

DOSE (Database of Occupation-Specific Exposures): Development and Case Example

Marcus Yung & Amin Yazdani

Canadian Institute for Safety, Wellness, & Performance

SUMMARY

Ergonomic, physical, psychosocial, and environmental conditions interact, and play a role in the risk of workplace injuries, including musculoskeletal disorders (MSD). There is a need for accurate and ecologically valid assessments of job exposures and demands to more effectively prevent MSD. This presentation describes the development of the multi-dimensional Database of Occupation-Specific Exposures (DOSE), a new initiative based on direct field measurement, that will support effective MSD prevention and open avenues of research in studying exposure-disease associations.

KEYWORDS

Injury Prevention, Exposure Assessment, Task Exposure Matrix

Introduction

Major international public health agencies have prioritized reducing musculoskeletal disorders (MSD). Understanding the aetiology, the determinants, and the risk factors of MSD are critical elements in MSD prevention. Historically, there has been emphasis on ergonomic factors (e.g., repetition, force, posture) and their contributions to MSD development. However, there is greater recognition that ergonomic, physical, psychosocial, and environmental conditions interact, and directly and indirectly play a role. Despite considerable progress in this research area, there continues to be a significant need for accurate and ecologically valid assessment of job exposures and demands to advance our understanding of the factors and mechanisms of injury and illness. More importantly, there is need for applied field research that characterizes the interacting effects of the totality of factors that is aligned with current integrated models of MSD development.

A new Canadian initiative called DOSE (Database of Occupation-Specific Exposures) is the first comprehensive database in the world consisting of multi-dimensional job demands and exposures based on direct measurement for each National Occupational Classification (NOC) job code. In this presentation, the method for DOSE data collection, processing, and analysis, will be described, and a case example of its application, based on ergonomic factors, for a single NOC will be provided.

Methodology/Approach

Pre-Study Preparation

Between 2025 and 2028, DOSE will prioritize jobs within construction and paramedic sectors. These sectors employ over 515,000 Ontarians in 2024 and represent almost 18% of all lost time compensation injury claims in Ontario. For each NOC job code, the job's duties and tasks were identified through extensive consultation with industry subject matter experts. Based on established work sampling approaches, a minimum of 300 observations per task are required to calculate reasonably accurate and precise task demand and exposure estimates (Mathiassen et al., 2014), across a minimum of 15 to 25 workers (David, 2005) for each job. Additionally, participants were

observed for full work shifts over an entire five-day work week, enabling repeated measures of tasks both within and between multiple days; established strategies may help improve precision of estimates, particularly for highly dynamic work environments (Burdorf & van Riel, 1996). Study participants were current workers in each NOC and were recruited with support from industry partners.

Data Collection

Enabled by mobile laboratories, researchers have brought “research into the field” across the entire province of Ontario. Participants were outfitted with wearable sensors, including electromyography to capture muscular exertion and accelerometers to capture kinematics of the hand/wrist, shoulders, lower back, neck/upper back; core body temperature to estimate thermal risk; and heart rate monitors to estimate whole body fatigue. Work environment data was captured using noise dosimeters, wet bulb globe temperature (WBGT) measures, and dust monitors. When required, these measures were complemented with eye tracking devices, vibration measurement, electrodermal response, and oculomotor tests. Worker participants were observed over their work shift, and their performed duties and tasks were video recorded.

Data Processing and Analysis

Wearable sensor data were digitally filtered and then synchronized to the sampling rate of the video. A timeline analysis was conducted on video observations to notate duties and tasks. Measures of central tendency and variability were calculated for each measure for each task, and when required, measures of distribution of activity levels during the task duration (e.g., amplitude power distribution function). A task exposure matrix (TEM) was then constructed by assigning the exposure and demand estimate to each task for each NOC job code.

Example of Application of DOSE (Ergonomic Demands) to Construction ICI Roofers

Roofers install, repair, and replace flat roofs and work with shingles, shakes, or other roofing tiles on sloped roofs. According to WSIB statistics, between 2014 and 2024, MSD account for 41% of all lost time claims, primarily affecting the low back (33% of MSD claims), lower extremities (28%), and trunk (16%). The most frequently performed tasks were installing membrane flashings, installing insulation, applying membranes, preparing concrete surfaces, and installing protection boards (Figure 1).

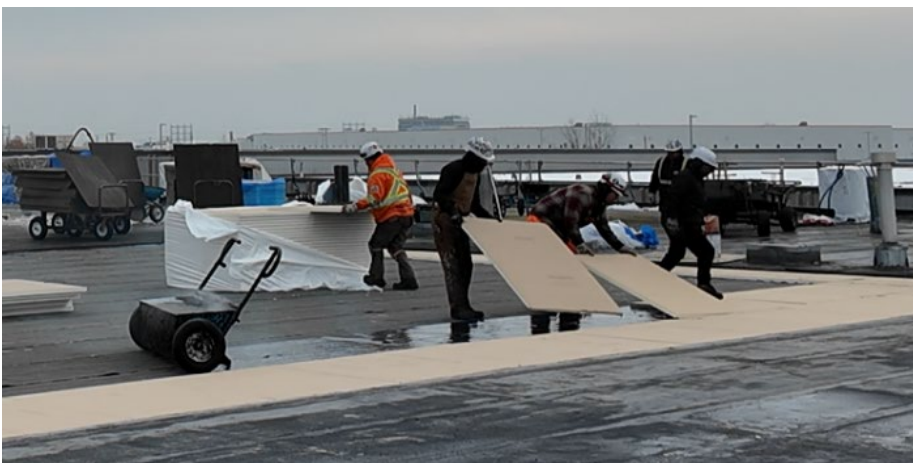


Figure 1: Construction ICI roofers performing *installation of insulation* task.

For interpretation, exposure/demand estimates were assigned to risk categories (low/moderate/high) established from the body of literature. Across all five most frequently observed tasks (job-level),

risk scores were derived from a time-weighted average of task durations (Table 1). There was moderate ergonomic risk of the lower back, mainly due to prolonged (i.e., more than 10% of task duration) and repetitive (i.e., more than 1 action every 2 minutes) trunk flexion greater than 45 degrees. There was moderate ergonomic risk of the hand-arm, mainly due to moderate hand exertions (i.e., greater than 10% but less than 30% maximum voluntary contraction). Across the five tasks, there was moderate risk of whole-body physical fatigue, where heart rate reserve was greater than 30% for 50-90% of the task time, and moderate thermal risk.

Table 1: Time-weighted averaged risk classification across five most frequently observed tasks for ICI Roofer job.

	MSD Risks				Whole-body Fatigue Risk	Thermal Risk
	Neck and upper back	Hand-arm	Shoulder	Low back		
ICI Roofer (NOC 73110)	Low (1)	Moderate (1.6)	Low (1)	Moderate (2)	Moderate (1.8)	Moderate (1.2)

Additionally, risk scores can be calculated for each individual task (task-level). For instance, *installation of insulation* task was characterized by moderate ergonomic risks of the low back and moderate whole body fatigue risk (Table 2). In this example, targeted job- and task- specific interventions can be developed to address high- or moderate- risk tasks.

Table 2: Risk classification for *Installation of Insulation* task.

Body Region	Force	Posture		MSD Risk
		Duration	Repetition	
Neck and upper back	<input type="checkbox"/> High: Muscle exertion > 14% <input type="checkbox"/> Moderate: Muscle exertion 10-14% <input checked="" type="checkbox"/> Low: Muscle exertion < 10%			Low
Shoulder	<input type="checkbox"/> High: Muscle exertion > 15% <input checked="" type="checkbox"/> Low: Muscle exertion ≤ 15%	<input type="checkbox"/> High: > 10% of task time in above-shoulder posture <input checked="" type="checkbox"/> Low: ≤ 10% of task time in above-shoulder posture	<input type="checkbox"/> High: Above-shoulder posture repetition > 1 count/min <input checked="" type="checkbox"/> Low: Above-shoulder posture repetition ≤ 1 count/min	Low
Low back	<input type="checkbox"/> High: Muscle exertion > 15% <input checked="" type="checkbox"/> Low: Muscle exertion ≤ 15%	<input checked="" type="checkbox"/> High: > 10% of task time in forward bending <input type="checkbox"/> Low: ≤ 10% of task time in forward bending	<input checked="" type="checkbox"/> High: Forward bending repetition > 0.5 counts/min <input type="checkbox"/> Low: Forward bending repetition ≤ 0.5 counts/min	Moderate
Hand-arm	<input type="checkbox"/> High: Muscle exertion > 30% <input type="checkbox"/> Moderate: Muscle exertion 10-30% <input checked="" type="checkbox"/> Low: Muscle exertion < 10%			Low
Heart Rate Reserve				Whole-body

			Fatigue Risk
<input type="checkbox"/> High: Cardiovascular effort > 30% for > 90% of task time <input checked="" type="checkbox"/> Moderate: Cardiovascular effort > 30% for 50–90% of task time <input type="checkbox"/> Low: Cardiovascular effort > 30% for < 50% of task time			Moderate
Core Body Temperature	Temperature Gradient	Heart Rate	Thermal Risk
<input type="checkbox"/> High: Core body temperature > 38°C <input checked="" type="checkbox"/> Low: Core body temperature ≤ 38°C	<input type="checkbox"/> High: Temperature gradient < 3.3°C <input checked="" type="checkbox"/> Low: Temperature gradient ≥ 3.3°C	<input type="checkbox"/> High: Heart rate > 110 bpm <input checked="" type="checkbox"/> Low: Heart rate ≤ 110 bpm	Low

Findings and Key Takeaways

DOSE is the world's first comprehensive database of task exposures for jobs, based on direct measurement. DOSE will enable the construction of a multi-dimensional TEM, which minimizes exposure misclassification, particularly of jobs with many variable tasks (Benke et al., 2000). TEMs may be used to estimate current and past exposures when retrospective collection of direct measurement is impossible and is important for occupational epidemiology research to study the effect of exposures on any health condition, including the impact of known and suspected markers of workplace vulnerability (Yung et al., 2019). DOSE may also enable re-investigation of existing risk threshold levels by optimizing exposure-disease associations, leading to more effective risk assessment tools. DOSE may assist in identifying and prioritizing high risk jobs and their tasks for intervention and inform better decision-making during injury claims adjudication processes and support effective return-to-work. Ultimately, DOSE opens avenues of research in the prevention of workplace injuries and support businesses based on evidence from direct exposure measurements.

References

- Benke, G., Sim, M., Fritschi, L., & Aldred, G. (2000). Beyond the job exposure matrix (JEM): the task exposure matrix (TEM). *Annals of Occupational Hygiene*, 44(6), 475-482.
- Burdorf, A., & van Riel, M. (1996). Design of strategies to assess lumbar posture during work. *International Journal of Industrial Ergonomics*, 18, 239-249.
- David, G.C. (2005). Ergonomic methods for assessing exposure to risk factors for work-related musculoskeletal disorders. *Occupational Medicine*, 55, 190-199.
- Mathiassen, S.E., Jackson, J.A., & Punnett, L. (2014). Statistical performance of observational work sampling for assessment of categorical exposure variables: A simulation approach illustrated using PATH data. *Annals of Occupational Hygiene*, 58(3), 294-316.
- Yung, M., Evanoff, B.A., Bucker-Petty, S., Roquelaure, Y., Descatha, A., & Dale, A.M. (2019). Applying two general population job exposure matrices to predict incident carpal tunnel syndrome: A cross-national approach to improve estimation of workplace physical exposures. *Scandinavian Journal of Work, Environment, and Health*, 46(3), 248-258.