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THE LEVEL OF PERCEIVED OCCUPATIONAL HEALTH AND SAFETY KNOWLEDGE IN SKILLED TRADES APPRENTICES: IMPACT, INFLUENCING FACTORS, AND LEARNING PREFERENCES

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The Level of Perceived Occupational Health and Safety Knowledge in Skilled Trades Apprentices: Impact, Influencing Factors, and Learning Preferences

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EXECUTIVE SUMMARY

Introduction

Canada's skilled trades shortage has negatively impacted organizations and consumers and has cost billions of dollars from healthcare expenditure and productivity loss. This issue is compounded by the high risk of disabling injury to workers in the skilled trades, particularly apprentices. While occupational health and safety (OHS) training may improve health and safety outcomes in theory, we must emphasize the appropriate delivery of OHS content to better suit skilled trades apprentices. It may be possible to maximize the impact of OHS training by first understanding how apprentices perceive their current training. The findings presented in this study improves on the current understanding of the potential links between a skilled trades apprentice's perceptions and preferences of their OHS training, and their injury outcomes. Through effective delivery of OHS training, including considerations of apprentice preferences, we may be able to maximize the retention of health and safety information and contribute towards the development of a safer workforce.

Objectives

We aim to explore the relationships between a skilled trades apprentice's perception of their OHS knowledge and their self-reported physical and cognitive demands. This report also aims to explore the relationship between a skilled trades apprentice's self-reported functional limitations and their knowledge acquisition. Finally, we seek a better understanding of an apprentice's preferred delivery method when learning about OHS.

Key Findings

An apprentice with a lower self-perception of their OHS knowledge was also more likely to report a negative OHS outcome. Inexperienced apprentices that have a lower self-perceived knowledge in their OHS training were also more likely to report that they had sustained an injury over a 12-month period. There were also relationships between an apprentice's self-perceived knowledge of health and safety, and the self-reporting of feeling burned out and overwhelmed.

The program release type, age, and level of an apprentice influenced their perceived OHS confidence and subsequent relationship with injury and pain self reporting. Day release apprentices were 1.5 times more likely to self-report an injury, while younger apprentices perceived themselves as more confident than older apprentices but were twice as likely to self-report an injury. Older apprentices, while less likely to self-report an injury, were 1.24 times more likely to report non-injury related body pain.

There was a greater self-reporting of cognitive functional limitations compared to physical functional limitations (e.g. walking). While apprentices with these functional limitations overall perceived that they were unaffected by them, trends indicated that these

apprentices perceived themselves as less likely to be able to manage their own safety, and the safety of their coworkers. This may indicate that apprentices with functional limitations may not be fully aware of the underlying impacts of their functional limitations on their work ability, including their ability to implement their OHS training. Hands-on training was overwhelmingly preferred by apprentices as a means of improving the retention of information and improving the situational awareness that would otherwise be underdeveloped through traditional classroom lectures. A combination of receiving foundational OHS training through their apprenticeship training and workplace specific OHS training from the employer may improve an apprentice's ability to identify and manage OHS hazards.

Practical Implications

We may be able to improve an apprentice's OSH outcomes by improving their confidence in their OSH training. However, a confident apprentice is not necessarily a safe apprentice, as that confidence must be proportional to their OHS knowledge. Apprentices will benefit from receiving hands-on OHS training that is directly aligned with the most relevant workplace hazards. This requires that the apprentice receive not only foundational OHS knowledge in the classroom, but also more specific, situationally relevant training from their employer. If implemented correctly, OHS training may facilitate a reduction in workplace injuries and MSD development through the application of well-retained and relevant OHS knowledge.

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TABLE OF CONTENTS

1. INTRODUCTION

Skilled trades workers are critical in the development and maintenance of Canada's infrastructure. This includes manufacturing products, providing goods and services, and managing information and digital platforms. However, there is a skilled trades shortage; approximately 700 000 workers are estimated to retire between 2019 and 2028, [1] which resulted in a $38.4B loss to the Canadian small business economy in 2022. [2] If the target of 75 000 new skilled trades apprentices per year is not achieved, there will be continued economic losses to both businesses and consumers.[1] Workers are also at high risk of disabling acute and chronic injuries, both physical and mental, [3,4] which further contributes to the workforce shortage. One way of addressing the injury rates and lost time claims is through the proper training of skilled trades workers during their apprenticeship. A worker effectively trained on occupational health and safety (OHS) has been shown to contribute positively to their workplace's health and safety climate, and are less likely to have an injury resulting in time off from work.[5,6] However, there is a lack of clear guidelines that indicate what aspects of OHS should be emphasized, and how this information should be presented.[7,8] The quality of the training content also depends on the quality of the developed OHS curriculum, the expertise of the instructor, and the applicability of OHS information to each workplace.[7–11] These factors all then have a varied impact on each apprentice based on their own learning characteristics if presented in a generalized, nonspecific way. To address this variability, current evidence insists that OHS training should be presented using hands-on, workplace-relevant approaches presented through well informed bodies, such as OHS trained instructors in classrooms, or through participatory, peer-led training in the workplace.[8,10]

Currently, skilled trades apprentices begin their training through employer-sponsored apprenticeship programs, which typically requires three levels of in-school training and can last between two to five years. Apprentices are trained either under a block release or day release program type. In block release, the apprentice would attend classes full-time for a determined number of weeks (typically eight weeks), whereas an apprentice in the day release program would only attend school one day a week. Over an apprenticeship, the apprentice learns theory through in-classroom education at colleges, union training centers, and other training environments. The apprentice then receives hands-on experience in

supervised classroom-style workshops, often only on the technical skills, before applying their knowledge in the field. Apprentices are also required to know about OHS hazards in accordance with the Occupational Health and Safety Act, [12] and undertake health and safety training through their school and/ or employer [12] as a means of proactively equipping themselves with the ability to identify and manage workplace hazards. However, while the information being presented may be valuable, apprentices may retain this information at varying levels based on their preferred mode of learning, age, and level of training. The OHS training currently being received may also be insufficient; in previous studies, Canadian Institute for Safety, Wellness, and Performance (CISWP) found gaps in the training of ergonomics, psychosocial health, hazard recognition, housekeeping and cleanliness, and the safe handling of equipment in the current skilled trades curricula. With the gaps in content exposed, there is now a need to not only incorporate these topics into the OHS curricula, but to also ensure that the quality, delivery, and application of the OHS training improves an apprentice's perceptions of their OHS knowledge towards keeping themselves and their coworkers safe.

Skilled trades workers are at risk of injury, physical disability, and working while injured.[3] Apprentices that work and study simultaneously may then be required to do so while managing their functional limitation(s); a personal, self-perceived physical or mental restriction that negatively impacts their performance within the classroom and/ or workplace.[13–15] The presence of injuries and functional limitations may affect how an apprentice perceives their OHS knowledge, and how useful they may find receiving OHS training to be. Apprentices may also have difficulties learning due to these functional limitations, which not only impact an apprentice's performance in traditional classroom environments,[16] but also their ability to retain OHS information through non-experiential formats.[17] Surveying the perceptions of apprentices with existing injuries and functional limitations will allow us to understand to what extent they perceive their OHS knowledge, and the influence of this perception on self-reported injury symptoms and their preferences of training delivery.

OHS training provided to skilled trades apprentices should help them in identifying, avoiding, and eliminating workplace hazards. Apprentices are also more likely to adhere to OHS training that they perceive to be relevant to the duties they perform on the job. [17,18] However, it is uncertain to what extent the current OHS training available to apprentices has

been effective in fostering their perceived knowledge of OHS. It is also of interest whether the preferred means of OHS training delivery have been identified or met. This project was developed to survey the perceptions of skilled trades apprentices regarding the OHS knowledge they received during their apprenticeship training and through their employer. We will explore the current demographics of surveyed skilled trades apprentices and their perceived understanding of their OHS training. The relationship between their self-perceived OHS knowledge and self-reported health outcomes will then be explored based on these perceptions. Finally, we seek an understanding of an apprentice's preferences regarding their OHS training, including how they want to be trained, and what they want to be trained on. Our findings will lend insight to the importance of an apprentice's perception of their OHS training, how this perception relates to their self-reported injury outcomes, and how we may align OHS training to improve perceptions.

2. METHODS

2.1 Survey Questionnaire

The initial survey was piloted using volunteer respondents of subject matter experts to ensure that the questions were relevant to the intended participants. We used feedback from the pilot survey to further clarify the wording of questions.

The final survey comprised of a combination of twenty-four multiple choice, multiple selection, and short answer questions, based on validated scales.[19,20] Questions inquired about the apprentice's general demographics, reasoning behind their choice of program and release type, the presence of pain, injuries, and functional limitations, and their preferred provider(s), topics, and delivery methods of OHS training. We also incorporated questions related to an apprentice's workplace health and safety knowledge readiness, knowledge of their rights, and perceived OHS knowledge related to operating workplace machinery, and recognizing workplace dangers. Through a set of Likert questions, we identified apprentice perceptions of their OHS knowledge, and their personal perceived impacts of the skilled trades labour shortage.

2.2 Data Collection

We surveyed apprentices from 14 skilled trades classrooms, across three different levels and several skilled trades programs between September 2022 and June 2024. Surveys were completed in-person, during class time, using pen and paper methods. Completed surveys were transcribed into a Microsoft Excel document. Any physical surveys were kept in a locked cabinet only accessible by research personnel.

2.3 Data Analysis

Data were analyzed using RStudio. Responses where the participant did not provide an answer (or provided a non-answer) were considered missing data and removed from that analysis. In addition to descriptive statistics and frequency, we used chi-square tests to explore whether there were possible statistical associations between an apprentice's perceived OHS knowledge, and their self-reported injuries, feelings of being overwhelmed and burned out. Data were stratified by age, level, program and/ or release type. For any significant omnibus test, pairwise comparisons were conducted to analyze differences between levels associated with the significant factor(s). The standard residuals of each

result were tested for their significance against cutoff values adjusted to account for the number of comparisons being made (i.e., Bonferroni adjusted cutoffs). Odds ratios were calculated to provide directionality and strength of associations to significant chi-square results.

3. RESULTS

A total of 1486 apprentices participated in the survey. Of these apprentices, 734 completed additional questions related to the perceived impacts of the skilled trades labor shortage, which was appended to the survey during the latter half of collections. Any apprentices that did not respond to all questions present in each subsection were removed from that section's data analysis.

3.1 Apprentice Demographics

Responses were obtained from 14 Ontario-recognized skilled trades, levels (1, 2, and 3), and release types (block and day release) (Table 1). Almost half of the respondents (47.6%) were Level 1 apprentices. Electrician apprentices were the most represented group (22.1%) followed by automotive service technicians (16.6%) and plumbers (11.5%). More apprentices were in the block release program (65.8%) than the day release program.

Table 1. Number of respondents stratified by Trade, Program Type, and Level (PNTA = Prefer not to answer).

	Block release			Day Release			PNTA			
Level	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Total by Trade**
Electrician	109	109	107	0	0	3	0	1	0	329
Automotive Service Technician	27	0	14	91	68	46	0	0	0	246
Plumber	69	15	84	0	0	0	0	2	1	171
Truck/ Coach Technician	36	0	27	62	20	14	1	0	0	160
General carpenter	40	17	36	1	0	0	0	3	1	98
Refrigeration/Air Conditioning	69	0	21	0	0	0	0	0	0	90
Brick/Stone mason	21	15	41	0	0	0	1	3	2	83
Metal fabricator	0	0	0	76	0	0	1	0	0	77
Millwright	22	22	0	22	0	7	0	1	0	74
General machinist	11	0	0	7	30	22	0	0	1	71
Cabinet maker	16	13	12	0	0	0	0	0	0	41
Tool/Die maker	4	0	0	0	0	21	0	0	0	25
Welder	18	0	0	0	0	0	0	0	0	18
Machine Tool Builder/ Integrator	3	0	0	0	0	0	0	0	0	3
Total by Level x Release	445	191	342	259	118	113	3	10	5	
Total by Release	Block 978			Day 490			PNTA 18			
Total by Level	Level 1 707			Level 2 319			Level 3 460			1486

We split our data into three age groups, based on groupings provided by Statistics Canada,[21] and adjusted based on previous literature that identified injury risk-related age groups of interest within skilled trades apprentices (Table 2).[22,23] There were comparatively similar

proportions of apprentices aged 15-24 years (40%) and 25-34 years (38.4%), and fewer apprentices aged 35 years and over (12.4%).

Table 2. Respondents stratified by Trade, Age Group, and Level (PNTA = Prefer not to answer).

	15-24			25-34			35 +			PNTA			Total
Level	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	
Electrician	55	46	23	24	39	49	15	12	24	15	13	14	329
Automotive Service Technician	72	28	22	32	30	29	3	8	5	11	2	4	246
Plumber	27	9	20	24	4	46	11	4	15	7	0	4	171
Truck/ Coach Technician	46	7	13	34	10	22	9	2	6	10	1	0	160
General Carpenter	25	6	9	10	11	22	4	2	4	2	1	2	98
Refrigeration/Air Conditioning	22	0	4	30	0	12	9	0	3	8	0	2	90
Brick/Stone Mason	13	10	11	7	7	21	2	1	6	0	0	5	83
Metal Fabricator	38	0	0	28	0	0	6	0	0	5	0	0	77
Millwright	10	10	0	17	10	3	8	0	3	9	3	1	74
General Machinist	9	8	8	6	13	10	2	7	1	1	2	4	71
Cabinet Maker	6	10	9	3	2	2	1	1	0	6	0	1	41
Tool/Die Maker	2	0	6	1	0	7	1	0	7	0	0	1	25
Welder	8	0	0	6	0	0	3	0	0	1	0	0	18
Machine Tool Builder/ Integrator	3	0	0	0	0	0	0	0	0	0	0	0	3
Total - Level x Age Group	336	134	125	222	126	223	74	37	74	75	22	38	
Total - Age Groups	595			571			185			135			1486

Most participating apprentices were male and did not self-identify as indigenous or as a visible minority (Table 3). The proportion of apprentices in the skilled trades that identified as female and/ or indigenous was consistent with the 2023 Statistics Canada estimate of the proportion (8.8%) of women working in the skilled trades, [24] and the 2021 Statistics Canada population of persons identifying as indigenous (2.9%) residing in Ontario. [25] Though the proportion of indigenous apprentices are similar to the population of Ontarians, there is a

noticeably smaller proportion of apprentices identifying as a visible minority (13.3%) relative to the proportion of visible minorities in Ontario's general population (38.6%). [26]

Table 3. Respondents stratified by identified Gender, and whether they identified as Indigenous or Visible Minority.

	Frequency	Percentage (%)
Male	1361	91.6
Non-binary	10	0.7
Transgender	13	0.9
Female	62	4.2
Other	11	0.7
Indigenous	31	2.1
Visible Minority	196	13.3

Sixty percent of respondents stated that they chose their program release type (i.e., block or day) based on self-preference, followed by employer preference and balancing their work and life commitments (Figure 1). A further analysis showed that an apprentice was almost twice as likely to select the block release program over the day release program based on their self-preference, compared to an apprentice that chose the program type based on the employer's preference ($\chi 2(1) = 27.92$, $p < 0.01$, OR = 1.93 (1.50,2.49)). We observed a relatively even split between whether an apprentice chose the block or day release program for work-life balance, work schedule and flexibility, or their employer's workload.

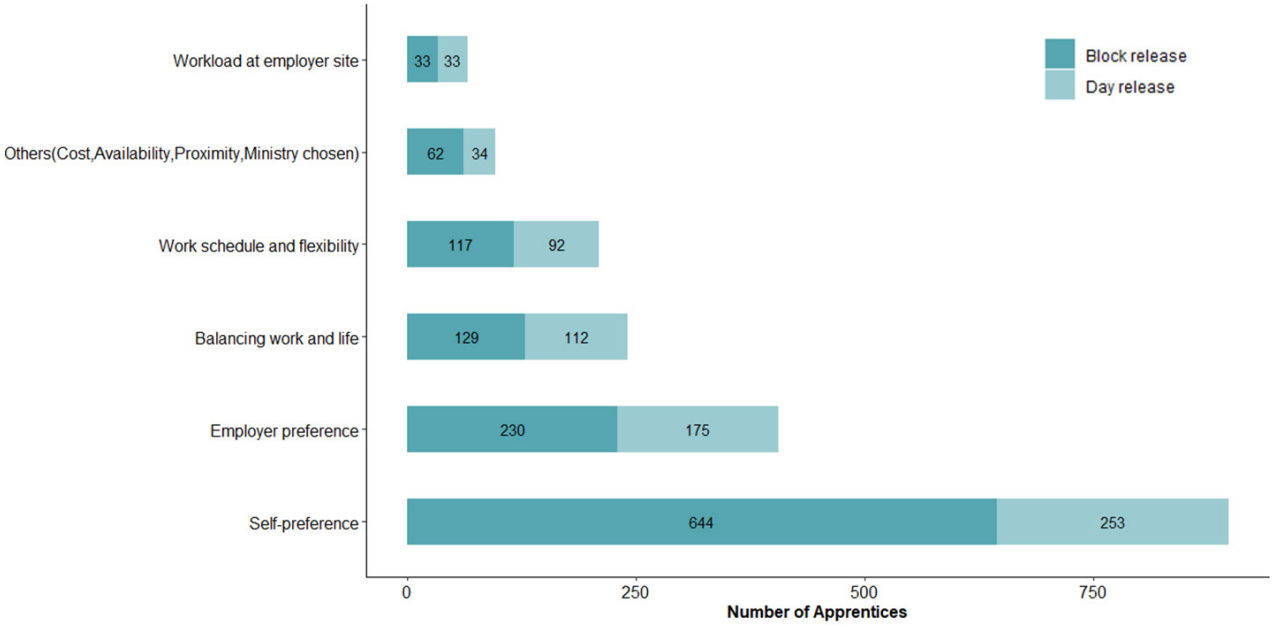

Figure 1. Distribution of reasons for choosing program (multiple selection).

3.2 Apprentice Perceived OHS Knowledge, Injuries, and Burnout

3.2.1 Overall self reported knowledge of health and safety, and Injuries

Overall, apprentices overwhelmingly agreed or strongly agreed that OHS training resulted in a range of benefits. Most apprentices either agreed or strongly agreed that OHS training would improve the inquired workplace safety metrics (96.8%) and were also in overall agreement or strong agreement that OHS training is beneficial (92.8%) (Figure 2). Apprentices overall agreed or strongly agreed that receiving OHS training can help in the reduction of workplace accidents (97.5%).

While apprentices agreed that OHS training is beneficial from a safety standpoint, less apprentices agreed or strongly agreed that OHS training specifically can help improve performance and productivity. Apprentices agreed or strongly agreed that they were confident in their ability to take precautions (97.0%), and to keep their coworkers (94.5%) and themselves (94.0%) working safely. Apprentices were also in overall agreement that they were confident in their knowledge of the physical (98.7%) and mental (95.9%) demands of the role. This higher level of confidence is despite a lower level of confidence that they knew where to find additional OHS information (81.3%). While apprentices overall agreed or strongly agreed that they were confident in the skills they built in their apprenticeship (94.6%), less apprentices agreed that their employer's training was adequate (85.1%), or that they were aware of the safety and ergonomics of their workplace tools (77%).

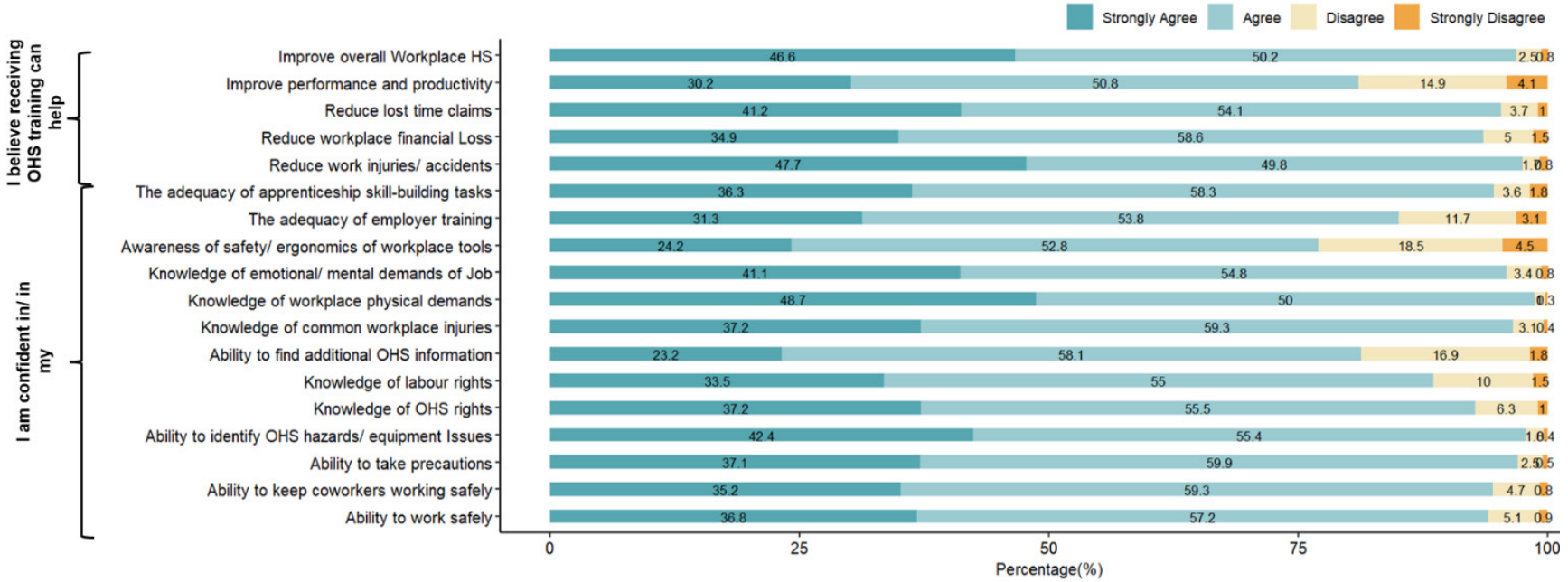

Figure 2. Breakdown of apprentice perceptions (n = 1308). Apprentices that preferred not to answer any of the questions were removed.

We observed what apprentices in each skilled trade reported regarding their perceived beliefs towards OHS training and their perceived OHS knowledge. Overall, participants from all trades, except welders, were over 80% agreement that OHS training could reduce workplace financial loss; only 70% of the 20 welders that responded agreed or strongly agreed (Table 4). Welders were also less likely to agree or strongly agree that OHS training may reduce work injuries/ accidents/ lost time claims and improve overall OHS. In contrast, while perceptions of OHS training towards the reduction of workplace injuries and loss were overwhelmingly positive across all trades, only 78% of apprentices perceived OHS training to improve workplace performance. A Wilcoxon signed-rank test indicated that this difference was statistically significant ($V = 1651$, $p < 0.001$). Of these trades, 70% of general carpenters (69.4%) agreed or strongly agreed that OHS training improved workplace performance. This trend may

indicate that OHS training may be perceived as positive towards maintaining safety but is not necessarily linked to improvements in performance and productivity.

Table 4. Breakdown of apprentice perceptions about their OHS training, grouped by program.

Program	Percentage (%) of apprentices that agreed with the statement that that OHS training would…				
	improve overall workplace health and safety	improve performance / productivity	reduce lost time claims	reduce work injuries / accidents	reduce workplace financial loss
Automotive Service Technician (n = 246)	92.7	80.1	89.8	92.3	88.2
Brick and Stone Mason (n = 83)	94.0	81.9	91.6	94.0	86.7
Cabinet Maker (n = 41)	97.6	80.5	97.6	100.0	97.6
Electrician (n = 329)	95.1	78.1	93.3	95.4	91.8
General Carpenter (n = 98)	89.8	69.4	88.8	90.8	85.7
General Machinist (n = 71)	94.4	83.1	90.1	97.2	88.7
Metal Fabricator (Fitter) (n = 75)	92.0	74.7	92.0	92.0	92.0
Millwright (n = 74)	91.9	78.4	90.5	91.9	87.8
Plumber (n = 171)	88.3	74.9	86.5	90.1	87.1
Refrigeration and Air Conditioning Systems Mechanic (n = 90)	92.2	76.7	92.2	93.3	86.7
Tool and Die Maker (n = 25)	96.0	88.0	100.0	100.0	92.0
Truck and Coach Technician	93.8	77.5	93.1	94.4	92.5

(n = 160)					
Welder (n =20)	80.0	70.0	85.0	85.0	70.0
Average (n = 1483)	**92.1 (±4.4)**	**77.9 (±5.1)**	**91.6 (±4.0)**	**93.6 (±4.1)**	**88.2 (±6.4)**

We further investigated the perceived workplace health and safety benefits of apprentices' current OHS training (Tables 5 and 6). Apprentices across all trades overall agreed that current OHS training has enabled them to identify OHS hazards/ equipment issues (93.0%), allowed them to take precautions when working (91.7), and allowed them to keep their coworkers (89.3%) and themselves (89.1%) working safely (Table 5). In contrast, apprentices did not agree, to the same extent, that their received OHS training contributed to their awareness of the safety/ ergonomics of their workplace tools (72.1%). This demonstrates a potential contrast in the awareness of skilled trades apprentices towards immediate workplace hazards, but a relative lack of awareness towards tool ergonomics, and the gradual physical impact from ill-fitting and poorly designed tools.

Table 5. Breakdown of apprentice perceptions about the benefits of OHS training towards improving health, safety, and ergonomics knowledge, grouped by program.

Program	**Percentage (%) of apprentices that agreed with the statement that that the OHS training they received so far would allow them to…**				
	work safely	**keep coworkers working safely**	**identify ohs hazards/ equipment issues**	**take precautions**	**be aware of the safety/ ergonomics of workplace tools**
Automotive Service Technician (n = 246)	93.5	90.7	95.1	93.5	73.2
Brick and Stone Mason (n = 83)	92.8	91.6	94.0	91.6	77.1
Cabinet Maker (n = 41)	97.6	97.6	97.6	97.6	87.8
Electrician (n = 329)	88.1	90.3	94.5	93.3	72.9
General Carpenter	91.8	92.9	93.9	94.9	77.6

(n = 98)					
General Machinist (n = 71)	91.5	94.4	95.8	95.8	70.4
Metal Fabricator (Fitter) (n = 75)	88.0	89.3	89.3	86.7	73.3
Millwright (n = 74)	93.2	94.6	91.9	94.6	67.6
Plumber (n = 171)	83.6	86.5	91.2	90.1	67.8
Refrigeration and Air Conditioning Systems Mechanic (n = 90)	86.7	86.7	94.4	92.2	72.2
Tool and Die Maker (n = 25)	84.0	80.0	92.0	88.0	60.0
Truck and Coach Technician (n = 160)	91.9	91.9	93.8	94.4	77.5
Welder (n =20)	75.0	75.0	85.0	80.0	60.0
Average (n = 1486)	**89.1 (±3.2)**	**89.3 (±6.2)**	**93.0 (±4.7)**	**91.7 (±5.8)**	**72.1 (±7.5)**

Apprentices overall perceived themselves to be knowledgeable about the physical (91.6%) and mental (88.7%) demands of their job, their knowledge of common workplace injuries (90.0%), their OHS rights (86.2%), and their labour rights (82.1%) (Table 6). However, apprentices overall perceived themselves to be relatively less knowledgeable about where to find additional OHS information (76.9%). Based on represented trades, fewer plumbers perceived having knowledge across all factors (less than 70% of respondents).

Table 6. Breakdown of apprentice perceived knowledge of occupational health, safety, and ergonomics, grouped by program.

Program	Percentage (%) that perceived that they had knowledge of…					
	where to find additional	common workplace injuries	emotional / mental	labour rights	OHS rights	workplace physical demands

	OHS information		demands of the job			
Automotive Service Technician (n = 246)	80.1	93.9	95.1	86.6	91.5	97.2
Brick and Stone Mason (n = 83)	85.5	94.0	92.8	88.0	90.4	95.2
Cabinet Maker (n = 41)	78.0	97.6	97.6	87.8	92.7	97.6
Electrician (n = 329)	73.6	91.5	88.8	83.0	86.9	93.6
General Carpenter (n = 98)	79.6	93.9	88.8	88.8	88.8	95.9
General Machinist (n = 71)	80.3	94.4	91.5	80.3	84.5	95.8
Metal Fabricator (Fitter) (n = 75)	84.0	93.3	93.3	88.0	93.3	94.7
Millwright (n = 74)	78.4	87.8	89.2	79.7	86.5	90.5
Plumber (n = 171)	52.6	63.2	67.3	62.6	63.7	67.8
Refrigeration and Air Conditioning Systems Mechanic (n = 90)	80.0	96.7	95.6	83.3	88.9	97.8
Tool and Die Maker (n = 25)	72.0	88.0	80.0	76.0	84.0	88.0
Truck and Coach Technician (n = 160)	81.2	95.6	92.5	83.8	89.4	96.2
Welder (n =20)	75.0	80.0	80.0	80.0	80.0	80.0
Average (n = 1486)	**76.9 (±8.2)**	**90.0 (±9.3)**	**88.7 (±8.4)**	**82.1 (±7.1)**	**86.2 (±7.7)**	**91.6 (±8.7)**

Although apprentices, in general, agreed that they received adequate OHS training from their employers (89.1%) and through the apprenticeship program (81.7%) (Table 7), the level

of agreement was different between trade programs. For example, only 73.8% truck and coach technicians agreed that their tasks through apprenticeship were sufficient to develop necessary skills, compared to 92.9% of general carpenters. Only 80% of welders and tool/die makers agreed that they received adequate training from their employers, compared to 95.2% of brick and stone masons.

Table 7. Breakdown of apprentice perceptions regarding the adequacy of their training, grouped by trade.

Program	Percentage (%) of apprentices that agreed that they...	
	received adequate training from their employer	built sufficient competency and skills through the work tasks they received during their apprenticeship
Automotive Service Technician (n = 246)	91.5	82.9
Brick and Stone Mason (n = 83)	95.2	90.4
Cabinet Maker (n = 41)	87.8	78.0
Electrician (n = 329)	92.1	79.3
General Carpenter (n = 98)	91.8	92.9
General Machinist (n = 71)	88.7	88.7
Metal Fabricator (Fitter) (n = 75)	88.0	82.7
Millwright (n = 74)	91.9	82.4
Plumber (n = 171)	91.8	81.9
Refrigeration and Air Conditioning Systems Mechanic (n = 90)	90.0	77.8
Tool and Die Maker (n = 25)	80.0	76.0

Truck and Coach Technician (n = 160)	90.0	73.8
Welder (n =20)	80.0	75.0
Average (n = 1486)	**89.1 (±4.5)**	**81.7 (±6.0)**

Figure 3 highlights the proportion of apprentices that reported body pain across each body segment, and the duration of pain that they experienced. On average, more than half of participating apprentices reported pain in at least one body part; back pain was most prevalent (63.6%) while elbow pain was least prevalent (37.6%).

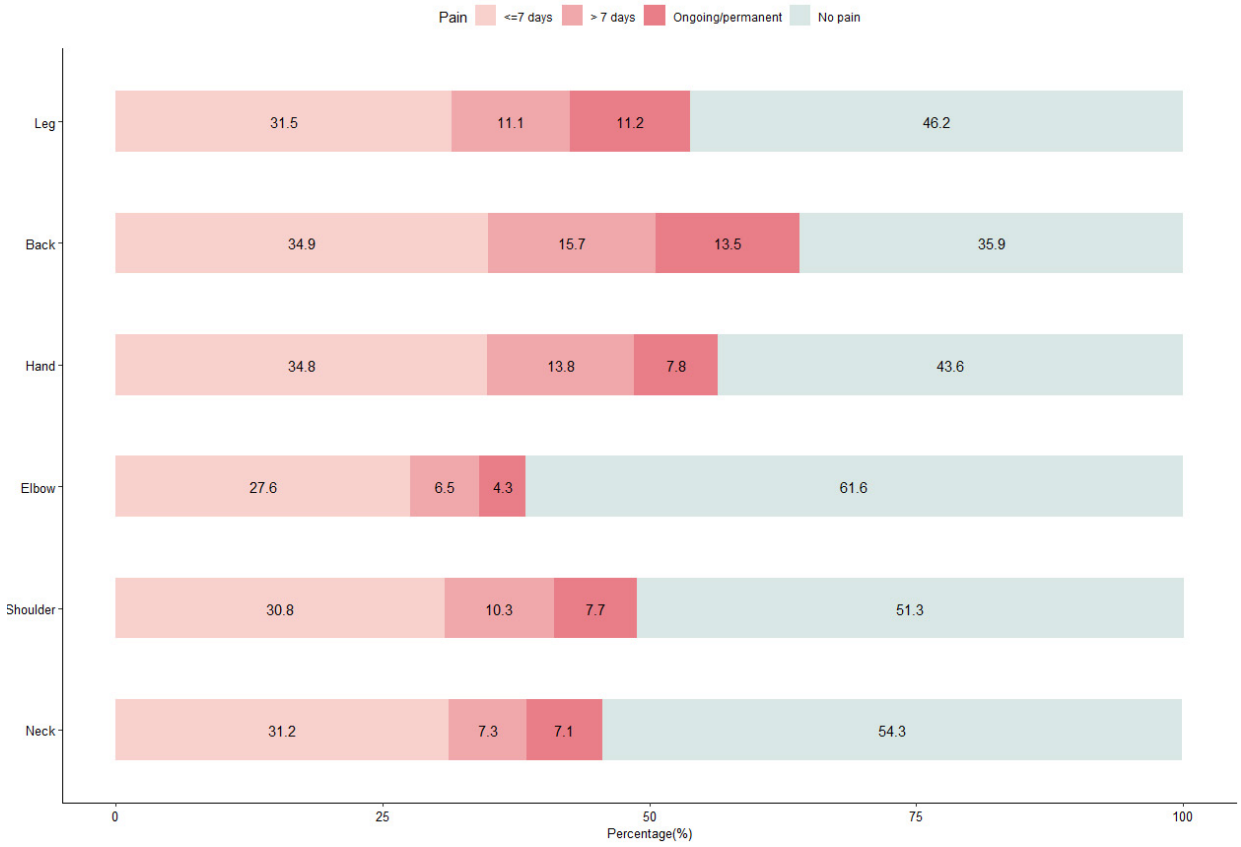

Figure 3. Breakdown of apprentice pain by body segment (n = 1286). Apprentices that preferred not to answer any of the questions were removed.

After stratifying the prevalence of pain by age group, we observed an increasing trend in self reported pain with increasing age of apprentices across all body segments, except for the back, which was uniformly high across all age groups (Figure 4). This pattern is particularly more pronounced for the reporting of elbow and hand pain between

apprentices aged 15-24 years (32.9% and 53.0%) and apprentices aged 34 years and older (48.4% and 68.2%).

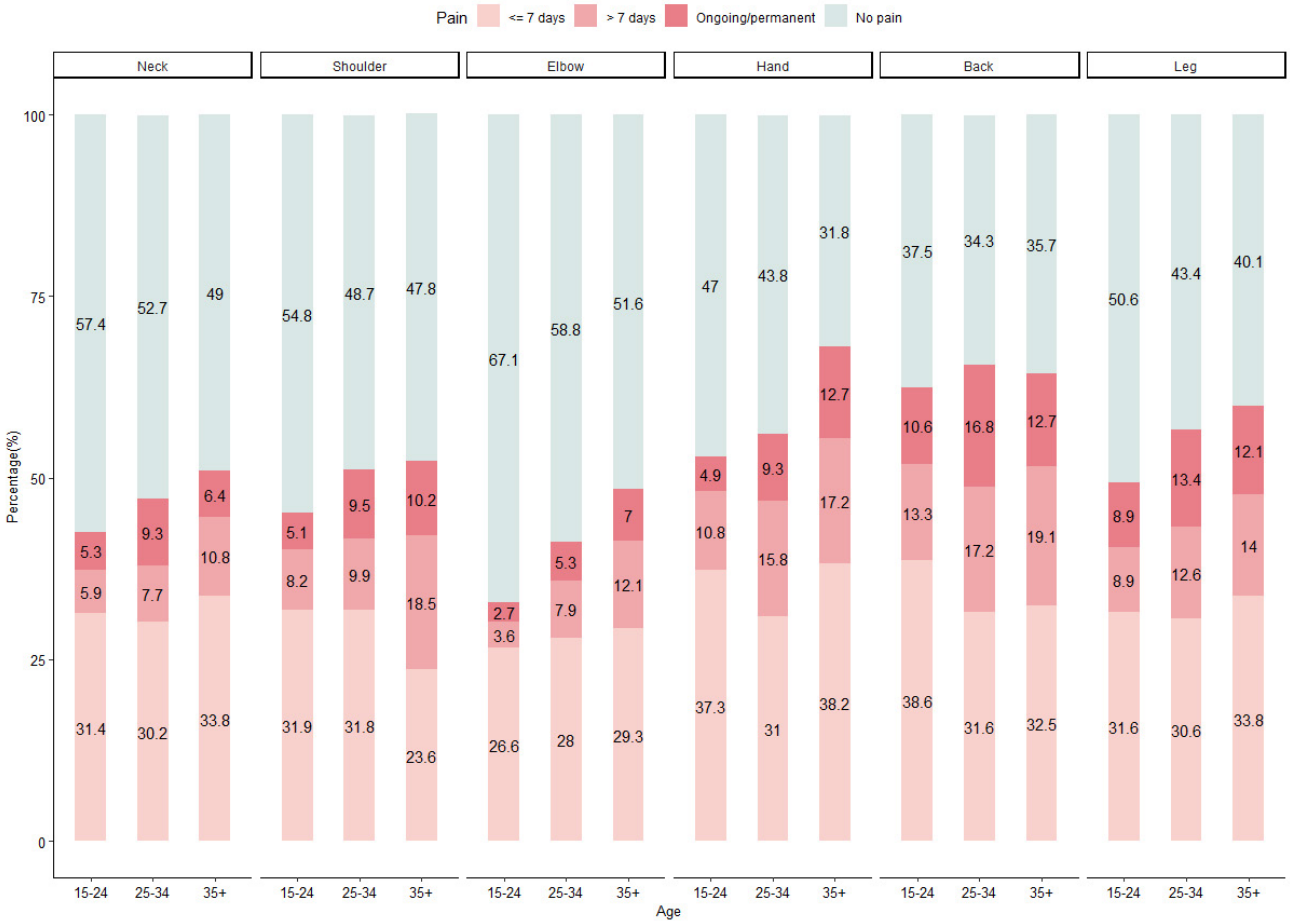

Figure 4. Breakdown of apprentices with pain across different body segments, grouped by age (n: 15-24 = 526; 25-34 = 493; 35+ = 157)

There was a statistically significant relationship between an apprentice's age and whether they reported experiencing any pain at any body segment ($\chi^2(2) = 43.2$, $p < 0.001$). A further analysis of the odds ratios revealed that apprentices aged 15-24 years had the least pain reporting, while those aged 35+ years were significantly more likely to report experiencing pain than those aged 25-34 years (OR = 1.24 (1.08,1.44)).

There was also a statistically significant relationship between an apprentice's age and whether they self-reported experiencing ongoing/ permanent pain at any body segment ($\chi^2(2) = 56.9$, $p < 0.001$). Apprentices aged 24-34 and 34+ years had similar permanent pain

reporting but were both almost twice as likely to report experiencing permanent pain compared to apprentices aged 15-24 years (OR = 1.92 (1.61,2.30) and OR = 1.83 (1.44,2.33), respectively).

After stratifying the prevalence of pain by level, we found that Level 2 apprentices had an overall higher pain reporting across all body segments compared to Level 1 and Level 3 apprentices (Figure 5). The association between an apprentice's level and their pain reporting was statistically confirmed ($\chi_2(2) = 18.96$, $p < 0.001$), but a similar association did not exist between their level and permanent pain reporting ($\chi_2(2) = 1.76$, $p = 0.41$). As observed in Figure 5, Level 1 and Level 3 apprentices had similar pain reporting (OR = 1.00 (0.90-1.10)), while Level 2 apprentices had the highest reporting compared to the other two levels (OR = 1.27 (1.13,1.42) and OR = 1.26 (1.12,1.43), respectively.

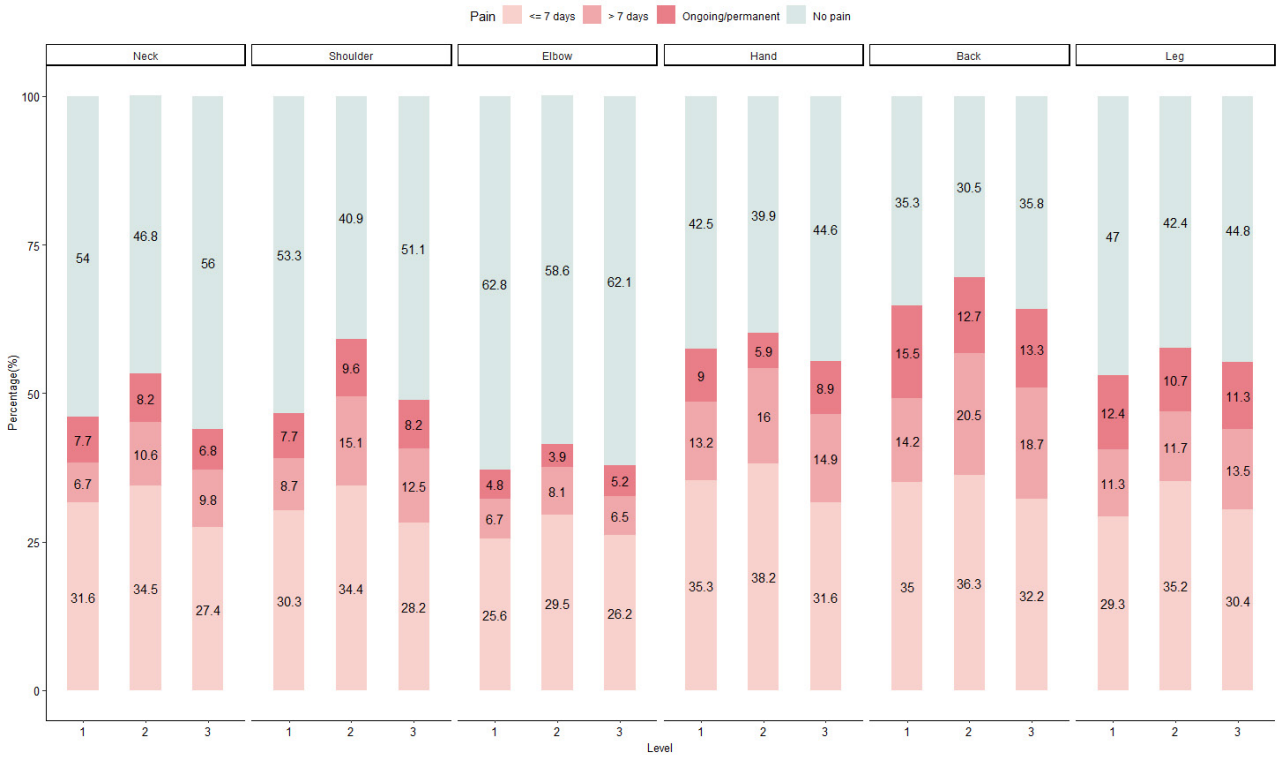

Figure 5. Breakdown of apprentices with pain across different body segments, grouped by level (n: Level 1 = 635; Level 2 = 283; Level 3 = 413)

A further breakdown across different body segments, stratified by trade, visually demonstrates the high prevalence of pain across all trades (Figure 6). More than 50% of apprentices reported experiencing back pain over the last twelve months; a large

proportion of apprentices from brick and stone mason (74.3%), truck and coach technician (72.1%), and plumber (70.7%) programs reported low back pain. Brick and stone masons and truck and coach technicians were also among the highest to self-report pain across all body parts but were lower in long term/ permanent pain reporting compared to metal fabricators, with over 15% reporting permanent pain in any body part. Of additional note, 30% of metal fabricators reported experiencing permanent hand pain. Welders overall self-reported the highest prevalence of permanent pain in the shoulder (20%) and were among the highest in the reporting of permanent pain in the back (20%) along with metal fabricators, and tool/ die makers (23.8%).

Figure 6. Breakdown of apprentice pain by program (n = 1178: welder = 15; truck and coach technician = 130; tool and die maker = 21; refrigeration and air conditioning systems mechanic = 70; plumber = 140; millwright = 54; metal fabricator = 61; general machinist = 55; general carpenter = 85; electrician = 247; cabinet maker = 30; brick and stone mason = 70; automotive service technician = 200).

Of the participating apprentices, 25.4% reported that they had experienced a bodily injury over the past 12 months (Figure 7). Of those that were injured, nearly half of them (or approximately 1 in 10 apprentices over the entire sample) had an injury that required serious medical attention and/ or time off from work.

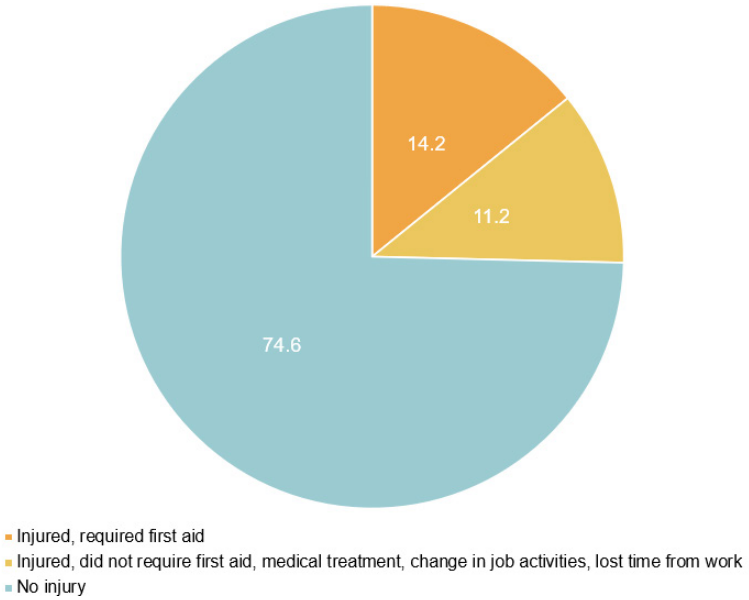

Figure 7. Breakdown of whether an apprentice has been injured over the last 12 months (n = 1426).

A further breakdown of injuries across trades identified that truck and coach technicians (36.8%), metal fabricators (36.0%), and tool/ die makers (36.0%) demonstrated the highest overall injury prevalence over the last twelve months (Figure 8). However, while tool/ die makers reported a higher proportion of non-serious injuries where they could continue working, injuries reported by truck and coach technicians and metal fabricators were more likely to result in time off from work. Note that brick and stone masons reported the lowest proportion of injuries (15.6%) across all trades but were among the highest to report pain across all body segments. This trend lends some insight into the trade-off between trades with a higher likelihood of developing pain through long-term MSD development such as brick and stone masons, and permanent pain associated with roles reporting high proportions of immediate injuries requiring time off, such as metal fabricators.

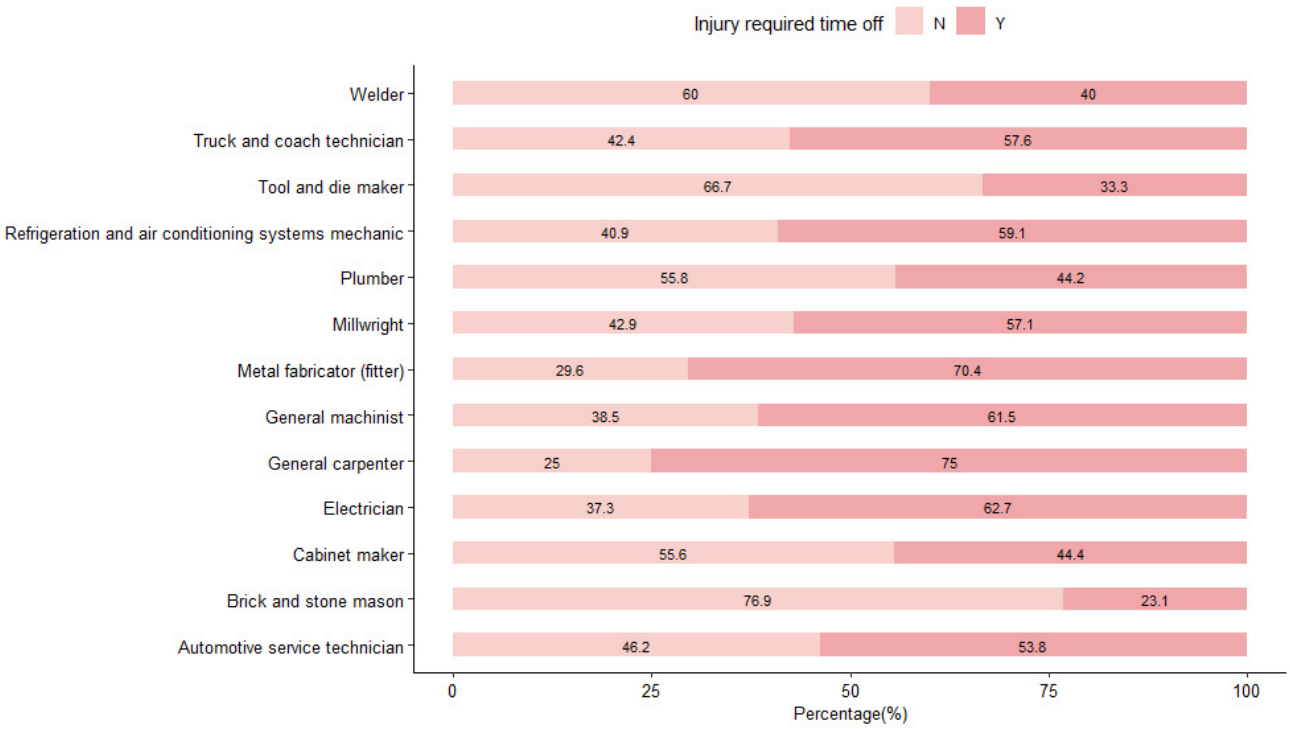

Figure 8. Proportion injuries that required time off work, across all apprentices that reported an injury, grouped by program (total n = 362 injuries/1486 apprentices: welder = 5/20; truck and coach technician = 59/160; tool and die maker = 9/25; refrigeration and air conditioning systems mechanic = 22/90; plumber = 43/171; millwright = 14/74; metal fabricator = 27/75; general machinist = 13/71; general carpenter = 16/98; electrician = 67/329; cabinet maker = 9/41; brick and stone mason = 13/83; automotive service technician = 65/246).

Across all age groups, there were no statistical differences regarding their perceptions of the benefits of occupational health and safety. However, there was a statistically significant difference between two age groups: apprentices 15-24 yrs and 35 yrs and older. Younger apprentices were 3.63 times more likely to have perceived themselves as being able to identify the emotional and mental demands of their job and perceived themselves to be more aware of the safety and ergonomics of the tools at the workplace (Table 8). The 15-24 age group had the most positive perception of their employer's training and mentorship when receiving OHS knowledge, whereas there was no difference between the 25-34 age group and apprentices aged 34 and over.

Table 8. Age differences in apprentice perceptions using Bonferroni-corrected pairwise Chi-squared comparisons.

Age Group Comparison	**1x2**		**1x3**		**2x3**	
I am confident in my…	**χ^2**	**Adjusted Probability ($p < 0.05$)**	**χ^2**	**Adjusted Probability ($p < 0.05$)**	**χ^2**	**Adjusted Probability ($p < 0.05$)**
Ability to work safely	1.33	1.00	0.67	1.00	0.00	1.00
Ability to keep coworkers working safely	1.08	1.00	0.00	1.00	0.68	1.00
Ability to take precautions	0.52	1.00	0.00	1.00	0.27	1.00
Ability to identify OHS hazards/ equipment Issues	0.42	1.00	0.00	1.00	0.32	1.00
Knowledge of OHS rights	1.72	1.00	0.09	1.00	1.49	1.00
Knowledge of labour rights	0.00	1.00	0.30	1.00	0.25	1.00
Ability to find additional OHS information	3.01	0.50	1.50	1.00	0.00	1.00
Knowledge of common workplace injuries	0.00	1.00	3.14	0.46	3.00	0.50
Knowledge of workplace physical demands	1.52	1.00	0.68	1.00	0.00	1.00
Knowledge of the emotional/ mental demands of my job	2.58	0.65	**12.49**	**OR = 3.63 (1.66 – 7.97) p=0.00***	4.21	0.24
Awareness of safety/ ergonomics of workplace tools	2.27	0.79	**7.37**	**OR = 1.74 (1.15 – 2.60) p=0.04***	2.41	0.72
Training and mentorship received by my employer	**14.45**	**OR = 2.02 (1.39 – 2.95) p=0.00***	**29.50**	**OR = 3.36 (2.10 – 5.37) p=0.00***	5.45	0.12
Competency and skills built through my assigned apprenticeship work tasks	0.06	1.00	2.78	0.58	1.87	1.00
I believe receiving occupational health and safety training can help…						

Reduce work injuries/ accidents	0.81	1.00	0.13	1.00	0.00	1.00
Reduce workplace financial loss	0.55	1.00	1.48	1.00	0.44	1.00
Reduce lost time claims	4.30	0.23	2.27	0.79	0.01	1.00
Improve performance and productivity	2.32	0.77	0.31	1.00	2.57	0.65
Improve overall Workplace Health and Safety	0.30	1.00	0.06	1.00	0.49	1.00

Age Groups: 1=15-24, 2=25-34, 3=35+

* *indicates a significant difference, and Odds Ratios (ORs) and confidence intervals were calculated.*

Comparing across apprenticeship training levels (Levels 1, 2, and 3) showed that Level 1 apprentices perceived themselves as being 2.3 times more capable of keeping their coworkers safe compared to Level 2 apprentices. There were no other statistically significant differences across other level comparisons (Table 9). There were also no other statistically significant differences between levels across any other perceptions. Compared to Level 3 apprentices, Level 2 apprentices were more likely to believe that receiving OHS training would improve their performance and productivity. There were no other differences in beliefs between other levels.

Table 9. Level differences in apprentice perceptions using Bonferroni-corrected pairwise Chi-squared comparisons.

Level Comparison	**1 vs 2**		**1 vs 3**		**2 vs 3**	
I am confident in my…	**χ^2**	**Adjusted Probability ($p < 0.05$)**	**χ^2**	**Adjusted Probability ($p < 0.05$)**	**χ^2**	**Adjusted Probability ($p < 0.05$)**
Ability to work safely	0.68	1.00	0.46	1.00	0.00	1.00
Ability to keep coworkers working safely	**7.33**	**OR = 2.30 (1.23 – 4.34) p = 0.04***	2.86	0.55	0.83	1.00
Ability to take precautions	0.05	1.00	1.15	1.00	1.63	1.00
Ability to identify OHS hazards/ equipment Issues	0.84	1.00	0.13	1.00	0.11	1.00
Knowledge of OHS rights	1.21	1.00	0.85	1.00	0.02	1.00
Knowledge of labour rights	1.01	1.00	0.01	1.00	1.16	1.00

Ability to find additional OHS information	0.17	1.00	0.41	1.00	0.95	1.00
Knowledge of common workplace injuries	0.31	1.00	0.00	1.00	0.33	1.00
Knowledge of workplace physical demands	0.11	1.00	0.00	1.00	0.30	1.00
Knowledge of the emotional/ mental demands of my job	0.13	1.00	0.15	1.00	0.00	1.00
Awareness of safety/ ergonomics of workplace tools	0.18	1.00	0.00	1.00	0.16	1.00
Training and mentorship received by my employer	0.48	1.00	1.07	1.00	0.01	1.00
Competency and skills built through my assigned apprenticeship work tasks	0.15	1.00	0.01	1.00	0.28	1.00
I believe that receiving occupational health and safety training can help…						
Reduce work injuries/ accidents	1.28	1.00	0.06	1.00	0.41	1.00
Reduce workplace financial loss	0.12	1.00	2.05	0.91	0.52	1.00
Reduce lost time claims	2.65	0.62	0.23	1.00	4.09	0.26
Improve performance and productivity	2.14	0.86	2.72	0.59	**7.68**	**OR = 1.79 (1.18 – 2.74) p = 0.04***
Improve overall Workplace Health and Safety	0.00	1.00	0.18	1.00	0.04	1.00

** indicates a significant difference, and Odds Ratios (ORs) and confidence intervals were calculated.*

After stratifying between release types, overall, the block and day release programs showed no statistically significant differences in their beliefs in OHS training (Table 10). However, apprentices in the block release program were 1.7 times more confident in the competency and skills they developed through their assigned work tasks.

Table 10. Block Release versus Day Release differences in perceptions using pairwise Chi-squared comparisons.

I am confident in my…	χ2	Probability (p < 0.05)
Ability to work safely	0.48	0.49
Ability to keep coworkers working safely	0.18	0.67
Ability to take precautions	0.06	0.81
Ability to identify OHS hazards/ equipment Issues	0.05	0.82
Knowledge of OHS rights	0.01	0.94
Knowledge of labour rights	1.61	0.20
Ability to find additional OHS information	0.74	0.39
Knowledge of common workplace injuries	0.00	0.95
Knowledge of workplace physical demands	0.79	0.38
Knowledge of emotional/ mental demands of Job	0.02	0.90
Awareness of safety/ ergonomics of workplace tools	0.00	0.96
Training and mentorship received by my employer	2.98	0.08
Competency and skills built through my assigned apprenticeship work tasks	**4.70**	**OR = 1.73 (1.04 – 2.84) p = 0.03***
I believe that receiving occupational health and safety training can help…		
Reduce work injuries/ accidents	0.60	0.44
Reduce workplace financial Loss	0.57	0.45
Reduce lost time claims	0.16	0.68
Improve performance and productivity	1.76	0.19
Improve overall Workplace HS	2.63	0.10

** indicates a significant difference, and Odds Ratios (ORs) and confidence intervals were calculated.*

3.2.3 Relationships between Apprentice Perceived OHS Knowledge and Injury

Overall, apprentices that perceived themselves to be confident in their OHS training were 51-76% less likely to self-report an injury over the last twelve months (Table 11). There were no associations between an apprentice's injury self-reporting and whether they were knowledgeable about their OHS rights or labor rights, and whether they were aware of the emotional/ mental demands of their job. Additionally, there were no significant associations between injured versus non-injured apprentices regarding their beliefs that receiving OHS training will help reduce work injuries/ accidents, reduce lost time claims, or improve performance and productivity. However, an apprentice was less likely to self-report an

injury if they reported that they believed that workplace OHS training can reduce workplace financial loss (41% reduction) or improve overall workplace health and safety (52% reduction).

Injury self-reporting was then stratified by age and program before analysis. There were no statistically significant differences seen across age groups ($\chi_2(2) = 2.82$, $p = 0.24$). However, there was a significant difference between programs; apprentices in the day release program were more likely to report having an injury over the last twelve months compared to apprentices in the block release programs ($\chi_2(1) = 9.23$, $p = 0.002$, OR = 1.5 (1.15,1.96)). An apprentice's level was also associated with whether they reported having an injury over the last twelve months ($\chi_2(2) = 21.60$, $p < 0.001$), but not between their level and their reporting of serious injuries ($\chi_2(2) = 1.10$, $p = 0.58$). Level 1 apprentices had similar injury self-reporting compared to Level 2 apprentices (OR = 1.27 (0.94,1.72)), and both levels had higher injury self-reporting compared to Level 3 apprentices (OR = 1.99 (1.48,2.66), and OR = 1.56 (1.10,2.22), respectively).

Table 11. Injury Status: Perceptions of apprentices that have reported to be injured over the last 12 months versus those that have not been injured.

I am confident in my…	**$\chi 2$**	**Probability ($p < 0.05$)**	**Odds Ratios (95% Confidence Intervals)**
Ability to work safely	**9.50**	**0.00***	**0.49 0 - 0.79)**
Ability to keep coworkers working safely	**14.14**	**0.00***	**0.41 0 - 0.67)**
Ability to take precautions	**6.35**	**0.01***	**0.44 0 - 0.86)**
Ability to identify OHS hazards/ equipment Issues	**5.95**	**0.01***	**0.39 0 - 0.87)**
Knowledge of OHS rights	0.70	0.40	-
Knowledge of labour rights	3.03	0.08	-
Ability to find additional OHS information	**15.08**	**0.00***	**0.56 0 - 0.76)**
Knowledge of common workplace injuries	**16.76**	**0.00***	**0.30 0 - 0.56)**
Knowledge of workplace physical demands1	**-**	**0.00***	**0.24 0 - 0.70)**
Knowledge of emotional/ mental demands of Job	0.47	0.49	-
Awareness of safety/ ergonomics of workplace tools	**40.00**	**0.00***	**0.43 0 - 0.56)**
Training and mentorship received by my employer	**35.61**	**0.00***	**0.40 0 - 0.55)**
Competency and skills built through my assigned appr enticeship work tasks	**19.10**	**0.00***	**0.36 0 - 0.59)**
I believe that receiving occupational health and safety training can help…			
Reduce work injuries/ accidents	2.33	0.13	-

Reduce workplace financial Loss	**5.16**	**0.02***	**0.59 (0 - 0.94)**
Reduce lost time claims	0.36	0.55	-
Improve performance and productivity	0.02	0.89	-
Improve overall Workplace HS	**5.24**	**0.02***	**0.48 (0 - 0.92)**

**indicates a significant difference, and Odds Ratios (ORs) and confidence intervals were calculated.*

3.2.3 Relationships between Apprentice Perceptions and Perceived Personal Impacts

We found a statistically significant relationship between societal factors (i.e., current skilled trades shortage) and apprentice's feeling of being rushed at work, across all levels (Table 12). Post-hoc Bonferroni-corrected pairwise comparisons of levels revealed that Level 3 apprentices felt 1.6 times more rushed at work compared to Level 1 apprentices. There were also significant differences between those in block and day release programs; apprentices in the day release program were 1.4 times more likely to report feeling physically fatigued compared to apprentices in the block release program.

Table 12. Perceived personal impact associated with the skilled trades shortage, stratified by level, age, and program.

Factor	Level		Age		Program	
	χ^2 (df = 2)	**Probability (p < 0.05)**	**χ^2 (df = 2)**	**Probability (p < 0.05)**	**χ^2 (df =1)**	**Probability (p < 0.05)**
Feeling overwhelmed at work	5.86	0.05	3.39	0.18	2.85	0.09
Feeling rushed at work	**7.49**	**0.02***	0.06	0.97	1.23	0.27
Working overtime	1.24	0.54	0.60	0.74	0.56	0.45
Feeling physically fatigued	2.83	0.24	0.54	0.76	**4.06**	**OR = 1.39 (1.08,1.91) p=0.04***

Feeling burned out	2.11	0.35	1.74	0.42	**6.94**	**OR = 1.53 (1.11, 2.11) p=0.01***

** indicates a significant difference, and Odds Ratios (ORs) and confidence intervals were calculated.*

There were observed associations between self-reported feelings of being burned out, and certain perceptions about OHS but not others (Table 13). However, there were no associations between the presence of burnout in an apprentice and any of their inquired beliefs in OHS training.

Table 13. Burnout: Apprentice perceptions and self-reported feelings of burnout in response to the skilled trades shortage versus those that did not report being burnt out.

I am confident in my…	χ2	Probability (p < 0.05)	Odds Ratios (Confidence Intervals)
Ability to work safely	2.88	0.09	0.52
Ability to keep coworkers working safely	0.43	0.51	0.74
Ability to take precautions	1.47	0.22	0.48
Ability to identify OHS hazards/ equipment Issues	0.23	0.63	0.69
Knowledge of OHS rights	3.10	0.08	0.55
Knowledge of labour rights	**7.37**	**0.01***	**0.45 (0 - 0.81)**
Ability to find additional OHS information	**16.39**	**0.00***	**0.42 (0 - 0.65)**
Knowledge of common workplace injuries	**5.72**	**0.02***	**0.30 (0 - 0.82)**
Knowledge of workplace physical demands [1]	**-**	**0.02***	**0.11 (0 - 0.83)**
Knowledge of emotional/ mental demands of Job	0.81	0.37	0.61
Awareness of safety/ ergonomics of workplace tools	**27.84**	**0.00***	**0.36 (0 - 0.54)**
Training and mentorship received by my employer	**25.02**	**0.00***	**0.30 (0 - 0.49)**
Competency and skills built through my assigned apprenticeship work tasks	**11.24**	**0.00***	**0.29 (0 - 0.62)**
I believe that receiving occupational health and safety training can help…			
Reduce work injuries/ accidents	0.08	0.78	0.82
Reduce workplace financial Loss	1.24	0.27	0.69
Reduce lost time claims	0.43	0.51	0.77
Improve performance and productivity	0.94	0.33	0.81
Improve overall Workplace HS	0.76	0.38	0.67

** indicates a significant difference, and Odds Ratios (ORs) and confidence intervals were calculated. An odds ratio below 1 for a significant comparison is protective; the apprentice is less likely to report feelings of burnout*

Due to the skilled trades shortage, apprentices who reported feelings of being overwhelmed were less confident in their: ability to find additional OHS information, knowledge of physical demands, awareness of safety tools, training/ mentorship from their employer, and competence/ skills developed from their work tasks (Table 14). We did not find significant associations (either positive or negative) between reported feelings of being overwhelmed due to the workforce shortage and their beliefs in the value of health and safety training.

Table 14. Overwhelm: Apprentice perceptions and self-reported feelings of being overwhelmed in response to the skilled trades shortage versus those who did not report feeling overwhelmed.

I am confident in my…	**χ2**	**Probability (p < 0.05)**	**Odds Ratios (Confidence Intervals)**
Ability to work safely	0.08	0.77	0.86
Ability to keep coworkers working safely	0.13	0.72	1.21
Ability to take precautions	**4.31**	**0.04*** [1]	**0.33**
Ability to identify OHS hazards/ equipment Issues	0.00	1.00	1.06
Knowledge of OHS rights	1.40	0.24	0.66
Knowledge of labour rights	1.19	0.28	0.72
Ability to find additional OHS information	**7.06**	**0.01***	**0.57 (0 - 0.87)**
Knowledge of common workplace injuries	1.37	0.24	0.56
Knowledge of workplace physical demands[1]	**4.40**	**0.04***	**0.18 (0 - 0.92)**
Knowledge of emotional/ mental demands of Job	1.92	0.17	0.52
Awareness of safety/ ergonomics of workplace tools	**23.12**	**0.00***	**0.41 (0 - 0.59)**
Training and mentorship received by my employer	**14.48**	**0.00***	**0.41 (0 - 0.66)**
Competency and skills built through my assigned apprenticeship work tasks	**9.91**	**0.00***	**0.33 (0 - 0.68)**
I believe that receiving occupational health and safety training can help…			
Reduce work injuries/ accidents	0.00	1.00	1.08
Reduce workplace financial Loss	1.19	0.27	0.70
Reduce lost time claims	0.00	0.96	0.94
Improve performance and productivity	0.10	0.75	0.92
Improve overall Workplace HS	1.51	0.22	0.59

** indicates a significant difference, and Odds Ratios (ORs) and confidence intervals were calculated.*

1 Fisher's exact test used for calculations where at least one subset of observed frequencies was less than 5).

The reporting of physical fatigue by apprentices was observed to be associated with feeling less confident in their ability to find additional OHS information, in their awareness of the safety/ ergonomics of workplace tools, in the training and mentorship they received from their employer, and in their assigned apprenticeship work tasks (Table 15). There were no significant associations in the presence of self-reported physical fatigue in an apprentice and their beliefs in OHS training.

Table 15. Fatigue: Apprentice perceptions and self-reported feelings of feeling physically fatigued in response to the skilled trades shortage versus those who did not report feeling physically fatigued.

I am confident in my…	**χ2**	**Probability ($p < 0.05$)**
Ability to work safely	1.03	0.31
Ability to keep coworkers working safely	0.00	1.00
Ability to take precautions	1.25	0.26
Ability to identify OHS hazards/ equipment Issues	0.00	1.00
Knowledge of OHS rights	2.53	0.11
Knowledge of labour rights	5.02	0.03
Ability to find additional OHS information	**9.25**	**OR = 0.52 (0.34-0.80) p=0.00***
Knowledge of common workplace injuries	2.76	0.10
Knowledge of workplace physical demands[1]	2.56	0.11
Knowledge of emotional/ mental demands of Job	2.31	0.13
Awareness of safety/ ergonomics of workplace tools	**21.05**	**OR = 0.42 (0.28-0.61) p=0.00***
Training and mentorship received by my employer	**17.29**	**OR = 0.36 (0.21-0.60) p=0.00***
Competency and skills built through my assigned apprenticeship work tasks	6.60	**OR = 0.38 (0.17-0.81) p=0.01***
I believe that receiving occupational health and safety training can help…		
Reduce work injuries/ accidents	0.00	1.00
Reduce workplace financial Loss	0.25	0.62
Reduce lost time claims	0.12	0.72
Improve performance and productivity	0.15	0.70
Improve overall Workplace HS	0.30	0.59

** indicates a significant difference, and Odds Ratios (ORs) and confidence intervals were calculated.*

3.3 Functional Limitations

Of the 1486 apprentices surveyed, 298 (20.0%) reported at least one functional limitation that may impact their ability to perform in the classroom and/ or workplace (Figure 9). Of those 298 apprentices, 36.9% reported having more than one functional limitation.

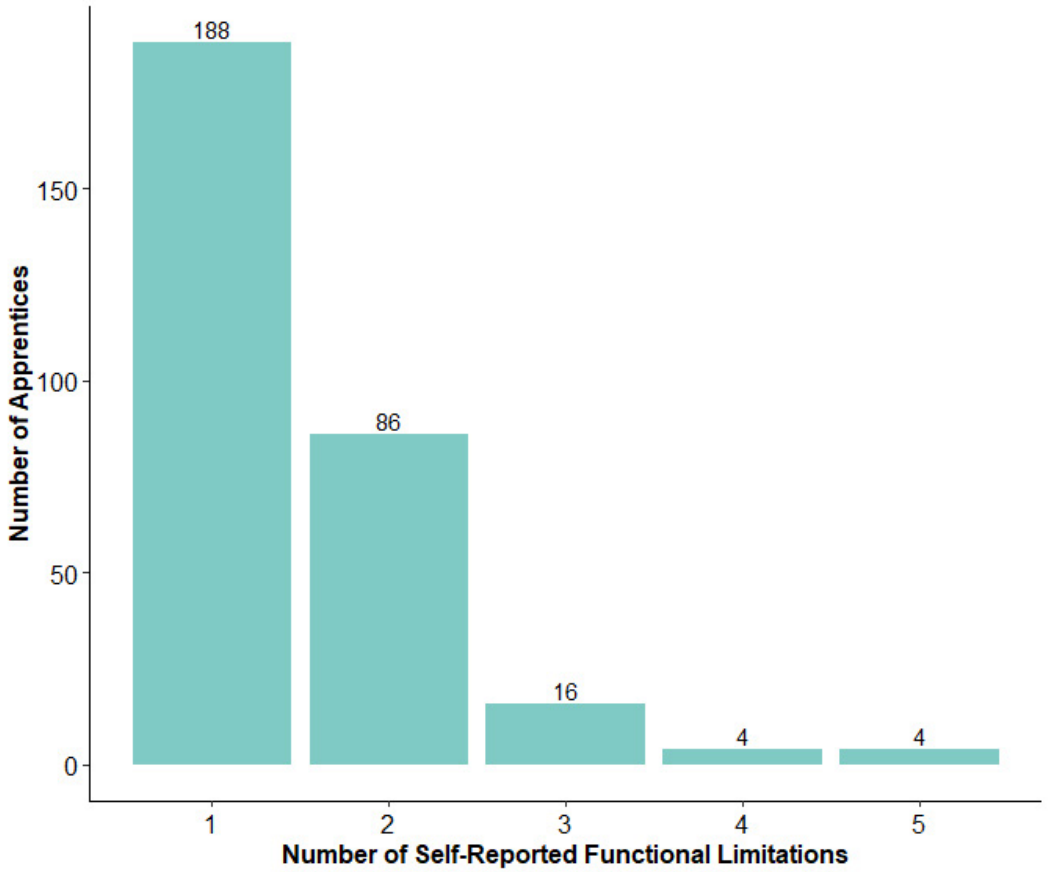

Figure 9. Breakdown of apprentices that reported at least one functional limitation.

A total of 437 functional limitations were self-reported by the 298 apprentices. These limitations were either physical (seeing, hearing, walking/ climbing stairs) or cognitive (concentrating/ remembering/ making decisions, learning) (Figure 10). Most self-reported functional limitations were related to difficulties learning (47.4%) and concentrating, remembering and/ or making decisions (36.8%).

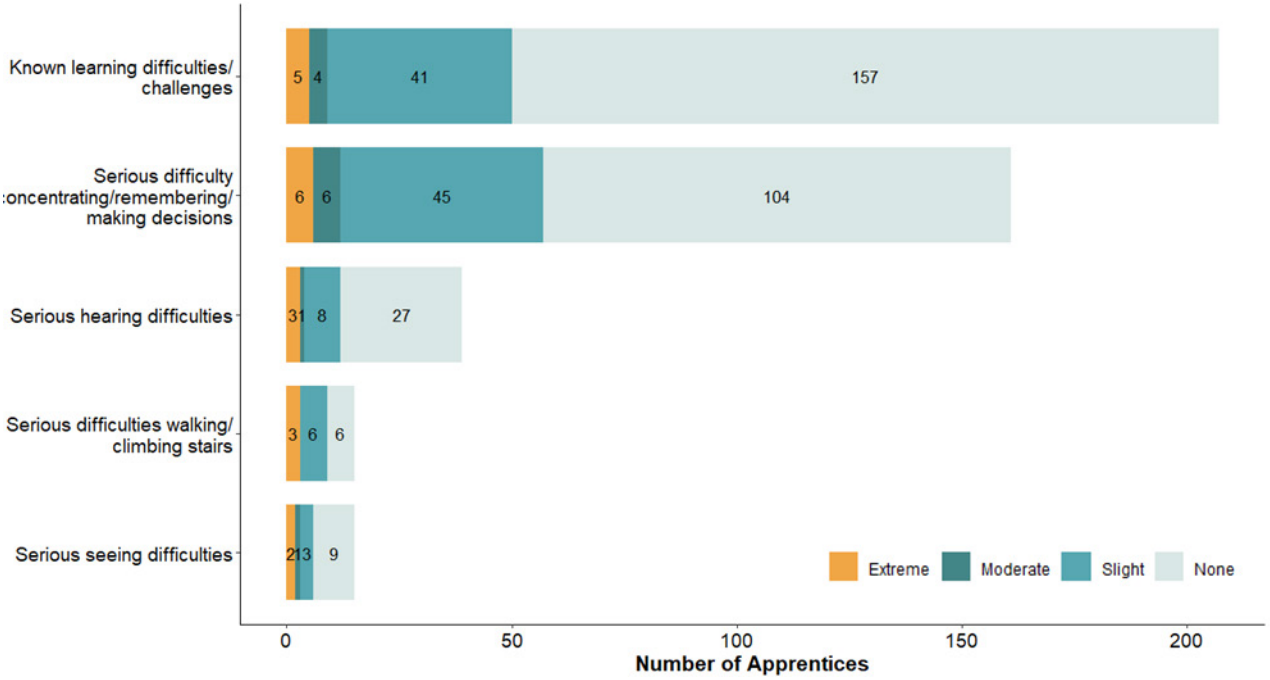

Figure 10. Frequency of limitations, and their level of impact on an apprentice's ability to work.

Most apprentices (69.5%) reported that they did not perceive that they were impacted by their functional limitations (Figure 10). A greater frequency of apprentices self-reported that they were impacted by difficulties seeing and hearing, compared to other functional limitations (Table 16).

Table 16. Apprentices affected by their functional limitations.

Functional limitation	Impacted (out of 437 reported limitations)
Serious seeing difficulties	57 (35.4%)
Serious hearing difficulties	50 (24.2%)
Serious difficulty concentrating/ remembering/ making decisions	12 (30.8%)
Serious difficulty walking/ climbing stairs	9 (60.0%)
Known learning difficulties/ challenges	6 (40.0%)
Total	**134 (30.2%)**

Despite an apprentice's self-report that they are unaffected by their functional limitations, apprentices with at least one functional limitation perceived themselves overall as less

confident in their OHS knowledge (Table 17). Apprentices with at least one self-reported functional limitation were also less likely to believe that OHS training can help reduce injuries, financial loss, lost time claims, and improve overall workplace health and safety.

Table 17. Relationships between the presence of functional limitation(s) and perceptions regarding OHS training.

I am confident in my…	χ^2	Probability ($p < 0.05$)	Odds Ratio (Confidence Interval)
Ability to work safely	**11.14**	**0.00***	**0.46 (0 - 0.74)**
Ability to keep coworkers working safely	**11.12**	**0.00***	**0.44 (0 - 0.74)**
Ability to know which health and safety precautions to take while doing my current or future job	**9.63**	**0.00***	**0.37 (0 - 0.73)**
Ability to identify OHS hazards/ equipment Issues	**10.72**	**0.00***	**0.30 (0 - 0.66)**
Knowledge of OHS rights	**1.08**	**0.30**	**0.76 (0 - 1.25)**
Knowledge of labour rights	**17.52**	**0.00***	**0.47 (0 - 0.68)**
Ability to find additional OHS information	2.15	0.14	0.78 (0 - 1.09)
Knowledge of common workplace injuries	**4.48**	**0.03***	**0.51 (0 - 0.98)**
Knowledge of workplace physical demands[1]	**21.59**	**0.00***	**0.12 (0 - 0.36)**
Knowledge of emotional/ mental demands of Job	**11.20**	**0.00***	**0.40 (0 - 0.71)**
Workplace to provide equipment that is safe and ergonomically designed	**7.91**	**0.00***	**0.66 (0 - 0.89)**
Training and mentorship received by my employer	**9.84**	**0.00***	**0.59 (0 - 0.83)**
Competency and skills built through my assigned apprenticeship work tasks	**18.57**	**0.00***	**0.36 (0 - 0.59)**
I believe that receiving occupational health and safety training can help…			
Reduce work injuries/ accidents	**9.69**	**0.00***	**0.35 (0 - 0.72)**

Reduce workplace financial loss	**5.85**	**0.02***	**0.57 (0 - 0.91)**
Reduce lost time claims	**7.72**	**0.01***	**0.48 (0 - 0.83)**
Improve performance and productivity	0.05	0.83	0.95 (0 - 1.34)
Improve overall Workplace HS	**6.36**	**0.01***	**0.45 (0 - 1.87)**

Apprentices with at least one functional limitation were almost three times more likely to report having ongoing pain that lasted more than 30 days, or permanent pain ($\chi2(1) = 158.26$, $p < 0.01$, OR = 2.71 (2.30,3.18)). A further breakdown of pain reporting notes that apprentices with functional limitations had a higher pain self-reporting across all body parts compared to apprentices without a reported functional limitation (Figure 11).

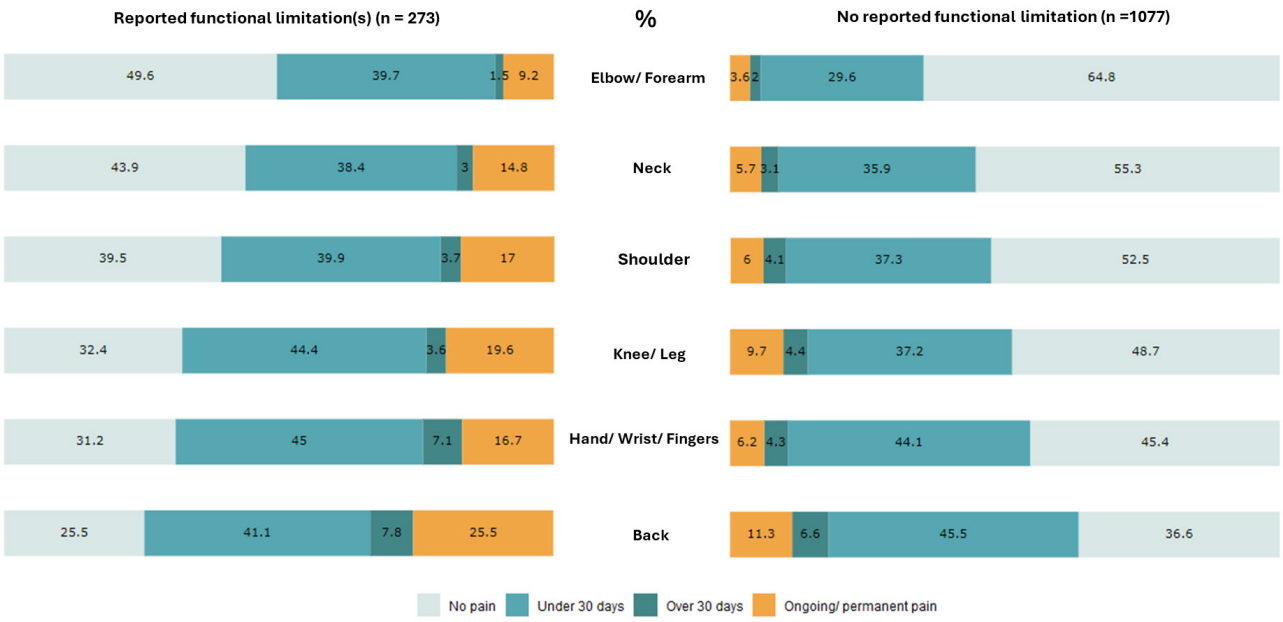

Figure 11. Differences in proportions of pain across all body parts between apprentices with and without a self-reported functional limitation.

3.4 Training Preferences

Most surveyed apprentices (62.8%) believed that the employer shares the most responsibility in delivering OHS training, followed by the government (e.g., Ministry of Labour) (23.4%), colleges (16.2%), and labour unions (7.4%) (
Figure 12).

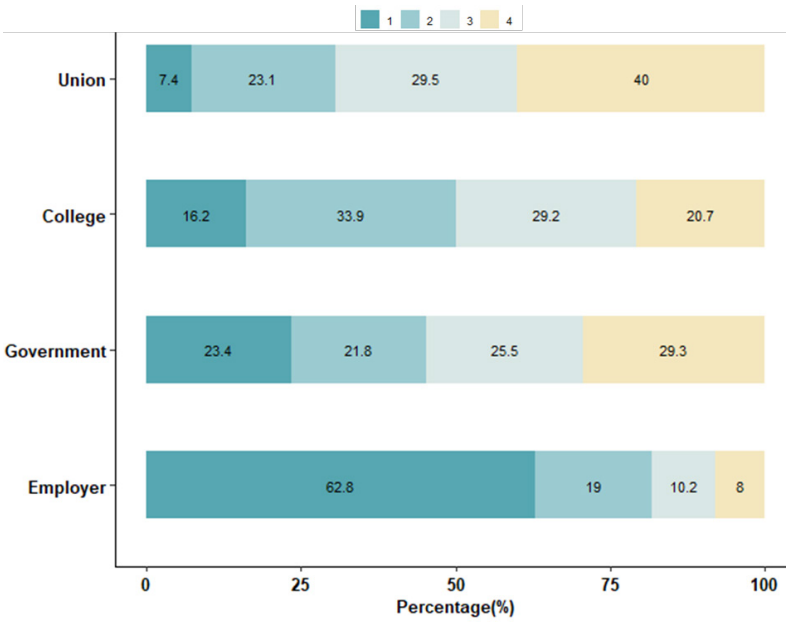

Figure 12. Apprentice opinion on the onus of responsibility for the delivery of OHS training (1 = most preferred, 4 = least preferred).

Apprentices largely chose hands-on practice (58.4%) as their preferred means of acquiring OHS knowledge, over traditional, hands-off approaches (e.g., assigned readings, case studies, PowerPoint presentations, videos), and experiential delivery methods (e.g., games, extended reality) (Figure 13). Assigned readings were least preferred as 34.5% of participating apprentices rated it last among learning modalities.

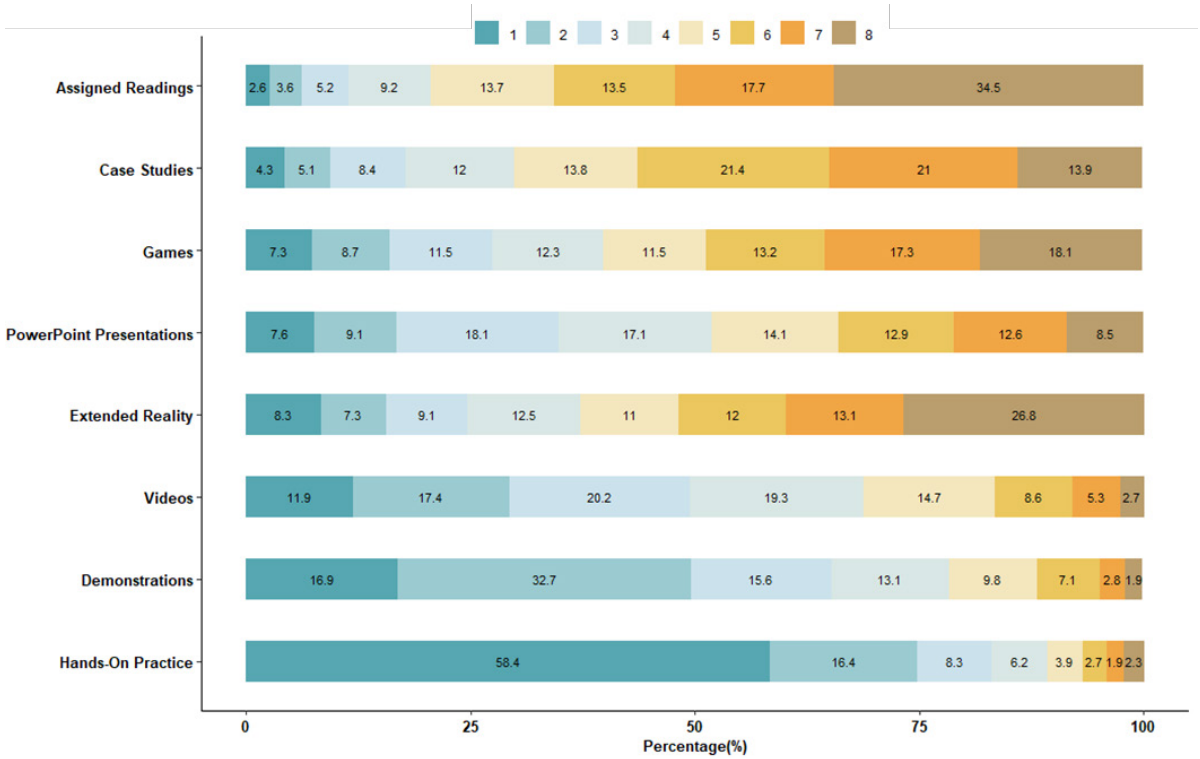

Figure 13. Apprentice opinions on their preferred learning styles (1 = most preferred, 8 = least preferred).

When apprentices were asked to rate their preferred training topics for future instruction, the results were mixed (Figure 3). The largest proportion (23.8%) of apprentices chose *recognizing and eliminating hazards* as one of their top three learning topics and was consequently determined to be the most preferred topic overall. However, *ergonomics* was selected as the first preference most frequently.

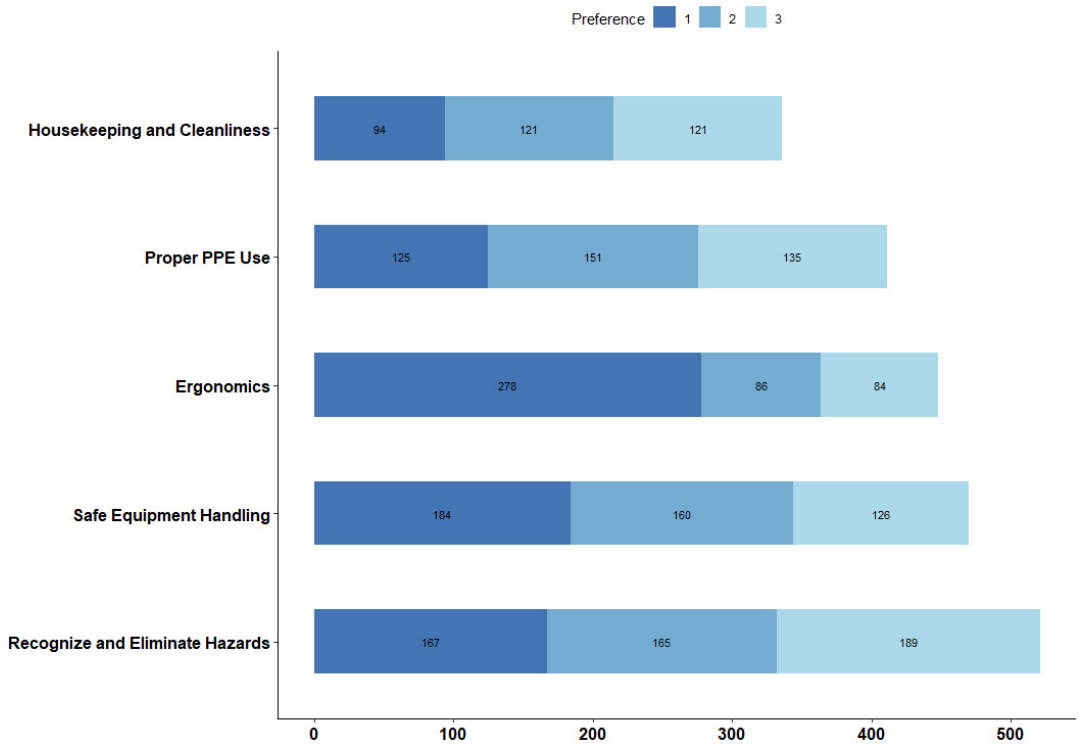

Figure 14. Apprentice opinion on their top three preferred training topics (1 = most preferred).

Better design of the workplace environment, equipment, and tools was rated most frequently within the top 3 workplace improvement recommendations to reduce workplace pain and injuries (Figure 15). Apprentices also saw the value of properly fitting PPE, with this being the most selected as the number one preference as a workplace improvement recommendation.

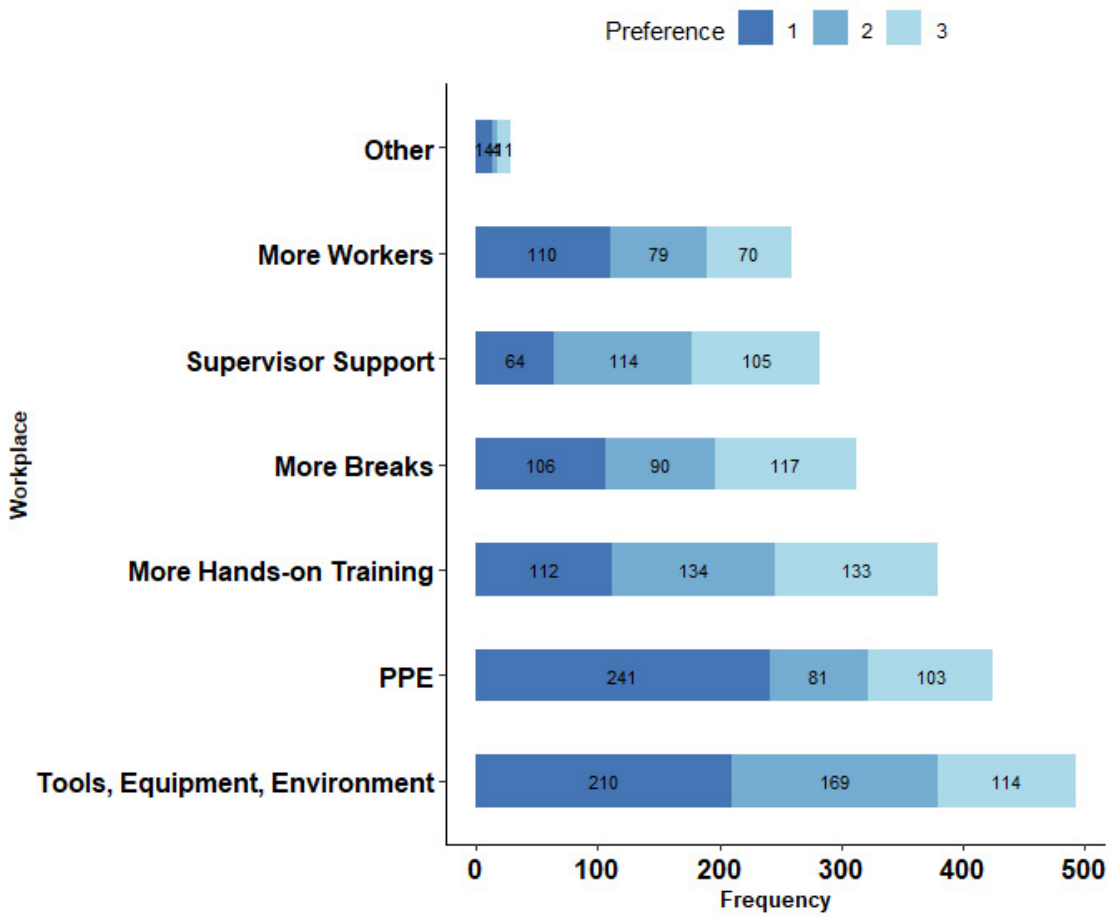

Figure 15. Apprentice opinion on the top 3 workplace improvement recommendations (1 = most useful).

4. DISCUSSION

We surveyed 1486 skilled trades apprentices on their perceptions of the OHS training they receive in-class and through their employer. Surveyed apprentices represented 14 trades across construction, industrial, motive power, and service sectors. We also explored the potential impact of functional limitations on an apprentice's perceived OHS knowledge, and the possible link to self-reported physical and perceived personal impacts.

4.1 Demographics

The study sample was representative of the Canadian skilled trades demographic. In our study, 91.6% of participants identified as male, which is consistent with the proportion of females (4.2%) in Canada's construction sector.[27] As expected, most of the apprentices that completed the survey were non-minority identifying males between the ages of 15 and 34 years. The predominance of young, male apprentices in the skilled trades may be attributed to the lack of facilitation of non-males joining and staying in the skilled trades [28], the negative perceptions associated with joining the skilled trades [29], and the implicit and explicit barriers that exist for minorities attempting to join the skilled trades.[30] The barriers to minorities in the skilled trades also exist despite efforts to incorporate neutral practices that ultimately may not safeguard against inequalities.[31]

4.2 Apprentice perceived OHS knowledge and their self-reported health outcomes

An apprentice's perceived confidence in their OHS knowledge did not differ across training levels and programs. However, younger apprentices (aged 15-24 years) perceived themselves as being more aware of the emotional demands of their role, the safety and ergonomics of workplace tools, and the employer's training and mentorship, when compared to apprentices aged 35 and older. According to the scientific literature, apprentices in younger age groups may overestimate their skills and abilities relative to older apprentices and are in fact at a greater risk of injury due to their lower ability to identify and manage workplace hazards.[18,22,32] In our study, there were no significant differences of self-reported injuries between age groups. However, Level 1 and Level 2 apprentices were almost twice as likely to report that they experienced an injury over the last twelve months compared to Level 3 apprentices. This is despite Level 1 apprentices perceiving themselves as more capable of keeping their coworkers working safely

compared to Level 2 apprentices. Therefore, an apprentice's years of experience, and not merely their age, may be the driving factor of work-related injuries. [33,34] Lower-level apprentices, who have relatively less job experience, may also overestimate their skills [35] and may not be fully aware of their work-specific hazards,[36] which ultimately may pose a greater injury risk to themselves and others at work.[17,32]

While inexperienced apprentices appear more likely to self-report acute injuries, the opposite relationship existed between age and pain reporting; apprentices aged 35+ were more likely to report experiencing pain than the younger groups of apprentices and were also more likely to report experiencing permanent pain. While apprentices with more experience may be more likely to avoid acute injury exposure, older apprentices may have a lower physical capacity to the prolonged and repetitive exposure related to their challenging roles, and may be progressing towards long term MSD development.[13] Interestingly, Level 2, and not Level 3, apprentices had the highest pain self-reporting, while the pain reporting from Level 1 and Level 3 apprentices were similar. This may mean that very inexperienced apprentices may not yet be exposed to a volume of work resulting in pain, but also that very experienced apprentices may "work smarter, not harder" and complete work tasks with a more skilful and less physical approach. It could also mean that apprentices with high pain self-reporting are less likely to reach or complete the highest levels of training. In any instance, the prevalence of both pain and injury reporting among Level 2 apprentices is concerning.

Block release programs, despite being exposed to the same learning material, have been previously identified as being more vocationally sound in their ability to prepare a skilled trades apprentice for work. [36,37] Day release programs have been more aligned with the employer's ability to support the apprentice's education while prioritizing business logistics and timelines.[38] Apprentices were more likely to choose the day release program at the discretion of their employer, and were more likely to choose the block release program based on their self-preference (Figure 1). However, apprentices in the day release program were more likely to report that they had an injury over the last twelve months and reported feeling more physically fatigued and burned out compared to block release apprentices. This aligns with previous literature suggesting that learning through the block release program develops safer and more successful workers. [36,37] We also highlight that day

release apprentices have lower perceptions regarding the adequacy of their assigned apprenticeship work tasks.

Day release apprentices are more likely to be working while receiving their training, which may result in a higher probability of developing acute pain or injuries during their apprenticeship. The lack of confidence in their material, coupled with the need to balance a full-time workload and meeting course requirements may place apprentices at a greater likelihood of injury. Apprentices in day release also may have less locus of control, given that the decision to choose day release was often based on the preference of the employer rather than the apprentice. Locus of control may reflect the level of organizational support across several business performance indicators and is considered an important determinant in health and safety and injury incidence.[39] Although day release apprentices are most likely working during formal training, it is unknown whether they work a shortened shift before or after class, or both. Similar to working multiple jobs, combining training, work, and commuting time on the same day may act in concert to increase fatigue and injury risk due to long work hours, lack of sleep, and additional and varied physical and mental stress from alternating between different responsibilities.[40]

Overall, apprentices who reported feeling overwhelmed or burned out were less confident in their OHS training and the training provided through their workplace. Negative psychological states, such as feeling overwhelmed and being burned out, have been related to injury outcomes experienced by workers, [3] and combined with their physical demands of work and reduced confidence in their OHS skills, further exacerbate the risk of workplace injuries.

4.3 Perceived limitations

The proportion of apprentices that self-reported that they experienced at least one functional limitation (20%) is slightly lower than the estimated Canadian population of working age individuals with disabilities (24%), but higher than those of this population that are actively working (14.8%).[41] The middling nature of this number may be due to the relatively younger sample of surveyed apprentices; younger apprentices with functional limitations may not experience them to the extent where they cannot work. The demands of skilled trades labor may have also excluded a proportion of individuals with disabilities from entering the skilled trades workforce, which could have resulted in a slightly lower reporting

than the population estimate. Note that male dominated, physically laborious professions, such as the skilled trades, have under-represented injury reporting both at the worker and organizational level, and the reported proportion may by higher. [42] The under-reporting of injuries and functional limitations have also been valorized due to hegemonic masculinity in skilled trades workplaces,[42] and perpetuates a culture of working through pain and small injuries until they become even more serious and debilitating.

Of those apprentices with functional limitations, more apprentices reported functional limitations with learning (47.4%) and concentrating (36.8%) than physical limitations collectively (20.1%). The proportion of apprentices that reported functional limitations with learning and concentrating are both lower than those reported by the United States Department of Labor in 2022 (16%), while the overall proportion of physical limitations reported were relatively similar (18%).[43] It should be noted that the overall proportion of workers with reported physical limitations was quite low relative to the entire sample (1.8%). In addition to the potential under-reporting of functional limitations by skilled trades workers,[42] there is a small reporting of physical functional limitations in the sample. It could mean that apprentices have not worked long enough to experience an eventual injury, or that individuals with functional limitations are not able to join the skilled trades as apprentices (i.e., survivorship bias).[44] . In contrast to those with reported physical functional limitations, more apprentices reported having limitations learning or concentrating (7.2%). Apprentices with cognitive functional limitations may also be more drawn to careers in the skilled trades over other educational pathways due to preference, but also due to [16,45]accessibility and self-perceptions in their abilities towards technical pursuits.

Apprentices with functional limitations were more likely to perceive that they were unaffected by their functional limitation. This contrasts with the relationships that were identified between the presence of functional limitations and their lower perceived ability to manage their safety in the workplace. Apprentices with at least one functional limitation perceived themselves as less than half as able to keep themselves or their coworkers safe. Overall, this may indicate that apprentices may not be aware of the impacts their functional limitations may have on their work ability, including their ability to implement their OHS training. This may predispose apprentices with functional limitations to heightened risk of workplace injuries due to alterations in their risk perception and situational awareness.

Alternatively, workers with physical functional limitations that received them through work may not have been aware of the mechanisms resulting in these injuries.

4.4 Training recommendations

Ideally, OHS training is only one of many potential interventions and should be combined with other strategies (e.g., workplace changes, hazard control) to effectively address health and safety challenges. The relevant content and effective delivery of training can improve the attitudes of apprentices regarding their knowledge and approach to workplace health and safety [17]. Current training practices may be inconsistent with preferred delivery methods, as described by one of the apprentice respondents who completed the survey:

> *" I'm a hands-on person, always have been. I've always found classroom settings hard. Most teachers have been helpful where others seem to act like this is university".*

Our results indicate that most apprentices (>90%) perceived that OHS training can improve workplace safety (Figure 2). While providing OHS training that is misaligned with apprentice learning preferences is not necessarily ineffective, workers and apprentices are also more likely to adhere to health and safety training that is properly presented, and is relevant to the immediate hazards faced. [46] A combination of foundational OHS training in the classroom, and specific OHS training in the workplace will maximize the apprentice's ability to identify and manage occupational health and safety hazards. According to apprentices, employers should be the main deliverers of OHS training. An emphasis by the employer to implement OHS training allows for the integration of workplace-specific injury prevention strategies.[17] However, it remains important that the foundation for this training is set in the classroom, which allows for a standardized repository of skills that prepares apprentices for the management of workplace hazards.

Apprentices prefer to receive OHS training through hands-on practice, opposed to demonstrations. With hands-on practice, apprentices can more effectively connect their theoretical understanding of OHS with a visual understanding of how a safety risk may present itself in the workplace.[17,47] Within the workplace, approaches where apprentices learn about hazards from a well-trained supervisor using a "learning by doing" approach to solve problems have also been effective in minimizing injury risk. [48]

While all acquired OHS training should be considered important, special emphasis should be placed on learning about the ability to recognize and eliminate hazards, and about proper workplace ergonomics (Figure 14). These topics, in addition to being identified as "want to haves" by apprentices, were also identified as "need to haves" from CISWP's report that identified gaps in skilled trades training curricula. Given the potential progression of pain in older apprentices, and the higher risk of acute injury in inexperienced apprentices, addressing both of these gaps are potentially high-impact towards the reduction of workplace injuries and MSD development.[49] These competencies will also build an apprentice's appreciation of their personal safety, as well as that of their peers.[49]

4.5 Study limitations

This study used a survey design to collect the perspectives of apprentices in the skilled trades. This was an effective way to quickly gauge the opinions from many apprentices but is also based on self-reporting. Therefore, we cannot fully confirm the accuracy of the claims made. Responses from apprentices could be affected by their emotional state at the time of completing the survey, their interpretation of the questions, and their recall (especially with questions that ask them to remember events up to one year prior). Questions that asked how an apprentice was affected by the skilled trades shortage were amended later onto the survey. This reduced the sample size for which we could have captured the additional opinions of apprentices and would have aided the robustness of conclusions drawn. However, this sub-sample of over 700 apprentices provides critical information on the trending responses of skilled trades apprentices and reveals the need to address the psychosocial aspects of OHS. Additionally, while increasing the size of the sample may better represent the overall population, [50] the alignment of these results with previous literature addressing the impact of psychosocial factors to workplace OHS injury reporting provides a degree of confidence that the sample may be representative of the larger population of apprentices. [51]

Inquiries regarding functional limitations were only received from apprentices that were relatively able-bodied to a point that they were able to attend apprenticeship training without undue hardship. We could not capture the responses of potential apprentices that were injured or experienced a functional limitation to the extent where they could not have attended class. This may have contributed to the lower reporting of physical limitations overall. However, this further highlights the problem of MSDs in the trades; working in the

trades may be physically and mentally challenging to the point where it served as a barrier of entry for those who are the most impacted by their functional limitations and is related to an additional self-reporting of injuries and pain by those who attempt to work with their functional limitations.

Using a cross-sectional survey design impacts analyses regarding an apprentice's level of training and their injury reporting over the last twelve months; an apprentice could have been injured during their Level 1 apprenticeship but completed the survey while in their Level 2 apprenticeship, less than a year later. While we collected a relatively large sample to minimize these occurrences, future surveys should incorporate questions about the apprentice's level at the time of injury. This overlap could also be minimized by collecting higher-level participants near the end of their school year.

The cross-sectional design also means that we cannot provide definite causation and direction of the identified associations. For example, while an apprentice that reported experiencing physical fatigue in the workplace may be less confident in their ability to find OHS information, the inverse may also be true. However, though we cannot state claims about the directionality of this relationship, we may seek to improve an apprentice's OHS outcomes through the implementation of appropriate, relevant, and timely training practices.

5. CONCLUSION

The level to which a skilled trades apprentice perceives their OHS knowledge is associated with their self-reported pain and injury. This association is further influenced by whether an apprentice reported experiencing functional limitations that may impact their ability to perform their role. Though we cannot definitively state the direction of this relationship, these findings may contribute towards the improvement of an apprentice's OHS outcomes through the implementation of timely and relevant training practices. Finally, apprentices reported that they prefer to learn about OHS through hands on practice specific to their workplace, which opens future avenues in developing experiential learning tools and studying their impact on acquiring effective OHS skills and knowledge in the skilled trades.

It should be noted that OHS training, while potentially effective, has not been shown to be the sole driver towards the elimination of all workplace injury risks. The responsibility for

OHS training compliance should be placed across all levels of an apprentice's education, and should be upheld by the apprentice, employer, and apprenticeship program, for significant long-term improvements to be seen. However, while standardized and relevant OHS training of apprentices is not an all-encompassing solution to the problem of workplace musculoskeletal disorders (MSDs) and injuries,[10,52] it is a necessary step towards protecting workers, especially less experienced apprentices,[9,17,32] and preparing apprentices to better manage workplace hazards and assess the safety of workplace practices in variable environments.

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