geographic variation and disability. Evaluating the effect of geographic difference on disability would be improved using claim rates because (1) a majority of workers live in Urban Core, and (2) there are reports that occupational injury and illness rates vary geographically [24, 48]. One limitation of our study is lack of accurate denominators for calculating the above mentioned claim rates. Even though the total number of jobs is available at the census tract level, we cannot differentiate jobs that mandate State Fund workers' compensation coverage, our study population. Another limitation of this study is the exclusion of self-insured which represents bigger companies and accounts for more than one-quarter of all claims in Washington State. Analyses of work disability outcome excluding self-insured limit the generalizibility of the results from this study.

Previous studies have demonstrated that return-to-work outcomes are affected by factors including physical capabilities in relation to work demands, ergonomic risk factors on the job, and psychological factors related to worker traits, psychological readiness to return to work, and ability to manage symptoms [29, 49–51]. Self-reported physical disability is positively associated with time to return to work after back injury [52] and seems to be more important than pain intensity in predicting work disability duration [53, 54]. These factors are absent from our current study.

The results of our study supports the notion that multiple factors, including worker's residential location and work-commuting, were collectively contributing to poor work disability outcomes in Rural or Sub Urban areas. These findings have important implications on developing occupational injury prevention and return-to work programs. The provision of local health care needs to promote policies that enable easily accessible, effective, safe, and well-coordinated care to all workers; focus on the prevention of chronic work disability; and allocate resources to the communities and workers that have most needs. On the workplace-level, employers need to focus on promoting safe and healthy work environment and provide appropriate alternative duties and resources to support injured workers.

Conclusions

Our findings indicate that workers living in Sub Urban and Small Town and Isolated Rural areas represent a particularly vulnerable group with respect to risk of long-term work disability. Occupational injury prevention and return-to work programs should be developed based on policies which consider all risk determinants including residential location and work-commuting patterns.

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Appendix

See Table 4 and Fig. 3.

Table 4 Four-tier consolidation of secondary RUCA codes in this study (Adopted from WWAMI Rural Health Research Center, University of Washington)

Class	Tier	RUCA codes	Description and secondary RUCA codes
Urban Core	1	1.0	Contiguous built-up area of 50,000 persons or more. These areas correspond to US Census Bureau's Urbanized Areas
Sub Urban	2	2.0, 2.1, 3.0, 4.1, 7.1, 10.1	Areas, often in Metropolitan Counties, with high commuting flows to Urban Cores. These areas also include all other areas where 30–49 % of the population commutes to Urban Cores for work
Large Rural Town	3	4.0, 4.2, 5.0, 5.2, 6.0, 6.1	Towns with populations between 10,000 and 49,999 and surrounding rural areas with 10 % or more primary commuting flows to theses towns, as well as secondary commuting flows of 10 % or more to Urban Cores
Small Town and Isolated Rural	4	7.0, 7.3, 7.4, 8.0, 8.4, 9.0, 10.0, 10.2, 10.3, 10.4, 10.5, 10.6	Towns with populations below 10,000 and their surrounding commuter area and other isolated rural areas with more than 1 h diving distance to a nearest city

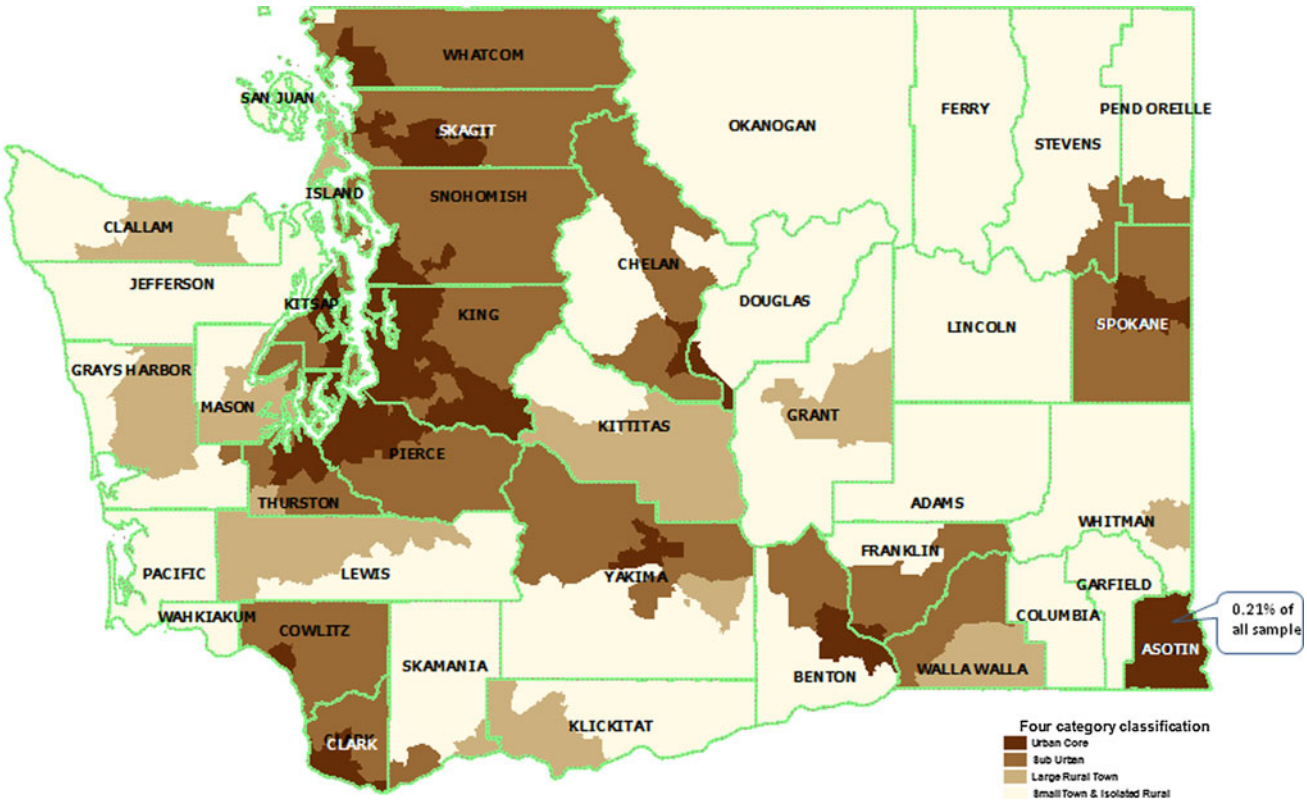

Fig. 3 Four category classification of Rural Urban Commuting Area at the 2004 census tract level, Washington. Data obtained through WWAMI Rural Health Research Center, University of Washington. No. of census tract ranges from 1 (Columbia) to 373 (King) per county

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