



# **An occupational hazard exposure index for economic sectors in Ontario**

Cameron A. Mustard, Jacob Etches, Peter Smith,  
Imelda Wong, Laura Bogaert

Institute for Work & Health  
Plenary  
April 14, 2015



## Background

The Expert Advisory Panel on Occupational Health and Safety reported to the Minister of Labour on December 10, 2010.

The Expert Advisory Panel report included a recommendation to improve the indicators of occupational health and safety performance at the workplace level and at the system level (Recommendation 6). The Expert Advisory Panel gave emphasis to strengthened indicators that have predictive validity (indicators that predict the future performance of a workplace or an economic sector). The phrase 'leading indicators' was used by the Expert Advisory Panel to describe this class of measures.



## Introduction

Epidemiology has used occupation classifications to assign typical attributes of working conditions or exposures in an occupation. The imputing of working conditions to occupational groups is typically assigned by an expert consensus process.

Ordinal rankings of occupations on the attribute of the physical demands of the occupation are common and have predictive validity. More complex job exposure matrix approaches have imputed multiple working condition characteristics to occupational groups and have been found to correlate well with self-reported work exposures.

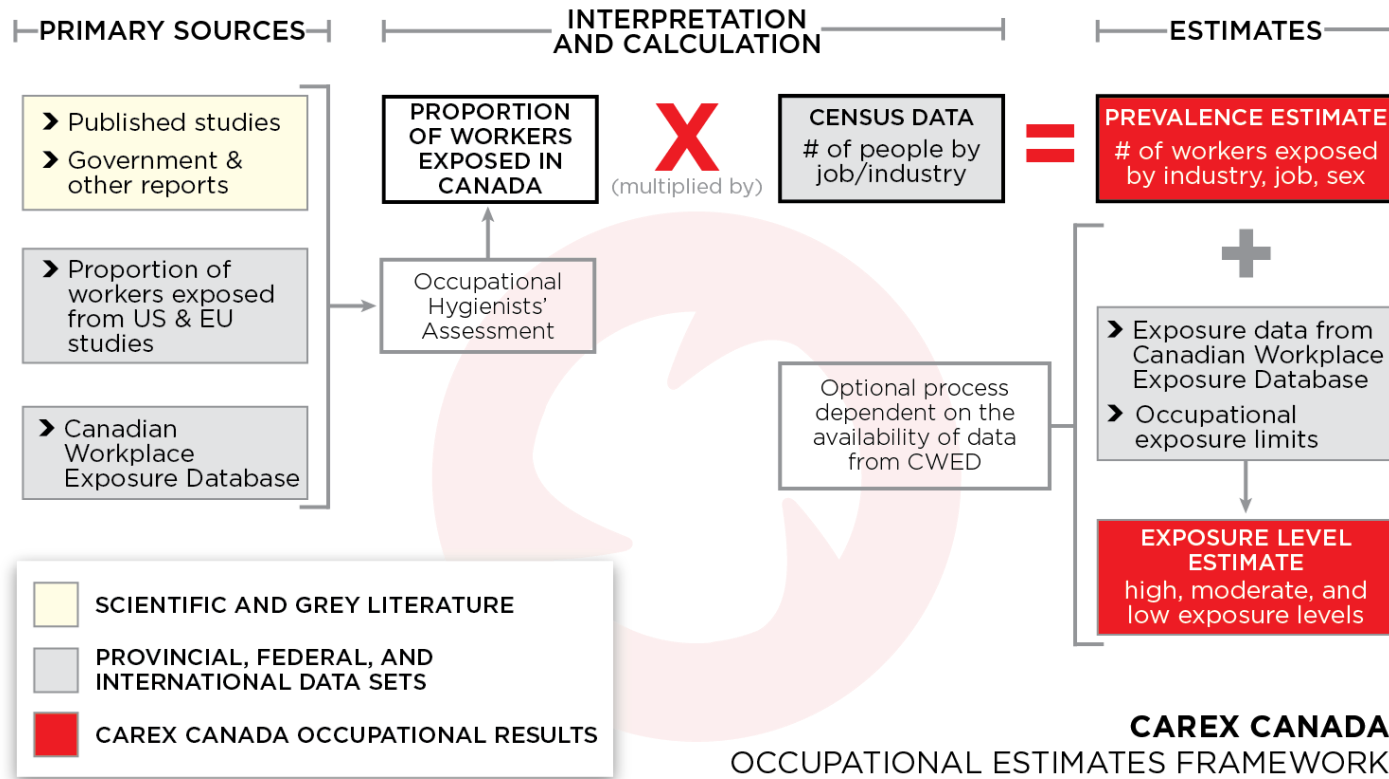


## Some Examples: CAREX Canada

CAREX Canada is a multi-institution team of researchers that combines academic expertise and government resources to generate an evidence-based carcinogen surveillance program for Canada. The purpose of CAREX Canada is to estimate the number of Canadians exposed to substances associated with cancer in the workplace and community environments.

The occupational exposure estimates calculate the numbers of workers exposed to 44 specific carcinogens by industry, occupation, province, and sex.

Labrèche F, Duguay P, Ostiguy C, Boucher A, Roberge B, Peters CE, Demers PA. Estimating occupational exposure to carcinogens in Quebec. *Am J Ind Med*. 2013 Sep;56(9):1040-50. doi: 10.1002/ajim.22200. Epub 2013 Jun 26.





## Some Examples: O\*NET (US)

Several hundred variables describing characteristics of more than 800 occupations.

Information is obtained from a sample of respondents over the period 2004-2009, N=28,000

Work context questionnaire collects self-reported information on job incumbent's working conditions:

- exposure to ergonomic hazards,
- outdoor work,
- operating a motor vehicle,
- exposure to contaminants,
- hazardous equipment/conditions



## Some Examples: O\*NET (US)

Occupational noise exposure and hearing loss,  
US general population

Noise exposure (quintile) at longest job

	Q1 (low) N=695	Q2 N=830	Q3 N=731	Q4 N=805	Q5 (high) N=767
Hearing loss (%)	8.8	8.7	8.5	12.8	17.8
Noise notch (%)	13.8	14.2	11.8	22.4	27.0

Choi YH, Hu H, Tak S, Mukherjee B, Park SK. Occupational noise exposure assessment using O\*NET and its application to a study of hearing loss in the US general population. *Occup Environ Med.* 2012 Mar;69(3):176-83. doi: 10.1136/oem.2011.064758.



## Objective(s)

To apply hazard exposure measures imputed to occupations to estimate the burden of occupational hazard exposure in 56 economic sectors in the province of Ontario.

To use workers' compensation claims to assess the (concurrent) validity of the sector-specific hazard exposure estimates





## Methods

The 6M labour force participants in Ontario were assigned to 56 economic sectors (NAICS) on the basis of the Labour Force Survey (Statistics Canada).

We used 13 working condition characteristics imputed to more than 500 occupations (NOC) as the source of hazard exposure. The working condition characteristics were obtained from the HRSDC Career Handbook.

Occupational composition of 56 economic sectors was used to estimate the hazard exposure burden in each sector. We examined two methods to estimate the sector-specific hazard exposure burden.

To describe concurrent validity, we correlated the sector-specific hazard exposure index to the sector-specific incidence of total compensation claims



## Methods: Classification of occupation

National Occupational Classification (NOC)

Occupations grouped into 26 'major' groups, 140 'minor' groups (and more than 800 unit groups). Unit groups are nested within Minor groups, which in turn are nested within Major groups.

Major Group 31

### **Professional Occupations in Health**

- 311 Physicians, Dentists and Veterinarians
- 312 Optometrists, Chiropractors and Other Health Diagnosing and Treating Professionals
- 313 Pharmacists, Dietitians and Nutritionists
- 314 Therapy and Assessment Professionals
- 315 Nurse Supervisors and Registered Nurses



	LF 2007	2007	2008	2009	2010	2011
<b>14 Clerical Occupations</b>	<b>396,056</b>	<b>15.1</b>	<b>13.8</b>	<b>12.2</b>	<b>9.9</b>	<b>8.2</b>
141 Clerical Occupations, General Office Skills	105,607	6.0	5.9	5.2	3.9	3.4
142 Office Equipment Operators	15,105	4.2	4.7	3.5	2.9	2.6
143 Finance and Insurance Clerks	59,404	4.3	3.9	3.7	3.0	2.7
144 Administrative Support Clerks	29,409	6.6	6.0	5.7	4.9	4.5
145 Library, Correspondence and Related Information Clerks	66,392	13.9	12.9	14.0	11.6	10.6
146 Mail and Message Distribution Occupations	29,255	74.6	63.5	58.9	46.0	36.3
147 Recording, Scheduling and Distributing Occupations	90,884	19.2	16.7	12.4	11.2	9.9
<b>31 Professional Occupations in Health</b>	<b>138,092</b>	<b>14.9</b>	<b>14.7</b>	<b>13.7</b>	<b>12.2</b>	<b>8.7</b>
311 Physicians, Dentists and Veterinarians	23,618	0.8	0.9	0.6	1.5	0.4
313 Pharmacists, Dietitians and Nutritionists	11,093	3.0	2.8	2.0	3.3	5.0
314 Therapy and Assessment Professionals	10,497	10.6	10.4	8.9	8.7	5.6
315 Nurse Supervisors and Registered Nurses	90,259	21.0	20.8	19.5	16.8	11.9
<b>32 Technical and Skilled Occupations in Health</b>						
321 Medical Technologists and Technicians	23,517	10.5	12.2	10.0	7.1	6.1
323 Other Technical Occupations in Health Care	23,607	73.9	66.8	63.5	63.9	50.1
341 Assisting Occupations in Support of Health Services	71,129	40.2	40.9	35.8	37.5	28.4



## Methods: Classification of industry

North American Industry Classification System (NAICS)

NAICS (Canada) consists of 20 sectors, 102 sub-sectors, 323 industry groups, 711 industries. Nested structure.

We formed 56 economic sectors, consolidating sub-sectors in consultation with MOL officials.

The Ministry of Labour (regulatory enforcement) classifies employers using NAICS

The WSIB (and other provincial WCBs) classify employers using SIC (work disability income security benefits)

Not all sectors are under jurisdiction of Ministry of Labour.

Not all sectors have equivalent WSIB insurance coverage.



## A sample of 12 sectors (N=56)

	Total labour force	Insured labour force	Number of Claims	Claim rate per 1000 FTE
<b>All Sectors</b>	<b>6,597,361</b>	<b>4,698,125</b>	<b>178,435</b>	<b>38.0</b>
Utilities	57,665	57,022	1,257	22.0
Residential building construction	100,183	28,277	1,320	46.7
Food manufacturing	98,625	95,344	5,165	54.2
Wood product manufacturing	22,305	20,689	1,504	72.7
Transportation equipment manufacturing	154,882	153,304	10,332	67.4
Truck transportation	92,094	71,734	3,050	42.5
Finance and Insurance	339,230	17,190	170	9.9
Elementary and secondary schools	276,240	274,951	7,866	28.6
Hospitals	222,077	217,036	8,456	39.0
Nursing and residential care facilities	107,885	105,978	7,628	72.0
Provincial and territorial public administration	91,700	91,693	1,846	20.1
Other public administration	150,121	157,884	10,888	72.5



## Prevalence of 13 occupational hazards in the Ontario labour force, NOC Career Handbook

	Ontario labour force	Minimum and maximum values in 56 economic sectors
Total employment	6,597,362	9,550 to 630,100
<b>Proportion of employment:</b>		
requiring heavy strength	4.6	< 5% to 34.3%
requiring bending, stooping, kneeling, crouching in an unregulated indoor environment	21.6	< 5% to 90.8%
in an outdoor environment	10.9	< 5% to 49.1%
expected to operate a vehicle or heavy equipment	23.3	< 5% to 92.7%
exposed to hazardous chemical substances	7.9	<5% to 78.7%
exposed to hazardous equipment, machinery or tools	9.4	<5% to 89.3%
exposed to hazardous equipment, machinery or tools	25.5	< 5% to 89.5%
exposed to potential electrical hazards	2.6	< 5% to 24.0%
exposed to hazard of flying particles or falling objects	3.6	< 5% to 38.6%
exposed to fire, steam or hot surfaces	4.9	< 5% to 46.2%
exposed to dangerous locations	5.1	< 5% to 47.0%
exposed to noise that increases risk of hearing loss	16.8	< 5% to 74.3%
exposed to vibration	5.5	< 5% to 72.8%



**Top ten occupations: Heavy and civil engineering construction, 2011**

	<b>N</b>	<b>%</b>
<b>Total employment</b>	<b>40,771</b>	<b>100</b>
7611 Construction Trades Helpers and Labourers	7,490	18
7421 Heavy Equipment Operators (Except Crane)	6,143	15
7217 Contractors and Supervisors, Heavy Construction Equipment Crews	3,209	8
7411 Truck Drivers	2,357	6
0711 Construction Managers	2,228	5
0016 Senior Managers - Goods Production, Utilities, Transportation and Construction	786	2
1221 Administrative Officers	656	2
2131 Civil Engineers	835	2
7245 Telecommunications Line and Cable Workers	639	2
7252 Steamfitters, Pipefitters and Sprinkler System Installers	990	2
Other	15,436	38



## Occupational hazard prevalence: heavy & civil engineering compared to Ontario labour force

	Heavy Construction Sector 2011	Ontario labour force	Minimum and maximum values in 56 economic sectors
Total employment	<b>40,771</b>	6,597,362	9,550 to 630,100
<b>Proportion of employment:</b>			
requiring heavy strength	<b>21.8</b>	4.6	< 5% to 34.3%
requiring bending, stooping, kneeling, crouching in an unregulated indoor environment	<b>30.2</b>	21.6	< 5% to 90.8%
in an outdoor environment	<b>23.8</b>	10.9	< 5% to 49.1%
in an outdoor environment	<b>55.2</b>	23.3	< 5% to 92.7%
expected to operate a vehicle or heavy equipment	<b>25.0</b>	7.9	<5% to 78.7%
exposed to hazardous chemical substances	<b>25.0</b>	9.4	<5% to 89.3%
exposed to hazardous equipment, machinery or tools	<b>48.6</b>	25.5	< 5% to 89.5%
exposed to potential electrical hazards	--	2.6	< 5% to 24.0%
exposed to hazard of flying particles or falling objects	<b>17.5</b>	3.6	< 5% to 38.6%
exposed to fire, steam or hot surfaces	<b>16.5</b>	4.9	< 5% to 46.2%
exposed to dangerous locations	<b>38.4</b>	5.1	< 5% to 47.0%
exposed to noise that increases risk of hearing loss	<b>67.2</b>	16.8	< 5% to 74.3%
exposed to vibration	<b>28.9</b>	5.5	< 5% to 72.8%

( - ) less than 5% exposed





## Methods

Two methods to estimate a sector-specific hazard exposure index:

Method 1: a simple sum of the proportions of the work force within each sector expected to be exposed to each of the 13 hazards. The 'simple' method resulted in a range values from 100 to 750 across 56 sectors

Method 2: factor analysis, specified to give more weight to physical job demands. This method resulted in values ranging from 3.8 to 20.6



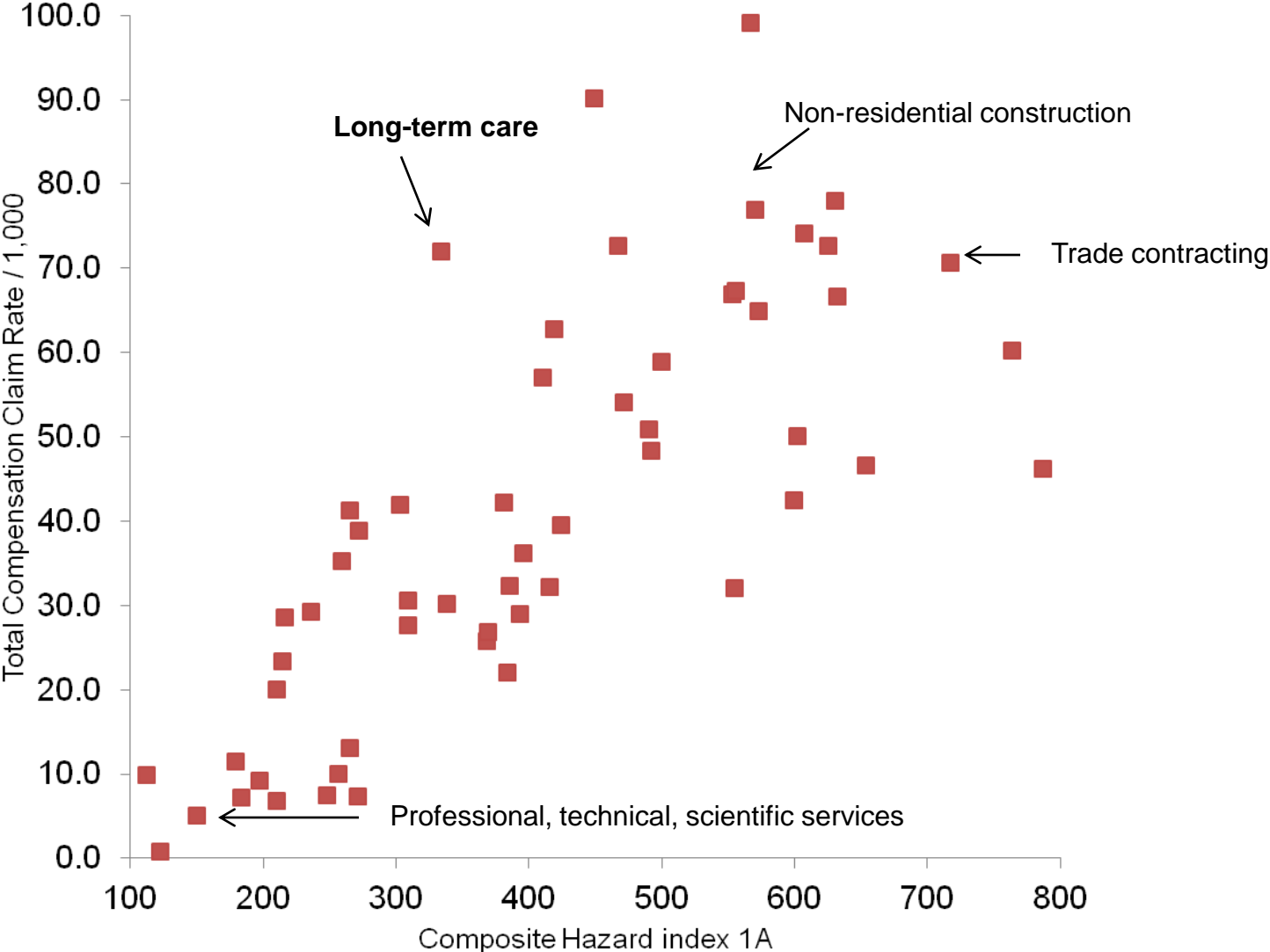
## Method 1

We computed a hazard exposure score for each of 520 unit group occupation categories. The composite measure weighted individual hazard exposure measures equivalently. This score ranged from 1 to a possible maximum of 17 (ordinal score of measure of strength requirement was used, 1-4).

We then multiplied the unit group hazard exposure score by the estimated number of workers in each occupation within each economic sector. These weighted unit group estimates were summed across all unit groups in the sector and divided by the estimated total sector labour force (we multiplied the final value by 100).

Values of this measure, termed the 'Composite Hazard Exposure Index', ranged from 100 (Finance and Insurance) to 750 (Farms).

**Figure 1**  
**Correlation of Composite 1A and total compensation claim rate**  
56 economic sectors, Ontario, 2011





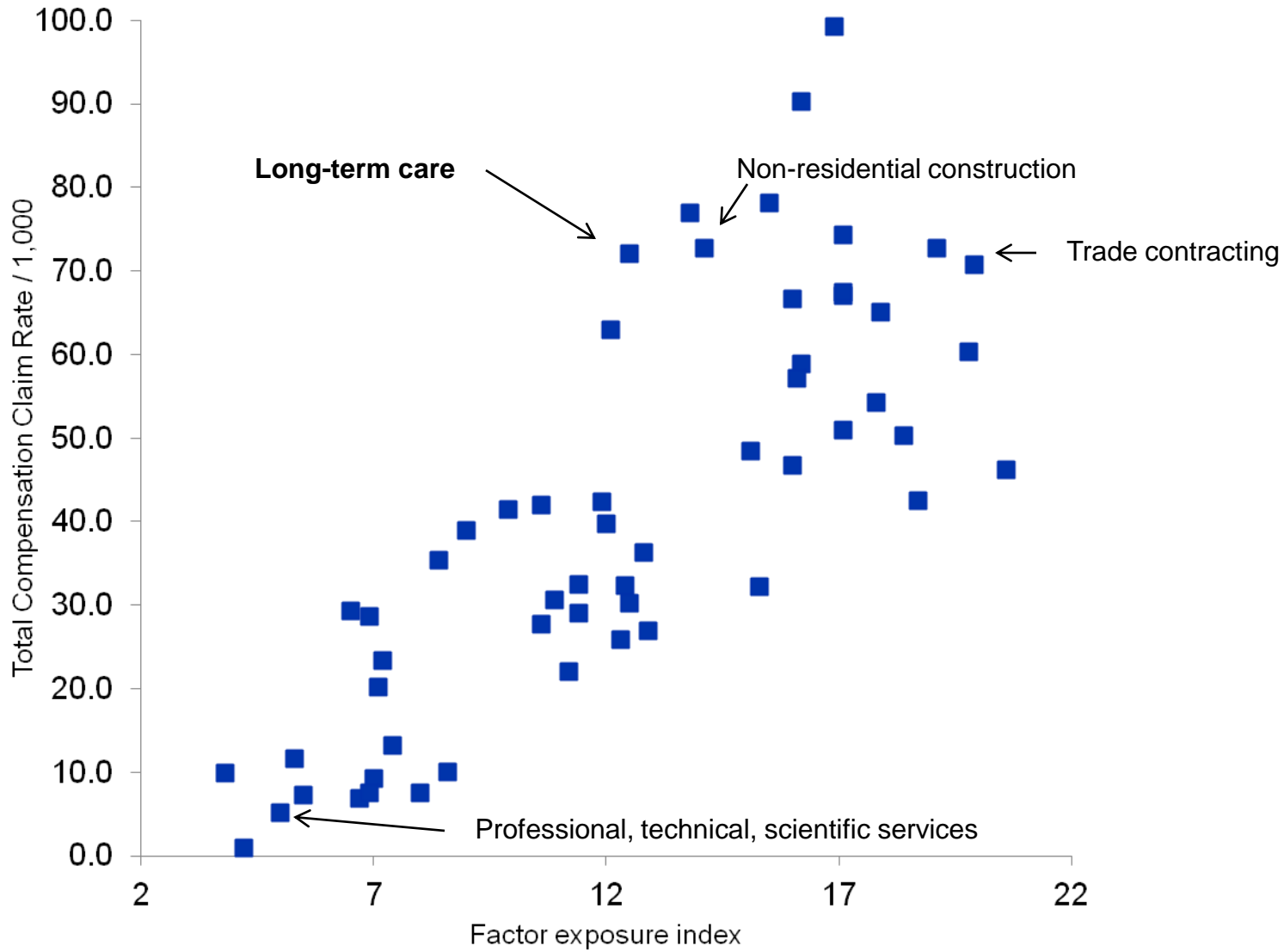
## Method 2

The second approach applied a principal component factor analysis (unrotated) to evaluate the factor structure of the 13 individual hazard exposure measures, using the 520 occupational groups as the unit of analysis. All measures loaded on the first factor (32% of variance explained)

Using the first factor, we computed a factor score for each of the 520 occupational groups( range 3.3 to 32.3).

We regressed occupation-specific lost-time incidence rates on the occupation-specific hazard factor scores to obtain a predicted compensation claim rate for each occupational unit group. Then the predicted compensation claim rate for each occupation group was multiplied by the estimated number of workers in each occupation within each economic sector, summed across all unit groups in the sector and divided by the estimated total sector labour force. Range: 3.8 (Finance and Insurance) to 20.6 (Farms).

**Figure 2**  
**Correlation of factor exposure index and total compensation claim rate**  
56 economic sectors, Ontario, 2011



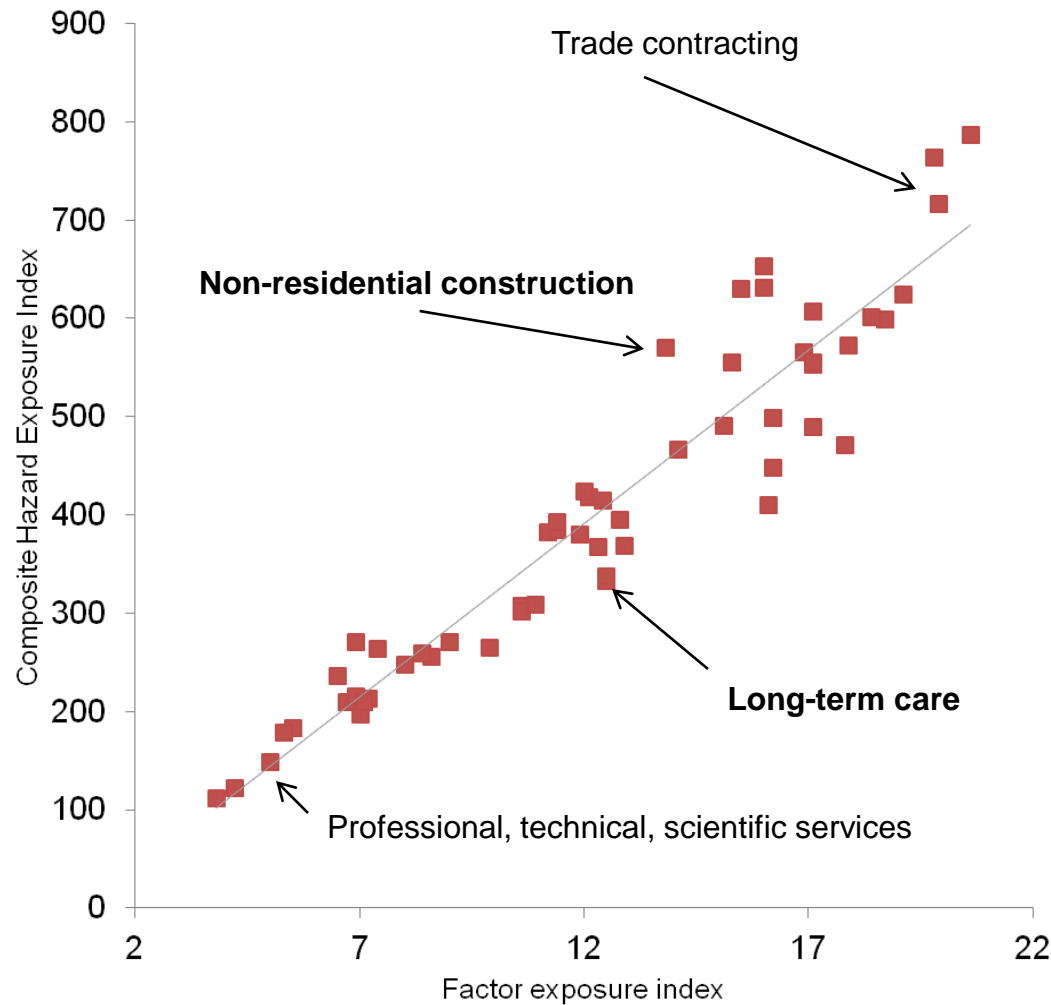


## Results

The correlation of the composite hazard exposure index with the total compensation claim rate was 0.76.

The correlation of the factor exposure index with the total compensation claim rate was 0.80

The two hazard index measures were strongly correlated: 0.95



Correlation of the two methods for estimating the hazard burden across 56 economic sectors



## Conclusion

An occupational hazard exposure index, derived from expert consensus assessment, appears to be a valid measure of differences between economic sectors in the prevalence of hazards for work-related injury and illness.

The composite JEM estimated from a factor analysis weighting physical job demands appears to improve concurrent validity compared to the simple sum of exposure prevalences.





## Application(s)

### **Labour inspection operational policy**

MOL officials have used hazard exposure index for 18 months.  
Method built from hazard measures has face validity for regulatory staff. Complements reliance on compensation claim statistics.

### **Analytic uses**

A method for adjusting for sectoral differences in injury risk that is not dependent on worker's compensation injury/illness claims

May be a valid proxy for defining sector differences in barriers to return to work



## Keep up on evidence-based practices from IWH



Sign up online for our monthly e-alerts, our quarterly newsletter, event notifications and more: [www.iwh.on.ca/e-alerts](http://www.iwh.on.ca/e-alerts)



Follow @iwhresearch on Twitter: [www.twitter.com/iwhresearch](http://www.twitter.com/iwhresearch)



Connect with us on LinkedIn:  
[www.linkedin.com/company/institute-for-work-and-health](http://www.linkedin.com/company/institute-for-work-and-health)



Subscribe to our YouTube channel: [www.youtube.com/iwhresearch](http://www.youtube.com/iwhresearch)



**Institute  
for Work &  
Health**

Research Excellence  
Advancing Employee  
Health

[www.iwh.on.ca](http://www.iwh.on.ca)



iwv