Occupational Injuries and Illnesses in Quebec's Dental Workforce: 15-Year Data on Musculoskeletal Disorders

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Dedication

I want to dedicate my thesis to my father, Rajeev Prakash. Without his support, I would not have accomplished any of my dreams, and my love and gratitude to him go beyond words.

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List of abbreviations

Abbreviation	Full Form
MSDs	Musculoskeletal Disorders
WMSDs	Work-Related Musculoskeletal Disorders
OHS	Occupational Health and Safety
CNESST	Commission des normes de l'équité de la santé et de la sécurité du travail
AROHS	Act Respecting Occupational Health and Safety
AIAOD	Act Respecting Industrial Accidents and Occupational Diseases
IRSST	Institut de recherche Robert-Sauvé en santé et en sécurité du travail
INSPQ	Institut national de santé publique du Québec
PPE	Personal Protective Equipment
WHO	World Health Organization
ILO	International Labour Organization
LFS	Labour Force Survey
RR	Risk Ratio
SD	Standard Deviation
CTS	Carpal Tunnel Syndrome
NSI	Needlestick Injury
HIV	Human Immunodeficiency Virus
HPV	Human Papillomavirus
TMS	Troubles Musculo-Squelettiques (French equivalent of MSDs)
FTE	Full-Time Equivalent
ALARA	As Low As Reasonably Achievable

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Abstract

Background

Musculoskeletal disorders (MSDs) are prevalent among dental professionals due to the demands of the occupation, including repetitive movements, awkward postures, and prolonged static positions. Although these occupational hazards are well-documented, much of the literature on MSDs in dentistry relies on self-reported surveys, lacks objective validation through compensation claim records, and is largely outdated. Current data is essential to understand the impact of these disorders on the dental workforce today.

Objective

The general aim of this MSc. research project was to provide a portrait of compensated claims among dental workers in Quebec. This aim was achieved through the following sub-objectives: (1) To describe the compensated claims in the provincial compensation claims database among dental professionals; (2) to estimate annual MSD claim rates across a 15-year period; and (3) To describe and categorize the types of MSDs most frequently reported in this workforce, identifying year-wise trends and evaluating potential factors associated with claim rates.

Methods

This study analyzed compensated claims from dentists, dental hygienists, dental assistants, and technicians within the Quebec Workers' Compensation Board (CNESST) database from 2005 to 2019. Claims were stratified by occupation, sex, age, and injury site. Annual MSD claim rates were calculated using denominators derived from total workforce estimates based on Statistics Canada and the Labor Force Survey. Negative binomial regression models (NBR) were used to identify MSD claim determinants such as sex, age group and occupation as well as assess temporal trends.

Results

Of the 2,229 compensated claims analyzed, 2,142 (96.1%) were filed by female dental workers. A total of 722 claims (32.4%) were attributed to MSDs. Among occupations, dentists accounted for 96 claims (4.3%), while 2,134 claims (95.7%) came from dental hygienists, assistants, and technicians. The NBR analysis revealed that men had a significantly lower rate ratio (RR) of 0.76 (95% confidence interval [CI]: 0.69–0.84, $p < 0.001$) compared to women. Age-related RRs decreased progressively with age, from 0.50 (95% CI: 0.48–0.53, $p < 0.001$) for workers aged 25–34 to 0.34 (95% CI: 0.31–0.36, $p < 0.001$) for those aged 55–64. Dentists, serving as the reference group, exhibited significantly lower RRs compared to dental hygienists, assistants, and technicians (RR = 11 95% CI: 10–13, $p < 0.001$).

The average annual MSD claim rate was 3.3 per 1,000 employed dental workers (95% CI: 3.1–3.6), with a non-significant yearly increase of 1.4% (95% CI: -0.0014–0.031; p = 0.074). Shoulder injuries accounted for 23% of claims, followed by wrist injuries (20%). Sprains, strains, and tears were the most frequent injury types, with a peak claim rate of 2.1 per 1,000 (95% CI: 1.4–2.9), showing an annual increase of 2.6% (p = 0.029).

Conclusions

MSDs accounted for nearly one-third of claims in the dental workforce, indicating a critical need for targeted ergonomic interventions and preventive measures to reduce occupational risks. This study underscores the importance of analyzing compensation data to gain an accurate understanding of MSDs in dental professionals, supporting evidence-based strategies for improving workplace health and safety.

Résumé

Contexte

Les troubles musculo-squelettiques (TMS) sont fréquents chez les professionnels de soins dentaires en raison des exigences de la profession, notamment les mouvements répétitifs, les postures contraignantes et les positions statiques prolongées. Bien que ces risques professionnels soient bien documentés, une grande partie de la littérature sur les TMS en dentisterie repose sur des enquêtes autodéclarées, manquent de validation objective par le biais des dossiers de demande d'indemnisation, et ne sont pas récentes. Des données actuelles sont essentielles pour comprendre l'impact de ces troubles sur le personnel dentaire.

Objectif

L'objectif général de ce projet de recherche de maîtrise était de dresser un portrait des demandes d'indemnisation des travailleurs dentaires au Québec. Ce but a été atteint grâce aux sous-objectifs suivants : (1) décrire les demandes d'indemnisation dans la base de données provinciale des demandes d'indemnisation chez les professionnels dentaires ; (2) estimer les taux annuels d'indemnisations de TMS sur une période de 15 ans ; et (3) décrire et catégoriser les types de TMS les plus fréquemment indemnisés dans cette main-d'œuvre, en identifiant les tendances annuelles et en évaluant les facteurs potentiels associés à ces indemnisations.

Méthodes

Cette étude a analysé les demandes d'indemnisation déposées par les dentistes, hygiénistes dentaires, assistants dentaires et techniciens dans la base de données de la Commission des normes, de l'équité, de la santé et de la sécurité du travail (CNESST) de 2005 à 2019. Les demandes ont été stratifiées en fonction de la profession, du sexe, de l'âge et du lieu de la lésion. Les taux annuels de demandes de prestations de TMS ont été calculés à l'aide de dénominateurs dérivés des estimations de la main-d'œuvre des données de recensement de Statistique Canada et de l'Enquête sur la population active. Des modèles de régression binomiale négative (RBN) ont été utilisés pour identifier les déterminants des indemnisations pour TMS tels que le sexe, le groupe d'âge et la profession, ainsi que pour évaluer les tendances temporelles.

Résultats

Sur les 2 229 cas d'indemnisations analysées, 2 142 (96,1 %) ont été déposées par des femmes. Au total, 722 cas (32,4 %) ont été attribuées à des TMS. Parmi les professions, les dentistes ont fait l'objet de 96 indemnisations (4,3 %), tandis que 2 134 (95,7 %) émanaient d'hygiénistes, d'assistants et de techniciens dentaires. L'analyse de RBN a révélé que les hommes avaient un rapport de taux (RR) significativement plus faible de 0,76 (intervalle de confiance à [IC] 95%

: 0,69-0,84, p < 0,001) que les femmes. Les RR diminuent progressivement avec l'âge, passant de 0,50 (IC 95 % : 0,48-0,53, p < 0,001) pour les travailleurs âgés de 25 à 34 ans à 0,34 (IC 95 % : 0,31-0,36, p < 0,001) pour ceux âgés de 55 à 64 ans. Les dentistes, qui constituent le groupe de référence, présentaient des RR significativement plus faibles que les hygiénistes dentaires, les assistants et les techniciens (RR = 11 IC à 95 % : 10-13, p < 0,001).

Le taux annuel moyen d'indemnisations pour TMS était de 3,3 pour 1 000 travailleurs dentaires employés (IC à 95 % : 3,1-3,6), avec une augmentation annuelle non significative de 1,4 % (IC à 95 % : -0,0014-0,031 ; p = 0,074). Les lésions de l'épaule représentaient 23 % des indemnisations, suivies par les lésions du poignet (20 %). Les entorses, les foulures et les déchirures étaient les types de blessures les plus fréquents, avec un taux de fréquence maximal de 2,1 pour 1 000 (IC à 95 % : 1,4-2,9), soit une augmentation annuelle de 2,6 % (p = 0,029).

Conclusions

Les TMS représentaient près d'un tiers des demandes d'indemnisation, soulignant le besoin d'interventions ergonomiques et préventives adaptées. Cette étude met en évidence l'importance des données d'indemnisation pour développer des stratégies basées sur des preuves, visant à améliorer la santé et la sécurité des professionnels dentaires.

Chapter 1: Literature Review

1.1. Occupational health and safety

Ensuring the occupational health and safety of workers typically requires implementing a set of measures, regulations, and training programs aimed at preventing work-related injuries and diseases, as well as safeguarding and enhancing worker health (International Labour Organization, 2024). It is a multidisciplinary field that requires collaboration with various scientific disciplines, such as occupational medicine, public health, industrial engineering, ergonomics, chemistry, and psychology (European Agency for Safety and Health at Work (EU-OSHA), 2024). It fosters a culture of safety in the workplace by prioritizing risk assessment, hazard control, and employee engagement, subsuming preventive measures, regulations and training so that workplace hazards, injuries and illnesses are minimal (Government of Alberta, 2024). Workplace hazards impact individual workers, the operational efficiency of organizations, and the broader economy (Canadian Centre for Occupational Health and Safety, 2023). Despite various efforts and regulations to reduce these hazards, their prevalence remains significant worldwide, as shown by epidemiological data from organizations such as the WHO and the International Labor Organization (ILO) (International Labour Organization, 2023). Statistics illustrating this are provided in the following section.

1.2. Regulatory aspects of Occupational Health and Safety

Occupational health and safety is promoted by international, country, and provincial frameworks. At the global level, the ILO's Promotional Framework for Occupational Safety and Health Convention, 2006 (No. 187) aims to continuously improve workplace safety and health to prevent injuries, diseases, and fatalities. It requires the development of a national policy, system, and program in collaboration with key employer and worker organizations. Each member must actively strive to create a progressively safer and healthier work environment by establishing national systems and programs, adhering to the principles set out in relevant ILO instruments. (International Labour Organization, 2006).

Occupational health and safety regulations vary from jurisdiction to jurisdiction and over time. Government authorities work to develop worker health and safety policies in response to interested parties. These policies must be effective considering competitive business

environments, modern labor market structures, resource constraints, labor-management power issues, health and safety professionals' perspectives, and political will (Tompa et al., 2016).

1.2.1. Regulatory aspects of OHS in Canada

In Canada, where the ILO Convention has been ratified, the core of OHS regulations is the Internal Responsibility System. This system emphasizes the joint responsibility of employers and employees in ensuring workplace safety. Employers are required to proactively work towards creating a safe work environment by informing employees about potential hazards and ensuring the use of appropriate safety equipment to reduce risks (Foster, 2016). Canada comprises fourteen jurisdictions—one federal, ten provincial, and three territorial—each with its own occupational health and safety legislation that defines the general rights and responsibilities of employers, supervisors, and workers (Rabinowitz & Hager, 2000). The regulatory framework for occupational health and safety in Canada includes various key organizations, laws, and guidelines to ensure a safe working environment for all employees. The Canadian Centre for Occupational Health and Safety (CCOHS) acts as the national resource for workplace health and safety, focusing on promoting safe work environments, addressing health and safety concerns, and disseminating occupational health and safety information online to benefit workers both in Canada and worldwide workers (Canadian Centre for Occupational Health and Safety, 2024).

1.2.2. Regulatory aspects of OHS in Quebec

In the province of Quebec, Canada, the key occupational health and safety legislation includes the *Act Respecting Occupational Health and Safety* (AROHS; *Loi sur la santé et la sécurité du travail*). This law outlines the responsibilities of employers and employees in maintaining a safe workplace. In 2021, the *Act to Modernize the Occupational Health and Safety Regime* (*Loi sur la modernisation du régime de santé et de sécurité du travail*) introduced significant revisions to AROHS, with several new measures being gradually implemented until 2026. These changes aim to enhance prevention mechanisms, improve worker compensation, and expand coverage for various categories of workers. Additionally, occupational health and safety regulations governed by law remain in effect under AROHS (Gouvernement du Québec, 1979). These regulations include the Regulation Respecting Medical Aid (Règlement sur l'assistance médicale), which details the care, treatment, professional services, and technical aids available to workers with employment injuries or occupational diseases. It specifies the types of medical aid covered, including rules for physiotherapy, occupational therapy, and

psychological care (Gouvernement du Québec, 1979). The regulation ensures that workers receive essential medical support, providing detailed guidelines on the cost, duration, and reporting requirements for various treatments and services (Lanoie, 1992). Its purpose is to ensure comprehensive medical care for injured workers and aid in their recovery process. The Scale of Bodily Injuries Regulation (Règlement sur l'échelle des dommages corporels), for which the Act Respecting Industrial Accidents and Occupational (AIAOD; Loi sur les accidents du travail et les maladies professionnelles) is the enabling statute, provides a detailed system for evaluating and compensating permanent physical or mental impairments caused by workplace injuries or occupational diseases (Gouvernement du Québec, 1979). This regulation under the AIAOD, includes specific schedules and tables that assign impairment percentages to various injuries, such as fractures, dislocations, and amputations. These percentages are then used to calculate the compensation due to the injured worker. The Act Respecting Industrial Accidents and Occupational Diseases (AIAOD; Loi sur les accidents du travail et les maladies professionnelles) governs compensation for workers who suffer from work-related injuries or diseases and ensures workers receive appropriate medical care and financial compensation (Lanoie, 1992). Quebec's main authority for workplace health and safety is the Commission des normes, de l'équité, de la santé et de la sécurité du travail (CNESST). Formed under the AROHS, the CNESST enforces the AROHS and the AIAOD (Gouvernement du Québec, 1979). It enhances occupational health and safety by implementing regulations, offering guidance, and aiding in the prevention of work-related injuries and illnesses. Additionally, it oversees workplace standards concerning conditions and equity, and manages workers' compensation programs, providing support and resources to both employers and employees (Government of Canada, 2020). The 2021 reforms expanded prevention obligations, requiring all employers to document workplace risks, including ergonomic hazards. CNESST also funds the Robert-Sauvé Research Institute for Occupational Health and Safety (IRSST; Institut de recherche Robert-Sauvé en santé et en sécurité du travail), a research institute in Quebec dedicated to advancing knowledge and fostering innovation in occupational health and safety. The IRSST primarily focuses on conducting scientific research to enhance workplace safety, prevent work-related injuries and illnesses, and develop effective interventions and solutions for occupational health issues. It collaborates with various stakeholders, including employers, workers, and government agencies, to apply research findings and improve workplace health and safety practices. As per the AIAOD, the research produced by IRSST is analyzed by a scientific committee established under the Act, which makes recommendations to the Minister and the Commission on occupational diseases (IRSST, 2024). The Occupational Health Public

Health Network (Réseau de santé publique en santé au travail) in Quebec aims to improve occupational health in each of Quebec's 18 health regions. Its mission involves enhancing workplace health and safety through research, policy development, and collaboration with public health entities, employers, and workers. The network envisions creating a healthier work environment by advancing knowledge, promoting effective interventions, and fostering a culture of safety and well-being in the workplace (Occupational Health Public Health Network). Its network of regional public health departments is tasked with creating and executing health programs tailored to local businesses, as well as organizations in the public and non-profit sectors. This process involves working closely with employers, the health and safety committee (HSC), and the employees (Occupational Health Public Health Network). The Institut national de santé publique du Québec (INSPQ) is another organization in Quebec dedicated to advancing knowledge and creating strategies to improve the health and well-being of Quebecers. Its Occupational Health (OH) team is part of the Réseau de santé publique en santé au travail (RSPSAT), a provincial-level component that provides support to regional and local teams through training, research, surveillance, intervention tool development, and evaluation. RSPSAT teams assist employers in evaluating workplace hazards, including chemical exposures, ergonomic risks, and psychosocial factors. They provide guidance on implementing effective control measures to mitigate identified risks. It provides support to the Minister of Health and Social Services, regional public health authorities, and health institutions through its expertise, specialized laboratory, and screening services. The INSPQ focuses on developing and monitoring public health knowledge, promoting health and prevention, including occupational health, and evaluating public policies and health systems. Additionally, it supports ongoing training, knowledge transfer, international collaboration, and oversees public health ethics and advisory roles (Institut national de santé publique du Québec, 2024). Thus, there are legislations, regulations and specialized agencies in Quebec to promote OHS. Having examined the regulatory framework governing occupational health and safety, we now turn our attention to defining occupational hazards themselves in the next section.

1.3. Definition of occupational hazards

A hazard is any source of potential damage, harm, or adverse health effects (Canadian Centre for Occupational Health and Safety, 2023). The six types of hazards recognized by the Occupational Safety and Health Administration (OSHA) have been documented in various resources, including safety management guidelines and hazard identification processes. These include physical safety hazards (risks such as slips, trips, falls and operating dangerous machinery), chemical hazards (exposure to harmful chemicals like solvents, adhesives, and toxic dusts), biological hazards (exposure to infectious diseases, molds, and toxic plants), physical hazards (environmental factors like excessive noise, extreme temperatures, and radiation), ergonomic risk factors (risks from repetitive motions, awkward postures, and heavy lifting), and psychosocial factors (factors related to workplace stress, such as job demands, lack of control, and poor social support) (National Institute for Occupational Safety and Health, 2021). These categories help employers and workers identify and mitigate potential risks in the workplace to ensure a safer environment.

1.4. Burden of occupational hazards

Data from WHO, ILO and other sources have highlighted the burden of occupational hazards. The WHO estimated that 20-50% of workers globally are exposed to various occupational hazards, with such exposure resulting in a number of occupational injuries and diseases (El-Menyar et al., 2016). A WHO/ILO joint estimates report found that from 2000 to 2016, approximately 1.9 million deaths and 90 million disability-adjusted life years (DALYs) were lost annually due to work-related diseases and injuries (World Health Organization (WHO) and International Labour Organization (ILO), 2021). Statistics from the International Labour Organization database (ILOSTAT) reveal that approximately 340 million occupational accidents occur annually worldwide, leading to about 2.8 million fatalities due to occupational accidents or work-related disease (Driscoll et al., 2005).

The burden of musculoskeletal disorders due to occupational hazards is also quite significant. In 2018, there were 900,380 cases of work-related injuries and illnesses in the U.S. private sector that resulted in days away from work, with 272,780 cases (30%) being MSDs (U.S. Bureau of Labor Statistics, 2023). In the European Union, approximately three out of every five workers report MSD complaints, with backache and muscular pains in the upper limbs being the most common (European Agency for Safety and Health at Work (EU-OSHA), 2019).

The burden of musculoskeletal disorders is also significant in Quebec. According to the Enquête Québécoise sur la santé de la population (EQSP, 2014-2015), 31% of female workers and 20% of male workers aged 15 and over, working at least 15 hours per week, reported experiencing MSDs in at least one body region due to their main job. The prevalence of MSDs is particularly high among manual and mixed-occupation workers, with older employees, particularly those aged 45-54, being most affected. Socioeconomic disparities also play a role, as workers with lower education levels and those perceiving themselves as financially disadvantaged report higher MSD prevalence (Tissot et al., 2021). Furthermore, the risk of MSDs significantly increases when exposure to physical work constraints is combined with high psychological demands, highlighting the multifactorial nature of these occupational hazards. Data from the INSPQ (2020) indicates that WMSDs are among the leading occupational health concerns in Quebec, accounting for a substantial proportion of compensation claims. An analysis of CNESST data from 2015–2019 found that WMSDs constituted approximately 35% of all accepted occupational disease claims in Quebec.

1.5. Occupational hazards in dentistry

Dental professionals encounter various hazards inherent to their work environment. Leggat et al. (2007) conducted an extensive literature review which targeted all manuscripts published in peer-reviewed journals relating to the topic of occupational health problems in dentistry. They provided an overview of the common hazards in dental practice, including musculoskeletal disorders, exposure to bioaerosols, and chemical hazards. The review revealed that despite numerous technical advances in the years prior, many occupational health problems persist in modern dentistry. These include percutaneous exposure incidents; exposure to infectious diseases (including bioaerosols), radiation, dental materials, and noise; musculoskeletal disorders; dermatitis and respiratory disorders; eye injuries; and psychological problems. Similarly, Ayatollahi et al. (2012) reviewed the literature focusing on specific hazards in dentistry, categorizing them into infectious hazards, psychological hazards, allergic reactions, physical hazards, mercury health hazard, ionizing radiation, non-ionizing radiation and anesthetic gases. The review by Ayatollahi et al. (2012) categorizes the occupational hazards that dental professionals face into several key areas: infectious, psychological, allergic, physical, mercury exposure, radiation (both ionizing and non-ionizing), and anesthetic gas-related hazards. It highlights the high risk of exposure to infectious agents such as HIV, Hepatitis B/C, Herpes simplex, and Tuberculosis through contact with blood and saliva,

stressing the importance of strict infection control measures like PPE, hand hygiene, and vaccination. The study also highlights the psychological stress faced by dental workers, including burnout, largely due to workload and patient demands, which echoes earlier studies. It discusses allergic reactions to materials like latex and acrylic, recommending hypoallergenic alternatives, and underlines MSDs, calling for ergonomic improvements. Mercury exposure from dental amalgam is noted as a potential long-term health risk, emphasizing the need for protective measures like ventilation and mercury separators. Ionizing radiation from X-rays poses a cancer risk, while non-ionizing radiation from lasers and UV devices can harm the eyes, making safety goggles essential. Overall, both reviews are complete, but they suffer from being dated.

The following sections will cover the latest knowledge about the most prevalent categories of hazards encountered by dental workers. Namely, hazards such as biological, chemical, psychosocial, biomechanical, and physical will be explored in terms of their prevalence and risk factors in dentistry. Awareness and understanding of these hazards are crucial for developing effective prevention and management strategies.

1.5.1. Biological hazards

Biological hazards in dentistry include bloodborne pathogens such as hepatitis B and C viruses and HIV, as well as airborne pathogens like *Mycobacterium tuberculosis*. Methicillin-resistant *Staphylococcus aureus* (MRSA) and other antibiotic-resistant bacteria also pose significant infection risks, spreading through contact with contaminated surfaces, instruments, or bodily fluids (Cleveland & Cardo, 2003). Herpes simplex virus, particularly HSV-1, is frequently encountered in dental settings, causing oral and facial sores and being highly transmissible through contact with infected saliva or lesions. Dental practitioners are particularly at risk of contamination when treating patients with active sores (Rowe et al., 1982). Additionally, dental professionals can be exposed to Human papillomavirus infection (HPV) through contact with infected oral tissues or saliva, which is linked to oral and oropharyngeal cancers (Ramqvist & Dalianis, 2010). One study evaluated bioaerosols from dental handpieces in the dental setting, highlighting the risks associated with aerosol-generating procedures (Zemouri et al., 2017). This experimental setup measured bioaerosol levels and provided data on potential exposure risks. Additionally, (Choudhary et al., 2022) concluded that aerosols from dental procedures pose a low health risk for bacterial and likely viral pathogens when common aerosol mitigation measures, such as evacuators, are used.

The COVID-19 pandemic has highlighted the susceptibility of dental professionals to emerging respiratory infectious diseases, with the elevated risk of aerosol transmission of the SARS-CoV-2 virus in dental environments adding to these concerns. Procedures that generate aerosols, such as ultrasonic scaling and the use of high-speed dental handpieces, significantly increase the chances of virus spread (Meng et al., 2020). Dental professionals are also susceptible to fungal infections, particularly those caused by Candida species, with *Candida albicans* being the most common. These opportunistic pathogens can lead to oral candidiasis and can be transmitted through contact with contaminated instruments or surfaces (Zemouri et al., 2017). Although cases of Candida transmission to dental professionals are not widely documented, the risk exists, especially when strict hygiene protocols are not followed. Dental professionals handling contaminated instruments or prosthetics, particularly without proper disinfection and glove use, may increase their risk of colonization or infection. This is particularly true for those working with immunocompromised patients, who are more likely to carry Candida in pathogenic forms (Hellstein & Marek, 2019). This infection appears as white lesions on the tongue, inner cheeks, gums, or tonsils. Denture Stomatitis is often seen in denture wearers but can also impact dental professionals who frequently handle dentures and so by adhering to strict hygiene and sterilization protocols, dental professionals can mitigate the risk of Candida infections (Ku et al., 2018).

1.5.2. Chemical hazards

Chemical hazards in dentistry are mainly related to cleaning agents, disinfectants, dental materials and chemicals, and they can pose respiratory, reproductive, and systemic health issues drugs (Di Lorenzo et al., 2022). Common chemicals in the healthcare sector include sodium hypochlorite, quaternary ammonium compounds, hydrogen peroxide, and alcohol-based solutions. Exposure to these chemicals can cause respiratory issues, skin irritation, and other problems like asthma or dermatitis (Japundzic & Lugovic-Mihic, 2019). Allergic contact dermatitis remains prevalent among dental workers due to exposure to latex gloves and chemicals in dental materials (Vangveeravong et al., 2011). A higher incidence of dermatitis is reported among dental professionals compared to other healthcare workers (Henriks-Eckerman et al., 2001). Other biomaterials, such as methyl methacrylate and volatile resin-based materials, have consistently caused occupational problems in dental workers over the years (Jacobsen et al., 1991). Acrylic resin-based polymers, such as bis-glycidyl-dimethacrylate, and triethylene glycol dimethacrylate, are commonly used (Hagberg et al.,

2005; The Canadian Agency for Drugs and Technologies in Health (CADTH), 2018); and some of them are classified as probably carcinogenic to humans (Group 2A) by the International Agency for Research on Cancer (IARC) (IARC Working Group on the Identification of Carcinogenic Hazards to Humans, 2020). Different types of inorganic fillers are also used such as glass, quartz and/or silica, a known carcinogen (IARC Group 1) (Guha et al., 2011). The proportion of crystalline silica in dental mold and porcelain materials can represent up to 70% of the total weight of the product, exceeding by far many construction-related materials (Centers for Disease & Prevention, 2004). Dental professionals may encounter exposure to various nanomaterials, including metal oxides and silica, particularly in dental labs when fabricating dentures, as well as in clinical settings during procedures such as polishing, working on restorations, and mixing powdered or liquid materials (Jandt & Watts, 2020; Schmalz et al., 2018). A newer source of chemical exposure is the use of 3D printers for producing dental prosthetics, utilizing materials like polymers, composites, ceramics, and metal alloys (Khorsandi et al., 2021). The CANJEM job-exposure matrix, which relies on expert assessments of occupational exposures, indicates that dental workers have a high likelihood of exposure to substances such as mercury compounds, aliphatic esters, crystalline silica, organic solvents, abrasive dust, and biocides, among others (Sauve et al., 2018). Dental professionals are also frequently exposed to mercury vapors released during the placement, removal, and polishing of amalgam restorations. A 2018 study in Norway reviewed the neurotoxic effects of mercury exposure in dental personnel during their work with dental amalgam, noting that chronic low-level exposure can lead to cognitive and motor function impairments (Bjørklund et al., 2019). A recent review emphasized the risks of cognitive and motor function impairments in dental personnel due to this exposure (Goodrich et al., 2016). The review reported a significant decrease in blood mercury levels among dental professionals compared to previous decades, attributed to advancements in dental technology and increased regulations concerning mercury use. Furthermore, educational initiatives aimed at reinforcing the importance of proper handling and disposal of dental amalgam have also been effective in minimizing exposure risks (Goodrich et al., 2016).

1.5.3. Psychosocial hazards

Psychosocial hazards encountered by dental workers include stress, burnout, and mental health issues due to high job demands, patient management, and the pressures of maintaining clinical precision and productivity (Ayatollahi et al., 2012). Dental workers often manage a high volume of patients, leading to significant time pressure and workload. The need to perform detailed and meticulous procedures within limited time frames contributes to stress and anxiety (Gorter et al., 1999). In addition to clinical duties, dental professionals often handle administrative tasks such as patient documentation, billing, and compliance with health regulations. This dual responsibility increases their overall workload and can exacerbate feelings of stress (Myers & Myers, 2004). Dealing with anxious or uncooperative patients is a common stressor in dental practice. Dental workers must manage their own stress while simultaneously trying to calm patients, which can be mentally exhausting (Ronneberg et al., 2015). The constant risk of exposure to infectious diseases, such as hepatitis, and HIV, can cause chronic stress and anxiety among dental workers (Gorter et al., 2000). The COVID-19 pandemic led to increased reports of anxiety, depression, and burnout among dental professionals. Dentists experienced heightened psychological distress due to the increased risk of exposure to the virus in their profession, particularly because dental procedures generate aerosols that facilitate viral transmission (Humphris et al., 2021). The fear of contracting HIV and HPV also persists among dental workers. A study reveals that HIV and hepatitis C are the most feared diseases among dental staff. HIV remains the greatest concern due to its lack of a vaccine and effective post-exposure prophylaxis (PEP) compared to other bloodborne pathogens. Dental professionals, especially students and assistants with less experience, perceive a high risk of infection transmission, often overestimating the actual statistical risks (Ramich et al., 2017). And finally, economic pressures, such as the need to maintain a profitable practice, meet overhead costs, and manage financial liabilities (e.g., student loans), can significantly contribute to stress and anxiety in those who manage their own clinics or laboratories (Humphris et al., 2002).

1.5.4. Physical hazards

Physical hazards in dental practice include noise, vibration, light, radiation, needle pricks, cuts and extreme temperatures. Dental professionals frequently handle sharp instruments such as needles, scalpels, and dental probes during procedures, putting them at risk for needlestick injuries (NSIs) (Ravi et al., 2023). These injuries often occur while administering local

anesthesia, suturing, or handling sharp tools, particularly during recapping needles or cleaning instruments (Ravi et al., 2023). Dental workers are frequently exposed to high noise from ultrasonic scalers, high-speed handpieces, and suction devices. An observational study by Messano and Petti (2012) found that the prevalence of hearing impairment among general dentist practitioners was as high as 30%. Additionally, a 2024 scoping review encompassing 542 publications concluded that dental professionals are at a much higher risk of noise-induced hearing loss than the general population (Ghorbani, 2024).

Dental professionals are also exposed to ionizing radiation when taking X-rays. It is documented that chronic exposure, even at low levels, can increase the risk of cancer and other health issues (Hwang et al., 2018). However, there is a decreasing trend in the amount of ionizing radiation dental workers are exposed to, suggesting that radiation protection measures have been effective (Zielinski et al., 2005). Proper protective measures, such as lead aprons and thyroid collars, and adhering to ALARA (As Low as Reasonably Achievable) principles are essential (Benavides et al., 2024).

1.6. Biomechanical hazards and Work-Related Musculoskeletal Disorders (WMSDs) among dental workers

In addition to physical hazards, dental professionals face significant biomechanical hazards, which contribute to the development of work-related musculoskeletal disorders (WMSDs). Biomechanical hazards, which are particularly relevant to WMSDs, include repetitive work, awkward postures, forceful exertion (including manual handling of loads), and vibrations. The biomechanical stresses placed on the musculoskeletal system—such as maintaining awkward positions for extended periods or applying precise forces in confined spaces—significantly contribute to the development of these disorders (Rose-Ange Proteau, 2009).

WMSDs are a significant occupational health issue among dental workers. Recent studies continue to highlight the prevalence of musculoskeletal pain in this profession. A review suggests that the prevalence of general musculoskeletal pain ranges between 64% and 93% (Soo et al., 2023). This pain is often attributed to a combination of biomechanical factors and workplace practices. These biomechanical risk factors, when combined with insufficient rest periods and improper ergonomic practices, can lead to cumulative trauma over time (Valachi & Valachi, 2003). These disorders can affect various parts of the body, including the neck, shoulders, back, and wrists. While dental professionals face various occupational hazards, our study focuses specifically on work-related musculoskeletal disorders, which we will explore in

detail in the following section. The following section delves into the prevalence and impact of WMSDs among dental professionals.

1.6.1. Definition

Musculoskeletal disorders (MSDs) are trauma-driven conditions that affect bones, joints, ligaments, muscles, tendons, bursae, blood vessels, and nerves. These disorders result from a series of microtraumas that accumulate over time, potentially leading to more severe injuries (National Academies of Sciences, 2020). According to the International Classification of Diseases (ICD-10), MSD are a group of soft-tissue injuries and disorders that affect the musculoskeletal system (i.e. muscles, tendons, joints, nerves, cartilages) (World Health Organization, 2004). Symptoms of MSDs include pain, paresthesia, stiffness, swelling, redness, and/or weakness. Furthermore, according to OSHA, an MSD is defined as a disorder of the muscles, nerves, tendons, ligaments, joints, cartilage, or spinal discs that are not caused by a slip, trip, fall, motor vehicle accident, or similar incident. WMSDs are a subset of MSDs specifically linked to the work environment and the performance of work tasks. These conditions are either caused or exacerbated by work-related activities (Centers for Disease Control and Prevention (CDC), 2020). They are also known as cumulative trauma disorders (CTDs), repetitive strain injuries (RSIs), repetitive motion trauma (RMT), or occupational overuse syndrome, and are prevalent in various professions, including dentistry. Examples of WMSDs include epicondylitis (tennis elbow), tendinitis, DeQuervain's disease (tenosynovitis of the thumb), trigger finger, and Reynaud's syndrome (vibration white finger). Carpal Tunnel Syndrome (CTS) and back strain are also common WMSDs (Stack, 2016). Hence, unlike acute injuries, WMSDs may develop gradually due to repeated wear and tear or microtraumas to the tissue (Stack, 2016).

1.6.2. Prevalence

The prevalence of MSDs among dental professionals is consistently high across various studies, with differences noted between specific dental occupations and body regions affected. A systematic review by (Hayes et al., 2009) examined the prevalence of MSDs among dental hygienists. They found that the 12-month prevalence of MSDs ranged from 60% to 96%. The most affected body regions were neck (54-83%), shoulder (35-76%), lower back (36-69%), wrist/hand (54-70%). Interestingly, they found that dental hygienists had the highest prevalence of neck pain (64%), while dentists reported the highest prevalence of lower back pain (50%).

A cross-sectional study by (Aljanakh, 2024) involving 204 dental assistants in Saudi Arabia revealed, overall MSD prevalence (85%), lower back pain (63.8%), neck pain (54%), shoulder pain (48.3%). They also noted that female dental professionals were more likely to report MSDs than their male counterparts (OR = 3.52, 95% CI: 1.86-6.66). The following Table 1 offers a summary of key studies examining the prevalence of musculoskeletal disorders among dental professionals, providing a view of the scope and focus of research in this field. It highlights various study types, sample populations, and MSDs identified. The table also illustrates the diverse methodologies employed, ranging from cross-sectional surveys and observational studies to review articles, further demonstrating the reliance on self-reported data and the need for more standardized, objective measures of MSD prevalence. These studies collectively reflect the global concern surrounding MSDs in dental professionals, with common trends emerging regarding the most affected body regions—namely the neck, shoulders, and lower back—while also revealing gaps in research methodologies that may influence reported prevalence rates.

Table 1- Summary of Studies on Musculoskeletal Disorders Among Dental Professionals

Authors	Country	Year	MSD	Sample type	Study Type
Ylipää et al. (1999)	Sweden	1999	Hand, neck, and shoulder disorders	Dental hygienists	Survey-based study
Valachi and Valachi (2003)	Global	2003	General musculoskeletal disorders	Dentists	Review article
Yamalik (2007)	Global	2007	Various musculoskeletal disorders	Dental professionals	Review article
Leggat et al. (2007)	Global	2007	General musculoskeletal disorders	Dental professionals	Review article
Jonker et al. (2009)	Sweden	2011	Hand and arm disorders	General practice dentists	Observational study measuring mechanical exposure and work activities
Aminian et al. (2012)	Iran	2012	Neck, shoulder, and upper extremity disorders	Female dentists and pharmacists	Nordic questionnaire-based cross-sectional study
Zoidaki et al. (2013)	Greece	2013	General musculoskeletal disorders	Dentists	Self-administered questionnaire cross-sectional study
Jonker et al. (2013)	Sweden	2013	General musculoskeletal disorders	Dentists	Questionnaire-based prospective study
Blanc et al. (2014)	France	2014	General musculoskeletal strain	Dentists	Electromyographic and goniometric study
Aljanakh et al. (2015)	Saudi Arabia	2015	General musculoskeletal disorders	Dentists	Nordic questionnaire-based cross-sectional study
Aminian et al. (2015)	Iran	2015	Neck and upper extremity disorders	Male dentists and pharmacists	Nordic questionnaire-based cross-sectional study
Lindegard et al. (2016)	Sweden	2016	Neck pain	Dental personnel	Questionnaire-based Longitudinal cohort study
Moodley et al. (2018)	Global	2018	General musculoskeletal disorders	Dental professionals	Review article
Oyapero et al. (2021)	Nigeria	2021	Hand, neck, and shoulder disorders	Dental surgeons	Descriptive survey using Nordic Questionnaire

1.6.3. Risk factors

The etiology of MSDs involves the accumulation of tissue microtraumas resulting from repetitive and/or forceful tasks, leading to local and maybe systemic inflammation, followed by structural tissue damage and eventually MSDs (Barr & Barbe, 2002). They develop over time and arise when the adaptive and repair capacities of affected structures have been exceeded (National Research et al., 2001). Hayes et al. (2009) describe MSDs as damages to the human support system, including muscles, ligaments, tendons, nerves, blood vessels, bones, and joints, which can occur from a single event or cumulative trauma. The severity of MSDs can range from mild and infrequent cases to severe and chronic conditions depending on various work factors, and workers with long work hours per week (more than 60 hours) and per day (more than 12 hours) significantly increased the likelihood of injuries, including MSDs, showing a clear dose-response effect (Dembe et al., 2005).

Musculoskeletal disorders have been recognized as having occupational etiologic factors since the early 18th century. However, it was not until the 1970s that occupational factors were systematically examined using epidemiologic methods, leading to the regular appearance of work-related MSDs in international scientific literature. Since then, the body of literature has grown significantly, with over six thousand scientific articles addressing workplace ergonomics. Despite this, the relationship between MSDs and work-related factors remains a topic of considerable debate (Bernard & Putz-Anderson, 1997).

MSDs arise from various risk factors, but their causes can generally be classified into three broad categories: those resulting from excessive movement, such as repetitive motions; repetitive strain injuries (RSIs) caused by insufficient movement, particularly prolonged static postures; and RSIs caused by a combination of repetitive movements and sustained postures. Holding body parts in a fixed position for extended periods−such as stabilizing a workpiece, gripping a tool, or using a keyboard and mouse−can lead to injuries associated with prolonged static postures (Rose-Ange Proteau, 2009). The WHO has characterized “work-related” diseases as multifactorial to indicate that a number of intrinsic or extrinsic risk factors contribute to causing these diseases (WHO, 1985). Indeed, several intrinsic or personal risk factors can contribute to the development of WMSDs, including physical conditioning, existing health problems, gender, age, work technique, hobbies, and organizational factors such as job autonomy, quotas, and deadlines (Canadian Centre for Occupational Health and Safety (CCOHS), 2024). Furthermore, according to Rambabu and Suneetha (2014), intrinsic factors

associated with WMSDs include age, genetic predisposition, obesity, and mental stress, while extrinsic factors encompass repetitive movements, prolonged static postures, suboptimal lighting conditions, and improper positioning of the operator or patient (Rambabu & Suneetha, 2014). An additional key risk factor is a previous event of musculoskeletal injury. Individuals who have suffered an MSD in the past are at significantly higher risk of recurrence due to residual weakness, scar tissue formation, and altered biomechanics. These factors can predispose workers to reinjury, particularly in occupations with high physical demands such as dentistry. More research has highlighted the significant association of MSDs with extrinsic factors. Ergonomic studies of dental professionals, including dentists, dental assistants, hygienists, and dental technicians, have identified several risk factors related to their working conditions (De Sio et al., 2018). These factors primarily pertain to the precision required in dental procedures and the physical positioning and movements involved. As detailed in the "Guide de prévention des troubles musculosquelettiques (TMS) en clinique dentaire" published by a joint sector-based association in Québec, risk factors in dental work include prolonged and repetitive static postures, high-precision manual tasks, and awkward working positions that generate excessive muscle strain (Rose-Ange Proteau, 2009). Indeed, many dental procedures require extended forward neck flexion, static muscle contractions in the cervical area and upper trapezius, and prolonged static contractions of the lower back muscles when seated. The guide identifies that maintaining a forward-leaning posture without lumbar support or bending sideways for extended periods contributes significantly to MSD development (Rose-Ange Proteau, 2009). Other key risk factors identified include extended periods of neck forward flexion causing static muscle contractions in the cervical area and upper trapezius during most dental treatments (Kawtharani et al., 2023), static contractions of lower back muscles when seated, particularly when leaning forward without lumbar support or bending sideways for prolonged times (Jung et al., 2020). There is significant pressure within the shoulder area when arms are extended away from the body for long periods. Difficult shoulder, wrist (flexion, extension), and forearm (rotation) positions are required when handling instruments to remove tartar or during procedures requiring directional force, particularly in hard-to-reach areas of the patient's mouth (Rose-Ange Proteau, 2009). In addition to physical stressors, time constraints and patient volume exacerbate biomechanical risk factors in dental settings. The guide highlights that tight scheduling and the need for efficiency can prevent sufficient micro-breaks, leading to cumulative fatigue and increased MSD risk. Stress from patient management, high cognitive load, and precision demands also contribute to musculoskeletal strain, as mental

stress can elevate muscle tension and reduce postural control development (Rose-Ange Proteau, 2009). This compilation of ergonomic risk factors underlines dental work's complex and demanding nature. (Blume et al., 2021). The job involves high visual demands, which result in postural adaptations. In their work, dentists often assume a kyphotic posture, bending and turning the head to adjust their field of vision with lumbar rotation and flexion.

Further, the design of dental workspaces and the equipment used can significantly impact ergonomics. Poorly designed chairs, workstations, and instruments can exacerbate musculoskeletal issues (Valachi & Valachi, 2003). In addition to physical strain, psychosocial factors play a pivotal role in MSD development. Stock et al. (2013) proposed a model that integrates psychosocial and biomechanical exposures, demonstrating that mental stress indirectly heightens biomechanical risks by reducing workers' ability to recover and by amplifying perceived task demands. In dental settings, where precision and prolonged static postures are necessary, the interplay of these factors may explain the high rates of WMSDs, particularly in the back, neck, and shoulders. Further, according to Susan R. Stock et al. (2018), high job demands, limited support from coworkers or supervisors, and an imbalanced effort-reward dynamic are notable psychosocial risk factors for work-related musculoskeletal disorders (WMSDs). These factors contribute to WMSD risk through the physical strain associated with demanding tasks and stress-related physiological responses. This combination of physical strain and the mental demands of providing patient care can lead to overall fatigue, affecting both physical and psychological health.

1.6.4. Clinical manifestations

WMSDs typically manifest as pain and functional impairment affecting muscles, tendons, ligaments, joints, and nerves (Côté et al., 2014). However, the symptoms of MSDs in dental professionals can vary due to their multifactorial etiology. In a study on WRMSD among dental students in the UK, initial symptoms include pain, swelling, tenderness, numbness, and loss of strength, along with other symptoms encompassing discomfort, aching, numbness, tingling, burning, stiffness, and fatigue (Nicholas N et al., 2020). Key manifestations include a marked reduction in the range of motion, often accompanied by diminished grip strength, which severely hampers the ability to perform tasks requiring precision and dexterity (Greggi et al., 2024). Furthermore, individuals frequently report a loss of normal sensation—ranging from tingling or numbness to complete sensory deficits—which, in turn, compromises their motor control and coordination. These impairments can lead to difficulty in maintaining posture,

executing fine motor movements, and performing repetitive tasks, which are critical in professions like dentistry. As the condition progresses, excessive fatigue, cramping, and discomfort in the neck, shoulders, and upper limbs are common, further exacerbating functional decline (de Almeida et al., 2024). These symptoms can significantly reduce a dental professional's ability to perform tasks effectively and increase the risk of errors (Hayes et al., 2009).

1.6.5. Burden of MSDs

The impact of musculoskeletal disorders on dental professionals extends far beyond physical discomfort, significantly affecting their psychological well-being, patient care quality, and economic stability. Physically, MSDs often result in reduced capacity to perform daily tasks at work, leading to increased sick leave, decreased work productivity, and a higher incidence of workplace accidents (de Santana Sampaio Castilho et al., 2021; Rambabu & Suneetha, 2014). Chronic pain and physical limitations can also contribute to a decline in job satisfaction and motivation, as dental professionals may feel increasingly unable to meet the demands of their profession (Ohlendorf et al., 2017). The psychological toll of MSDs on dental professionals is profound. Prolonged pain and the inability to perform essential tasks may lead to stress, anxiety, and depression, especially when compounded by the fear of career-ending injuries. In many cases, dental professionals with MSDs may experience burnout due to the dual pressures of physical strain and the mental exhaustion of coping with chronic pain. This can result in a sense of helplessness or professional dissatisfaction, leading to emotional disengagement from the work itself (Brown et al., 2010). Over time, these psychological effects can erode the overall well-being of dental professionals, increasing the risk of early retirement or career changes (Barry et al., 2017; Brown et al., 2010).

The ripple effect of MSDs also impacts patient care. When dental professionals are affected by MSDs, the quality of care they can provide often diminishes. Physical pain may lead to shortened appointment durations, less precision in clinical procedures, and decreased attentiveness to care. Consequently, patients may receive suboptimal treatment, increasing the risk of complications or requiring for repeat procedures. Moreover, frequent absences due to MSD-related sick leave can disrupt the continuity of care, leading to longer waiting times and patient dissatisfaction. The reputation of dental practices may also suffer as patients seek more reliable care elsewhere (Health Advocate, 2018).

Economically, the impact of MSDs on dental professionals and the broader healthcare system is substantial. For individual practitioners, the economic burden is twofold: lost income due to reduced working hours or absences and the potential cost of medical treatments, physical therapy, and ergonomic interventions. For dental practices, the costs of MSDs manifest in lost productivity, staff turnover, and the expense of hiring temporary or replacement staff to cover for those unable to work. The financial strain is further exacerbated when dental professionals are forced to retire early due to chronic MSDs, as practices must invest time and resources in recruiting and training new staff (Spine Research Institute, 2024).

1.7. Gaps in knowledge

The current body of literature highlights the serious impact of musculoskeletal disorders on dental professionals, yet significant knowledge gaps remain. A key limitation in many studies is the reliance on self-reported data, typically gathered through surveys and questionnaires as shown in Table 1 in section 1.6.2. While these methods are valuable for understanding subjective experiences, they are prone to several biases, including recall bias, social desirability bias, and selection bias. For instance, individuals experiencing severe symptoms may be more likely to participate in surveys, skewing the results and compromising the accuracy of prevalence estimates (Ohlendorf et al., 2017). Additionally, distinguishing between MSDs arising from occupational activities versus personal activities remains challenging, as symptoms can often overlap. Literature emphasizes the need for careful analysis to confirm occupational causes and mitigate biases, reinforcing the study's focus on work-related MSD prevalence (Punnett & Wegman, 2004).

One area where the literature falls short is in the use of objective, empirical data sources, such as workers' compensation claims (Seabury et al., 2014). However, workers' compensation data, while not self-reported, suffer from significant under-reporting, making them an imperfect alternative to survey-based research. These records, though offering complementary insights, are subject to their own biases, particularly due to underreporting and the complexity of claim approvals, which may exclude many work-related MSD cases (Stock et al., 2014). Analyzing these claims still offers useful information by shedding light on the types of injuries sustained, their economic costs, and the specific occupational tasks that pose the greatest risk. However, their limitations must be carefully considered, and their findings interpreted in conjunction with other data sources. This type of objective data could help identify trends and

inform more effective preventive strategies, while also quantifying the economic burden MSDs place on both individuals and the healthcare system.

Much of the existing literature on MSDs among dental professionals is over ten years old, with limited recent research addressing the full scope of these disorders. As dentistry continues to advance rapidly, incorporating new ergonomic technologies—such as specialized chairs, instruments, and improved workstation designs—there is a pressing need to investigate trends in the prevalence, causes, and impacts of MSDs in recent years. Updated research could provide insights into how these advancements influence the overall burden of MSDs, encompassing not only the physical but also the psychological and social effects, thereby offering a comprehensive understanding of their impact on dental professionals' health, job satisfaction, and career longevity (Puriene et al., 2007). Addressing these research gaps requires a multidisciplinary approach that combines epidemiology, occupational health, ergonomics, and data science. By moving beyond self-reported data and exploring objective measures such as compensation claims, the field can gain a more comprehensive understanding of the risks dental professionals face and develop more effective strategies to mitigate these hazards.

1.8. Research objectives

The general goal of this MSc. research project was to provide a portrait of compensated claims among dental workers in Quebec. This was achieved with the following sub-objectives:

1. To describe the compensated claims in the provincial compensation claims database among dental professionals from 2005 to 2019.
2. To estimate the annual claim rates for musculoskeletal disorders among dental workers from 2005 to 2019.
3. To describe and categorize the types of MSDs most frequently reported in this workforce, identifying year-wise trends and evaluating potential factors (such as age group, sex, and type of occupation) associated with the filing of claims.

Chapter 2: Manuscript

The article, titled "Patterns and Prevalence of Musculoskeletal Disorders in the Dental Workforce: Insights from 15 Years of Compensated Claims," was written following the analysis of data from the CNESST. Details of the methods used in this analysis are presented in detail in Appendix 1 of the thesis. The article was written by me and was reviewed and revised by my supervisors and co-authors Sabrina Gravel, Elham Emami, Maud Gonella, and Jaunathan Bilodeau.

Patterns and prevalence of musculoskeletal disorders in the dental workforce: Insights from 15 years of compensated claims

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Abstract

Background

Surveys have highlighted the prevalence of musculoskeletal disorders (MSDs) in dental workers. The aim of this study was to estimate and describe MSD claim rates using 15 years of compensation data.

Methods

Compensated claims from dental workers in the Quebec Workers' Compensation Board database from 2005 to 2019 were analyzed. Claims were stratified using occupation, sex, age, and site of injury. Annual MSD claim rates were calculated, and negative binomial regression models were used to assess MSD claims determinants and temporal trends.

Results

Of the 2229 compensated claims from dentists, dental hygienists, dental assistants, and technicians, 722 (32%) were for MSDs. The age group with the highest claim rate ratio (RR) was 25–34, with RRs decreasing progressively with age, from 0.50 (95% CI: 0.48–0.53, $p < 0.001$) for workers aged 25–34 to 0.34 (95% CI: 0.31–0.36, $p < 0.001$) for those aged 55–64. The average annual MSD claim rate was 3.3 per 1000 employed dental workers (3.1-3.6) and remained stable over the study period. Most claims for MSDs were in the shoulder (23%), followed by the wrists (20%). The most common types of MSDs were sprains, strains, and tears, with a peak claim rate of 2.1 (1.4-2.9) and an overall increase of 2.6% per year ($p = 0.029$). When stratified by occupation, dental hygienists, assistants, and technicians had a higher rate of injuries related to repetitive movements (5.3%) compared to dentists (3.1%).

Conclusions

Nearly one-third of claims in the dental workforce over 15 years were for MSDs, highlighting the need to strengthen interventions for a safer dental workforce.

Keywords

Occupational health, Dentistry, Musculoskeletal disorders, compensation claims

Key points

What is already known on this topic

Prior research identified significant occupational hazards in dental workplaces with a high prevalence of musculoskeletal disorders (MSDs) among dental professionals. Studies across different countries have documented the extent of MSDs, underscoring the global concern in the dental profession, but little is known about workers' compensation claims for MSDs. Therefore, there is a need for comprehensive data analysis.

What this study adds

This study analyzes the workers' compensation claims for Quebec's dental workers from 2005 to 2019, highlighting a higher claim rate of MSDs among dental hygienists, assistants, and technicians than in dentists. It provides new insights into the patterns and incidence of specific MSDs over time and reveals a notable gender disparity in injury claims.

How this study might affect research, practice, or policy

Targeted ergonomic and preventive interventions are necessary in dental practice. Our findings call for further research to assess and develop ergonomic solutions and strategies to reduce the incidence of MSDs and improve the occupational health and safety of dental professionals.

Introduction

In the past decade, the World Health Organization estimated that 20-50% of workers globally were exposed to various occupational hazards, which resulted in a number of occupational injuries and diseases (El-Menyar et al., 2016). In 2021, 227,217 occupational injuries were reported to workers' compensation agencies in Canada, of which an estimated 1% are within the dental workforce, based on typical proportions in the healthcare sector (Association of Workers' Compensation Boards of Canada, 2023). The dental workforce includes dentists, dental assistants, dental hygienists, nurses and therapists, dental technologists and technicians, and denturists, all of whom play a crucial role in public health and well-being, by maintaining oral health (Kapila, 2021). Among other tasks, dentists diagnose and treat dental issues, often performing procedures or surgeries requiring prolonged leaning over patients. Dental assistants support these tasks by managing materials, handling equipment, and maintaining patient comfort, which involves repetitive motions and awkward postures. Dental hygienists focus on preventive oral care, frequently adopting strained positions to clean teeth effectively. Dental technicians and denturists generally work in laboratories, often in sustained positions, making and fitting dental prosthetics. Hence, their many tasks can expose them to various occupational hazards, including biological, chemical, psychosocial, and physical demands (Ayatollahi et al., 2012). Among the physical challenges, those related to posture and ergonomics are highly prevalent (Harris et al., 2020; Morse et al., 2010; Sartorio et al., 2005). This magnitude is due to certain positions in dental settings, which include prolonged static posture, extreme-forward tilt, an overstretched neck, raising shoulders, increased curvature of the thoracic vertebral column, and constraining lower leg positioning. All these can contribute to the occurrence of musculoskeletal disorders (MSDs) in the dental workforce (Finsen et al., 1998; Ohlendorf et al., 2020).

Various studies have highlighted MSDs in dental workers. Among others, a survey in Australia revealed that 64% of dentists experienced musculoskeletal pain (Marshall et al., 1997). In another observational study in Australia, 87% of dentists reported having experienced at least one MSD symptom within a year (Ylipaa et al., 2002). In Italy, the prevalence of MSDs among dental workers was reported to be 85% (Gandolfi et al., 2021). Similarly, a study involving Canadian dental hygienists underlined the widespread nature of the problem, with 83% of respondents indicating occupation-related MSDs (Harris et al., 2020). However, most of these findings are based on self-reported data, and such surveys generally lack the confirmation by a health professional of the injury and its work-relatedness.

In the Canadian context, as in most middle and high-income countries, workers are covered by an insurance policy taken out by their employer. The province of Quebec, whose population represents around 22% of the Canadian population, has a dental workforce of approximately 18,860 dentists, denturists, dental assistants, hygienists and technicians, close to 20% of Canada's total dental workforce (2022 census) (Statistics Canada, 2022). Employed workers and self-employed elective contributors are insured against occupational injuries and illnesses by a workers' compensation board, which is administered by the Commission for Standards, Equity, Health, and Safety at Work (Commission des normes, de l'équité, de la santé et de la sécurité du travail; CNESST) (Commission des normes de l'équité de la santé et de la sécurité au travail, 2021b). It is estimated that nearly 75% of the dental workforce is covered, (Statistics Canada, 2022) which makes the claims database a crucial resource for understanding occupational diseases and injuries in the dental workforce. Despite the documentation on the prevalence of MSDs in dental workers, based on surveys, there is limited data based on compensation claims, and hence based on medical diagnosis, addressing the incidence and nature of MSDs in this workforce.

The aim of the current study is to estimate the claim rates for MSDs in dental workers, using a provincial compensation claims database over 15 years, and to describe the nature of the MSDs.

Methods

Database

Information on claims accepted for compensation from 2005 to 2019 was obtained from the administrative database of the CNESST. For the years under study, the database comprised anonymous information on claimants' occupations classified according to the 1971 Canadian Descriptive Classification of Occupations, (Bureau Fédéral de la Statistique, 1971a) where dental workers fall into one of two occupation codes: 3113 – Dentists, and 3157 – Dental hygienists, dental assistants, and technicians (Bureau Fédéral de la Statistique, 1971a). The CNESST database included individual demographic characteristics (e.g., age and sex), the year and a description of the injury, and the body part affected coded according to the Canadian Standard Association Z795-03 (Canadian Standards Association, 2003). Given the time lag between the initial filing of a claim and its final decision in the CNESST database, the data maturity period for this study is three years. Because of the nature of the database, this study includes only Quebec residents who are employed and excludes self-employed workers who are not insured by the provincial workers' compensation board.

Statistical Analyses

For descriptive analyses, claims were stratified according to occupation, sex, age, and site of injury. Workers were divided into six age groups: (1) <25 years, (2) 25–34 years, (3) 35–44 years, (4) 45–54 years, (5) 55–64 years, and (6) ≥65 years. The study included only salaried dental workers in Quebec who were employed and covered by the provincial workers' compensation board (CNESST). Self-employed workers were excluded since they are not insured by the CNESST. Occupations were classified based on the 1971 Canadian Descriptive Classification of Occupations, which groups dental professionals into two categories:

- 3113 – Dentists
- 3157 – Dental hygienists, dental assistants, and dental technicians

Instead of using specific diagnostic codes, the dataset classified WMSDs as a binary variable (Yes/No), indicating whether an accepted claim was related to an MSD. The annual MSD claim rates were calculated by dividing the yearly MSD claims by the number of salaried workers for that year. As salaried worker is defined as a worker who is employed and presumed to be covered by the compensation board. Similarly, the claim rate for each type of MSD was calculated by dividing the number of yearly claims for each type of MSD by the total number of salaried workers for that year. According to the following formula, these claim rates were expressed per 1000 employed workers. It is assumed that all salaried workers are covered by the provincial compensation board, ensuring comprehensive representation in the dataset:

$$Claim\ Rate = \frac{Number\ of\ MSD\ Claims\ (per\ year)}{Total\ salaried\ dental\ workers\ (per\ year)} \times 1000.$$

Additionally, we calculated frequencies for claims based on the affected body part, providing further insights into the distribution of MSDs by injury site.

The total number of salaried dental workers per year (denominator) was estimated using Statistics Canada's Census of Population data (from 2006, 2011, 2016, and 2021) and Labour Force Survey data (LFS 2005-2019) (Statistics Canada, 2024b; Statistiques Canada, 2022). While the Census provides detailed demographic and employment data every five years, it does not capture workforce information for the years in between. To fill in these gaps, we used the LFS, which provides annual updates on employment statistics, but lacks the detailed distribution of workers in every occupation. To estimate total worker populations for intercensal years, linear

interpolations were applied for the years between census data years (2006, 2011, 2016, 2021), with the line's slope adjusted for each year according to LFS data on healthcare workers.

Negative binomial regression (NBR) models were used to estimate the claim rate ratio (RR) with 95% confidence intervals (CIs) and to compare different demographic groups (Schober & Vetter, 2021). The negative binomial regression (NBR) is a generalization of the Poisson model, primarily used for modelling count data, mainly when the data exhibits overdispersion, with the variance exceeding the mean. This model allowed for random variability in the data, making it more suitable for our analysis than the simpler Poisson model. Claim counts were analyzed using a NBR model, with the number of claims as the dependent variable. The final model included sex, age group, and occupation as independent variables, with an offset for the number of employed dental workers in each category. This offset allowed us to adjust for varying workforce sizes across demographic groups, ensuring the focus remained on differences in claim rates rather than group size. Additionally, to analyze claim rate trends over the 15-year period, year was included as an independent variable, with the workforce size serving as the exposure variable. This approach enabled us to account for changes in the dental workforce population over time, providing a clearer perspective on how claim rates have evolved within the context of the profession.

The negative binomial regression model used in this study can be expressed mathematically as follows:

$$ln(\lambda_i) = \beta_0 + \beta_1 Sex_i + \beta_2 AgeGroup_i + \beta_3 Occupation_i + \beta_4 Year_i + ln(Workers_i)$$

In this equation, λ_i represents the expected number of claims for a given group i, while β_0 is the intercept of the model. The terms $\beta_1 Sex_i$, $\beta_2 AgeGroup_i$, and $\beta_3 Occupation_i$ correspond to categorical independent variables representing sex, age group, and occupational classification, respectively. The variable $\beta_4 Year_i$ captures temporal trends over the 15-year study period. Finally, $\ln(Workers_i)$ is included as an offset term to account for variations in workforce size across different demographic and occupational groups, ensuring that the model estimates claim rates rather than raw claim counts. Since the analysis employs a negative binomial regression model, the logarithm of the expected claim count is modelled as a linear combination of the predictor variables. The inclusion of the offset term ensures that the model appropriately adjusts for the number of employed dental workers in each category.

The model was selected as the most parsimonious, including the fewest number of variables while still explaining most of the variation in claim rates. NBRs were also used to assess overall trends in claim rates over the 15 years, with the year as the independent variable, the claim rate as the dependent variable, and the number of workers as the exposure variable to account for changes in the worker population.

A sensitivity analysis was conducted with the NBR model to assess the impact of excluding a data point from a worker <18 years of age, referred to as the 'outlier.' This analysis confirmed the robustness of our findings. Another sensitivity analysis was conducted, which focused on the impact of occupation on the rate ratio of MSD claims. This was done by comparing the results of the model with and without inclusion of the dichotomous variable representing the occupation of the dental worker in the analysis. The exclusion of the variable did not significantly alter the regression results. Statistical analyses were conducted using Stata 18.0 (StataCorp LLC, Texas).

Results

Total claims

A total of 2230 claims were identified for the 15-year study period. The mean age of dental workers was 37 years old (SD = 0.2 years), ranging from 16 to 80 years old. The claim from the 16-year-old was excluded from the remaining analyses, resulting in 2229 claims being included for this period. There were no missing observations in the dataset.

Distribution and characteristics of all claims

More claims were compensated by Female workers overall (n=2142), compared to male workers (n=87), representing 96% of the total dataset. However, the proportion of male claimants in dentist was statistically higher than in the other professions. Most compensation claims were filed by individuals in the 25-34 and 35-44 age groups, with 670 and 612 claims, respectively, accounting for 30% and 28% of the total claims. The differences in claim distribution across the age groups between Dentist and the other professions were not statistically significant. A majority (88%) of the claims did not incur permanent impairments in workers, and the proportion was statistically significantly higher in Dental hygienists, assistant and technicians, compared to Dentists. Finally, 32% of the claims were filed for musculoskeletal disorders, in a higher proportion again in the Dental hygienists, assistants and technicians' group. The distribution and characteristics of the accepted compensation claims are presented in Table 1.

Table M 1- Distribution (Percentage) and characteristics of all compensated claims in dental workers over 15 Years (n=2229)

	Occupational group			
	Dentists N (%)	**Dental hygienists, assistants, technicians N (%)**	**Total N**	**P value[a]**
Total	96 (100%)	2134 (100%)	2229 (100%)	
Sex				
Female	85 (89%)	2057 (96%)	2142 (96%)	
Male	11 (11%)	76 (3.6%)	87 (3.9%)	0.000
Age (years)				
18-24	19 (20%)	289 (14%)	308 (14%)	
25-34	35 (36%)	635 (30%)	670 (30%)	
35-44	24 (25%)	588 (28%)	612 (28%)	
45-54	14 (15%)	474 (22%)	488 (22%)	
55-64	4 (4.2%)	136 (6.4%)	140 (6.3%)	
> 65	0 (0%)	11 (0.52%)	11 (0.5%)	0.168
Permanent Impairment				
Yes	4 (4.2%)	259 (12%)	263 (12%)	
No	92 (96%)	1874 (88%)	1966 (88%)	0.018
Musculoskeletal disorder				
Yes	22 (23%)	700 (33%)	722 (32%)	
No	74 (77%)	1433 (67%)	1507 (68%)	0.043

[a] Pearson chi-square between the two occupational groups.

The number of salaried dental workers in Quebec ranged from a minimum of 12 285 to a maximum of 17 479, with a mean estimate of 14 489 (SD = 1 643) over the study period. The negative binomial regressions revealed significant differences in claim rates ratio (RR) between sexes. Indeed, men were found to have an adjusted RR of 0.76 (95% CI: 0.69-0.84, $p < 0.001$). Age was also a significant determinant of claims rate, where all age groups had lower claim rates than the youngest group. Indeed, RRs were ranging from 0.34 (95% CI: 0.31-0.36, $p < 0.001$) for workers aged 55-64 to 0.50 (95% CI: 0.48-0.53, $p < 0.001$) for those aged 25-34. Finally, dental hygienists, assistants, and technicians' RR was as high as 11 (95% CI: 10 to 13, $p < 0.001$). Detailed adjusted RRs are presented in Table 2.

Table M 2- Rate ratios of all workplace injuries by sex, age group and occupation with 95% Confidence Intervals and p-values.

Variable	RR	95% CI	p-value
Sex			
Female	1.0 (reference category)		
Male	0.76	0.69-0.84	<0.001
Age Group			
18-24 years	1.0 (reference category)		
25-34 years	0.50	0.48-0.53	<0.001
35-44 years	0.38	0.36-0.41	<0.001
45-54 years	0.41	0.39-0.43	<0.001
55-64 years	0.34	0.31-0.36	<0.001
65 and above	0.44	0.33-0.59	<0.001
Occupation			
Dentists	1.0 (reference category)		
Dental Hygienists, Assistants, and Technicians	11	10-13	<0.001

MSDs claim rates

MSDs accounted for 722 claims, which represents 32% of the dataset. The average MSD annual claim rate over the 15 years was 3.3 per 1000 employed dental workers (95% CI: 3.1- 3.6). The highest rate was 4.1 MSD claims per 1000 employed workers (95% CI: 3.1- 5.0) in 2018, and the lowest rate was 2.6 (95% CI: 1.8- 3.5) in 2014. Overall, the 15-year data shows a non-statistically significant yearly 1.4% increase in claim rates (95% CI: -0.0014-0.031; p=0.074). MSD claims rate estimates for all years among the dental workforce with their 95% CIs are provided in Figure 1 (detailed data in Supplementary Table 1). The total worker estimates (denominators) are also presented in Supplementary Table 1.

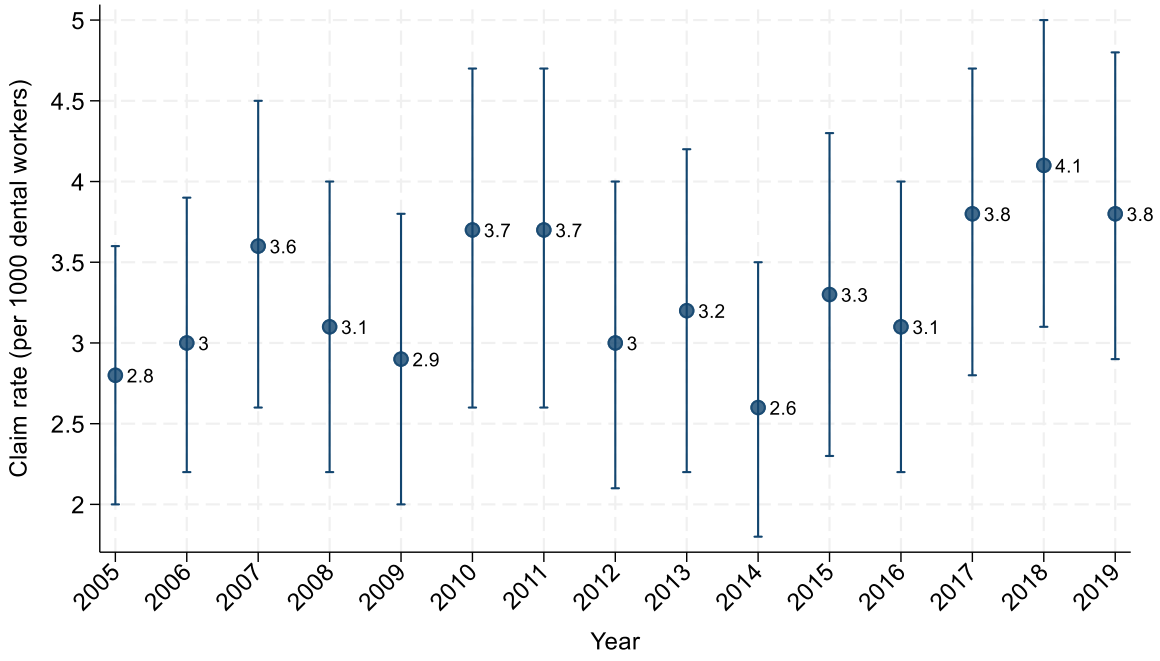

Figure 1- Annual MSD Claim Rates (per 1000 workers) with 95% CIs.

MSDs claim rates by occupation

Twenty-two claims for MSDs were filed by dentists, and 700 by dental hygienists, assistants, and technicians. When stratified by occupation, the latter had a much higher MSD claim rate of 3.0 per 1000 workers (95% CI: 2.9- 3.4) compared to the dentists (0.10 per 1000 workers, 95% CI: 0.033- 0.16). When stratified by occupation, dental hygienists, assistants, and technicians had a higher rate of injuries related to repetitive movements (5.3%) compared to dentists (3.1%). Excessive effort injuries were more common among dentists, with a rate of 4.2%, while the rate among dental hygienists, assistants, and technicians was 1.9%. Injuries related to body reactions

and static postures were slightly higher in dental hygienists, assistants, and technicians (3.6%) than in dentists (3.1%).

MSDs claim rates by body part

In terms of the body part affected, most claims for MSDs were located in the shoulder (23%), followed by the wrists (20%), lumbar region (lower back) (16%), elbow (7.8%), cervical (7.3%) and cervico-dorsal (1.7%) regions of the neck, and in the thumbs, fingers, and hands (9.4%). The distribution of most common MSD claims by body region is provided in Figure 2 and detailed in Supplementary Table 2. The chi-squared test results showed no significant differences between men and women in the occurrence of MSDs across the different injury locations (data not presented).

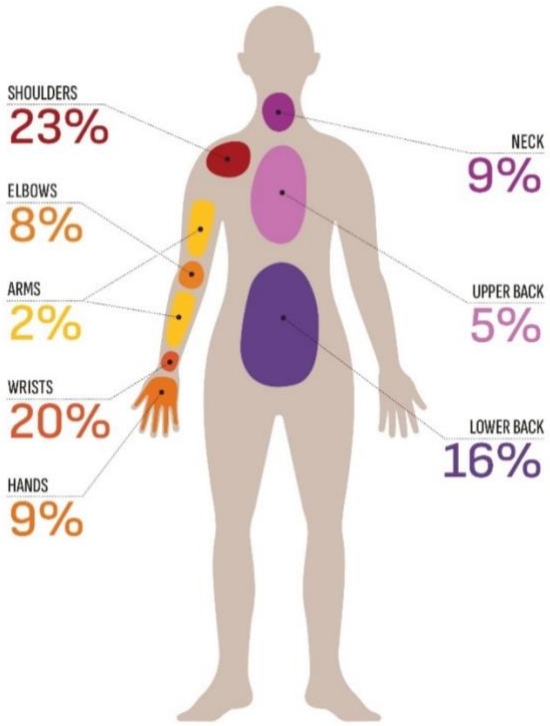

Figure 2- Distribution of most common MSD claims by body region (%)

Claim rates by types of MSDs

The most common types of musculoskeletal disorders (MSDs) in the dataset were sprains, strains, and tears, followed by tendonitis, carpal tunnel syndrome, epicondylitis/epitrochleitis, bursitis, and tenosynovitis (including de Quervain's). Sprain, strain, and tear had a peak claim rate of 2.1, occurring in 2008, 2017, and 2018, while the lowest rate was 1.0 in 2005. This type of injury showed a statistically significant increasing trend over the years, with an overall 2.6% increase in claims per year ($p = 0.029$). The rates for tendonitis showed notable variations, peaking at 1.6 in 2019, with the lowest at 0.82 in 2008. There was an overall 2.5% increase in tendonitis claims per year, though this trend was not statistically significant ($p = 0.069$). The claim rates for carpal tunnel syndrome showed a notable peak in 2011 at 0.57, and the lowest rate was recorded in 2006 at 0.062. Overall, carpal tunnel syndrome showed a statistically significant 5.6% increase in claims per year ($p = 0.03$). The rates for epicondylitis and epitrochleitis fluctuated over the years, with the highest rate at 0.47 in 2005 and the lowest rate at 0.077 in 2013. No statistically significant trend was observed for this type of injury, with an overall 0.82% decrease in claims per year ($p = 0.76$). The claim rates for bursitis also remained relatively low and stable throughout the period, with only slight fluctuations. The highest rate was observed in 2011 at 0.33, with no claims in 2008. Bursitis showed no significant trend, with an overall 0.15% increase in yearly claims ($p = 0.98$). The claim rates for tenosynovitis were generally low and stable, with the highest rate in 2018 at 0.49 and no claims in 2005, 2006, 2008, 2009, 2016, and 2017. Tenosynovitis also showed no statistically significant trend, with an overall 13% increase in claims per year ($p = 0.097$). The annual claim rates of different types of MSDs are presented in Figure 3 (detailed data in Supplementary Table 3 and data for negative binomial regression for trend analysis in Supplementary Table 4).

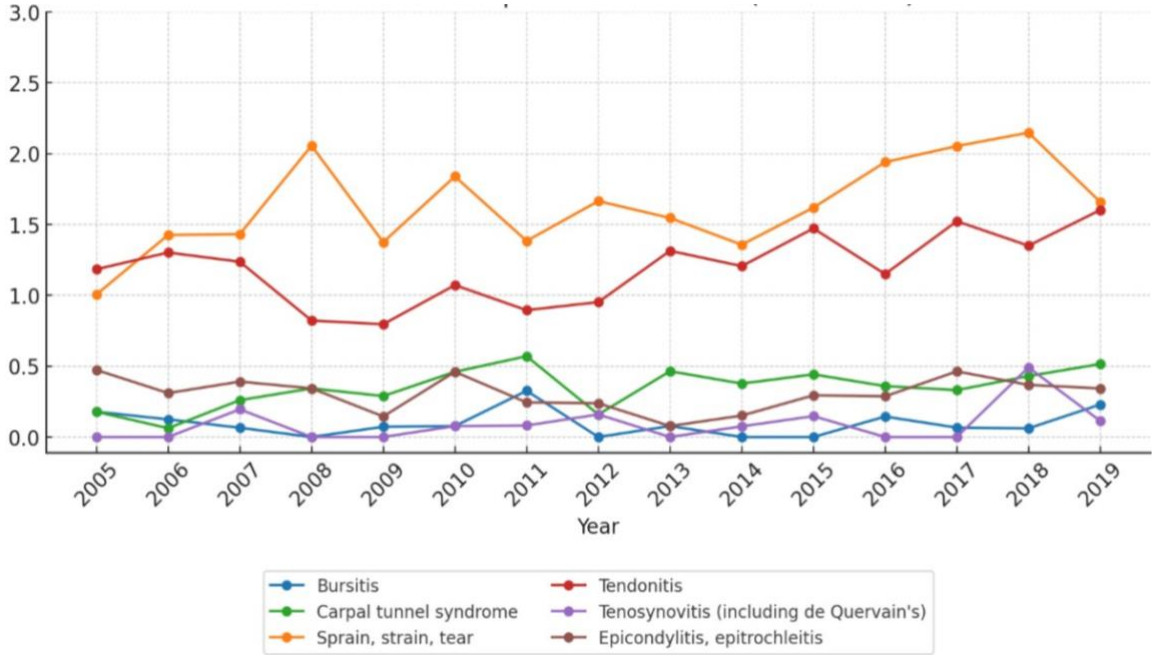

Figure 3- Annual claim rates by type of MSD (per 1000 workers).

Discussion

This study used workers' compensated claims database to estimate the incidence of MSDs claims in dental workers and to describe the nature of the MSDs. First of its kind, it presents many key findings that are relevant for workplace health promotion and well-being in the dental workforce. Foremost, MSDs accounted for 32% of all occupational injuries and disease claims, averaging at 3.3 per 1,000 employed dental workers. In contrast, office workers, who are also predominantly female and are known to suffer from upper limb injuries, have a lower MSD claim rate of 2 per 1,000 workers. Healthcare workers involved in more manual tasks, such as nurses and physical therapists, experience on the other hand much higher MSD claim rates, reaching up to 80 per 1,000 workers.19 While the units are consistent across these comparisons, the nature of the work, basis of the data including the admissibility of claims, calculations, and the specific types of MSDs may differ. Thus, while the comparison provides valuable insight into the relative risk of MSDs across professions, the exact causes, extent, and nature of the injuries may vary. While the MSD claim rate for dental professionals is not the highest compared to other professions, its persistence and, in some cases, increase over a 15-year period—accounting for nearly a third of all dental workforce claims are causes for concern. However, these figures may underestimate the true burden of MSDs due to underreporting, particularly in private dental clinics. In these settings, underreporting is more likely due to factors such as fear of job loss or reduced work

hours if reporting an injury, lack of awareness or reluctance to file claims due to administrative burden, preference for managing injuries privately (e.g., through personal insurance or out-of-pocket treatment) rather than through formal workplace injury claims. Furthermore, female workers represented 96% of the total claims, which is also reflected by their proportion in this workforce as a whole (Quinn et al., 2021; Statistiques Canada, 2022). Women have been often excluded from analyses in OHS research, and the occupational hazards that they may face have been generally underestimated. (Quinn et al., 2021) In this context, attention should be paid to this over-represented group in terms of MSD risk factors in the dental sector. Male workers, although they are less represented in the dental workforce, were also found to have a 24.1% lower incidence of workplace claims compared to female workers, with a rate ratio of 0.76 after controlling for occupation and age. This trend is aligned with observations by Macpherson et al. (2018), who reported a significant sex-based difference in workplace MSD injury claims among Canadian and Australian workers (Macpherson et al., 2018). This disparity could stem from differences regarding gendered job roles, safety practices, or reporting behaviors (Quinn et al., 2021). In the dental workforce, women are more likely to occupy roles such as dental hygienists or assistants, which involve prolonged static postures, repetitive hand movements, and patient handling—factors that contribute to WMSDs. In contrast, male workers may be more represented in dentist roles, where they may have different physical demands and ergonomic challenges. These variations in job tasks, along with potential differences in access to ergonomic training and workplace accommodations, may influence injury risk and reporting behaviors. Our study and Macpherson et al. highlight the need to consider differences between female and male in occupational health research and intervention development.

Age also seemed to be a significant factor in the incidence of MSD claims in dental workers. A review conducted by Laberge and Ledoux (2011) indicated that younger workers experience less severe and less frequent musculoskeletal disorders than older workers. However, they also highlight the significance of early career exposure to factors that may lead to more severe MSDs later in life. This contrasts with our findings, where we observed a lower claim rate in older age groups compared to the baseline group of 18-24 years old, with RRs ranging from 0.34 for individuals aged 55-64 years to 0.50 for those aged 25-34. This may be partially explained by the healthy worker effect, where individuals who develop significant musculoskeletal disorders or other health conditions may leave the workforce earlier, resulting in a working population of older individuals who are healthier and more resilient. Consequently, while younger workers may initially present with fewer and less severe MSDs, they are not necessarily at a lower risk for

workplace injuries in general (Li & Sung, 1999). This finding concurs with the prevalence of other injuries in the dental workforce, such as a higher reporting of needlestick and sharps injuries among Japanese dental workers who had less than 5 years of experience (Iwamatsu-Kobayashi et al., 2023). The higher claim rates among younger dental hygienists, assistants, and technicians, potentially highlighting higher risk of workplace injuries than their older peers and than dentists, emphasizes the necessity for early and role-targeted safety interventions in dentistry. Johnson and Kanji (2016) also support this finding, demonstrating the significant ergonomic challenges and high prevalence of musculoskeletal disorders among dental hygienists in Canada (Johnson & Kanji, 2016).

We highlighted the vulnerability of some body parts over others for MSDs. Notably, we found shoulders, wrists, back, neck, fingers, and hands, in that order, to be hotspots for these injuries. This is echoed by the epidemiologic evidence presented by Punnett and Wegman (2004) Their review also identified these body areas commonly affected in all dental workers due to occupational exposures to repetitive motions, forceful exertions, and awkward postures (Johnson & Kanji, 2016). The significantly higher rates of repetitive movement injuries among dental hygienists, assistants, and technicians highlight the physically repetitive nature of their tasks, such as scaling and polishing teeth. Recent technological advances, particularly in ergonomic equipment and motion-sensing technologies, have shown promise in reducing the physical strain on dental workers. For example, the development of ergonomic handpieces and instruments designed to minimize the force required for dental procedures can significantly reduce repetitive strain injuries (Valachi & Valachi, 2003). Additionally, wearable devices that monitor posture and movement in real-time are being used to provide feedback to workers, promoting better posture and reducing the risk of injury (Lazăr et al., 2024). Moreover, artificial intelligence (AI) and machine learning are being integrated into dental workflow management to optimize work breaks and limit continuous exposure to strenuous tasks, offering tailored intervention strategies for each worker (Schwendicke et al., 2020). These innovations, combined with participatory ergonomic interventions, have demonstrated a significant reduction in reported MSDs, as shown in a recent cluster-randomized controlled trial highlighting the effectiveness of involving workers in designing ergonomic solutions (Bezzina et al., 2023).

A strength of our research using a claims database is the requirement for a health professional's diagnosis and of its work-relatedness to be compensated and hence compiled. This addresses the limitation of potential reporting bias found in self-reported questionnaire surveys (Ohlendorf et al., 2017). Such an approach objectively portrays occupational health risks, highlighting

disparities in injury rates by sex, occupation, and age. These underline the importance of considering worker demographics in developing safe and comfortable work environments for dental professionals. Furthermore, we calculated the rate of MSDs among dental workers by combining Census and Labour Force Survey (LFS) data. By interpolating these datasets, we created a continuous estimation of worker populations over time, trying to address the restrictions of each data source.

Our study has some limitations. The study population includes employed workers covered by the compensation board, which although comprehensive, does not represent the entire population of dental workers in Quebec. Most dentists and denturists are self-employed (up to 83% of the 5900 practicing dentists in Quebec; and 85% for denturists) and, although self-employed workers can contribute voluntarily to the provincial compensation fund in order to be covered, it is not mandatory (Commission des normes de l'équité de la santé et de la sécurité au travail, 2021a). Therefore, this study may underestimate the true burden of MSDs and represent a conservative perspective on a broader problem. Also, the rates are not calculated by the number of working hours or full-time equivalents, which may limit the accuracy of workplace risk injuries assessment and can preclude from making accurate comparisons with other occupations. Further, until 2020, the CNESST relied on the 1971 National Occupation Classification, which, by grouping dental assistants, hygienists, and technicians, impedes the possibility of analyzing profession-specific hazards and risks.

Conclusion

This study provided insights into the occupational health risks faced by dental professionals. The high percentage of claims related to MSDs, particularly in the shoulders, wrists, and lumbar region, suggests that ergonomic issues remain a persistent challenge in dental workplaces. Current practices and interventions need to be re-evaluated or scaled up for a safe and sustainable dental workforce.

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Author contributions

SG conceptualised the study and acquired funding for it. TP developed the protocol, conducted the statistical analyses, and wrote the first draft. JB verified the negative binomial regression model's results. SG, EE, and MG provided expertise and critical revisions during manuscript preparation. All authors approved the final manuscript.

Conflict of interest

None of the authors have conflict of interests to disclose.

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Ethics approval and informed consent

The research was approved by the Research Ethics Board of McGill University (IRB Internal Study Number: A03-E11-23B).

Data Availability Statement

The data underlying this article were provided by Commission des normes, de l'équité, de la santé et de la sécurité du travail under an institutional agreement. Data will be shared on request to the corresponding author with permission of Commission des normes, de l'équité, de la santé et de la sécurité du travail.

Supplementary Material

Supplementary Table 1- Annual MSD Claim Rates (per 1000 workers) with 95% CIs

Year	MSD Claims	Total Workers (Estimates)	MSD Claim Rate	95% CI Lower	95% CI Upper
2005	48	16899	2.8	2.0	3.6
2006	49	16130	3.0	2.2	3.9
2007	55	15361	3.6	2.6	4.5
2008	45	14592	3.1	2.2	4.0
2009	40	13823	2.9	2.0	3.8
2010	48	13054	3.7	2.6	4.7
2011	45	12285	3.7	2.6	4.7
2012	38	12611	3.0	2.1	4.0
2013	41	12937	3.2	2.2	4.2
2014	35	13263	2.6	1.8	3.5
2015	45	13589	3.3	2.3	4.3
2016	43	13915	3.1	2.2	4.0
2017	57	15103	3.8	2.8	4.7
2018	66	16291	4.1	3.1	5.0
2019	67	17479	3.8	2.9	4.8

Supplementary Table 2- Distribution of most common MSDs claims by body region and location.

Body region	Location	Frequency	Percentage	Sum of %
Upper body				
Shoulders	Shoulders (clavicle and scapula)	164	23	23
Wrists	Wrist(s) (wrist bones: trapezius,carpal tunnel)	146	20	20
Arm	Arm (elbow to shoulder)	3	0.42	1.8
	Forearm (wrist to elbow)	10	1.4	
Hands	Hand(s), except finger(s) only	16	2.2	9
	Finger(s), except thumb	12	1.7	
	Thumb or thumb and other fingers	40	5.5	
Elbow	Elbow(s) (olecranon, epicondyle)	57	7.9	7.9
Neck	Cervical region (cervical vertebra)	53	7.3	9
	Cervico-dorsal region	12	1.7	
Back				
Upper Back	Dorsal region	24	3.3	4.9
	Dorso-lumbar region	8	1.1	
	Back (vertebral neck, spinal cord)	2	0.28	0.28
	Back, including spine, medullaoblongata	1	0.14	0.14
Lower Back	Lumbar region	114	16	16
	Lumbosacral region	3	0.42	
	Sacral region	1	0.14	
Lower Body				
Legs and Feet	Leg(s), not specified	1	0.14	0.42
	Foot(s), except toe(s) only	1	0.14	
	Foot(s) and ankle(s)	1	0.14	
Multiple sites				
	Multiple sites	28	3.9	7
	Multiple sites in arm(s)	4	0.55	
	Multiple sites upper limbs	10	1.4	
	Multiple dorsal regions	2	0.28	
	Cannot be classified	2	0.28	
	Finger(s), nail(s), n.p.	1	0.14	
	Thorax (ribs and internal organs)	1	0.14	
	Multiple dorsal regions	2	0.28	

Note: "n.p." stands for "not provided," indicating that specific details regarding the location were unavailable or not recorded.

Supplementary Table 3- Annual claim rates by type of MSD per 1000 workers, with their 95% Confidence Intervals (95% CI).

Year	Sprain, Strain,Tear	Tendonitis	Carpal Tunnel Syndrome	Epicondylitis, Epitrochleitis	Bursitis	Tenosynovitis (including de Quervain's)
2005	1 (0.59, 1.61)	1.2 (0.72, 1.83)	0.18 (0.04, 0.52)	0.47 (0.20, 0.93)	0.18 (0.04, 0.52)	0 (0, 0.22)
2006	1.4 (0.90, 2.14)	1.3 (0.81, 1.99)	0.062 (0.002, 0.35)	0.31 (0.10, 0.72)	0.12 (0.02, 0.45)	0 (0, 0.23)
2007	1.4 (0.90, 2.17)	1.2 (0.69, 1.85)	0.26 (0.07, 0.67)	0.39 (0.14, 0.85)	0.065 (0.002, 0.36)	0.2 (0.04, 0.57)
2008	2.1 (1.44, 3.01)	0.82 (0.42, 1.44)	0.34 (0.11, 0.80)	0.34 (0.11, 0.80)	0 (0, 0.25)	0 (0, 0.25)
2009	1.4 (0.83, 2.15)	0.8 (0.40, 1.42)	0.29 (0.08, 0.74)	0.15 (0.02, 0.52)	0.072 (0.002, 0.40)	0 (0, 0.27)
2010	1.8 (1.12, 2.64)	1.1 (0.59, 1.80)	0.46 (0.17, 1.00)	0.46 (0.17, 1.00)	0.077 (0.002, 0.43)	0.077 (0.002, 0.43)
2011	1.4 (0.81, 2.21)	0.9 (0.45, 1.60)	0.57 (0.23, 1.17)	0.24 (0.05, 0.71)	0.33 (0.09, 0.83)	0.081 (0.002, 0.45)
2012	1.7 (1.03, 2.54)	0.95 (0.49, 1.66)	0.16 (0.02, 0.57)	0.24 (0.05, 0.70)	0 (0, 0.29)	0.16 (0.02, 0.57)
2013	1.5 (0.88, 2.29)	1.3 (0.77, 2.10)	0.46 (0.17, 1.01)	0.077 (0.002, 0.43)	0.077 (0.002, 0.43)	0 (0, 0.29)
2014	1.4 (0.86, 2.24)	1.2 (0.69, 1.96)	0.38 (0.12, 0.88)	0.15 (0.02, 0.54)	0 (0, 0.42)	0.075 (0.002, 0.42)
2015	1.6 (1.01, 2.45)	1.5 (0.90, 2.27)	0.44 (0.16, 0.96)	0.29 (0.08, 0.75)	0 (0, 0.53)	0.15 (0.02, 0.53)
2016	1.9 (1.22, 2.74)	1.2 (0.71, 1.96)	0.36 (0.12, 0.84)	0.29 (0.08, 0.74)	0.14 (0.02, 0.52)	0 (0, 0.27)
2017	2.1 (1.45, 2.99)	1.5 (0.97, 2.28)	0.33 (0.11, 0.77)	0.46 (0.19, 0.95)	0.066 (0.002, 0.37)	0 (0, 0.24)
2018	2.1 (1.45, 2.92)	1.4 (0.90, 2.12)	0.43 (0.17, 0.89)	0.37 (0.14, 0.80)	0.061 (0.002, 0.34)	0.49 (0.21, 0.97)
2019	1.7 (1.16, 2.45)	1.6 (1.06, 2.31)	0.52 (0.24, 0.98)	0.34 (0.13, 0.75)	0.23 (0.06, 0.59)	0.11 (0.01, 0.41)

Chapter 3: Discussion

3.1. Key findings

This study sheds light on the compensated claims from the CNESST database and estimates the incidence of musculoskeletal disorders claims in the Quebec dental workforce over 15 years. The study is the first of its kind and presents many interesting findings. After analyzing 2229 claims, we found that MSDs accounted for 32% of all occupational injuries and disease claims among dental professionals, with an average incidence of 3.3 claims per 1,000 workers. In the following section, we will explore the various aspects of musculoskeletal disorder claims in the Quebec dental workforce using compensation claims data from the CNESST database. This section will provide insights into sex, age-groups and occupational disparities in the different types of MSDs reported, analyze trends in claim incidence and will assess the strengths and limitations of utilizing compensation claims data for such studies, highlighting the potential biases and implications for occupational health interventions and future research within the dental profession.

Sex Disparity

Female workers represent 96% of the total claims. This overrepresentation aligns with the gender distribution in the dental workforce (Canadian Dental Association, 2024) but also raises important questions about gender-specific risk factors and occupational health disparities. After accounting for occupation and age, the incidence of workplace claims was 24.1% higher among female workers compared to the male workers (rate ratio of 1.31), aligning with similar patterns observed across various other industries. According to a study from the Journal of Sex and Gender-specific Medicine, women tend to be more affected by non-fatal injuries like musculoskeletal disorders, repetitive strain injuries, and issues related to ergonomic hazards. They also face higher risks from chemical exposures and are more vulnerable to radiation-induced cancers, whereas men are more frequently exposed to physically demanding tasks, leading to higher rates of severe injuries like falls, vehicle-related accidents, and mechanical injuries in high-risk jobs like construction (Santoro et al., 2022). Workplace designs, including in dental work and office environments, may historically have been developed with male workers in mind, which can contribute to sex-specific ergonomic challenges for women. As a result, women may be more prone to musculoskeletal disorders and repetitive strain injuries due to a misalignment between task design and female physiology (Santoro et al., 2022). For

instance, a study highlights that women in general report higher rates of upper body injuries (like neck, shoulder, and wrist pain) compared to men, often due to ill-fitting equipment and workstations designed based on male anthropometric data. This leads to increased fatigue and a higher risk of occupational diseases for women (Salerno, 2022). This highlights the importance of implementing sex-specific interventions and conducting further research to understand the root causes of these disparities. Future research could focus on longitudinal studies and workplace assessments to examine the specific tasks, ergonomic conditions, and injury patterns experienced by women in the dental profession.

Age-related trends

The study's observation of lower claim rates in older age groups compared to the baseline group of 18-24 years old is intriguing and somewhat counterintuitive. This trend contrasts with the general understanding that older workers typically experience more severe and frequent MSDs (U.S. Bureau of Labor Statistics, 2024). The lower claim rates among older workers (RRs ranging from 0.34 for 55-64 years to 0.50 for 25-34 years) could be explained by several factors. First, a survivor bias may exist, where workers experiencing musculoskeletal disorders leave the workforce earlier, resulting in a healthier remaining cohort. This is typical in cross-sectional studies like ours, where the increasing severity of problems as effects cumulate over time, combined with a high physical workload, resulting in the fall-out from the sample in the older age categories (through sickness absence, disability, or choosing to leave the job), leaving those older workers that are still able to perform their tasks. As a result, work-related problems may be underestimated in the older age groups (Hildebrandt, 1995). Second, the advancements in ergonomics in dentistry between 2005 and 2019 may have significantly contributed to reducing injury rates, particularly among experienced workers. Developing dental chairs, stools, and instruments designed to promote neutral postures has played a role in reducing strain on dentists' and hygienists' bodies. Adjustable, magnification and ergonomic hand tools with lightweight, balanced designs became widespread, allowing practitioners to maintain better posture during procedures (Bethany Valachi, 2008). Proper lighting and the positioning of equipment to be within easy reach have been key ergonomic improvements (Valachi & Valachi, 2005). Integrating technology into dental practice, such as digital imaging and CAD/CAM systems, has reduced the need for repetitive motions and awkward positioning. Digital workflows allow for more precise work with fewer physically demanding tasks, indirectly lowering the risk of MSDs. Dental offices also saw improvements in overall

workplace design, with layouts that reduced unnecessary movement and minimized the need for practitioners to twist or reach awkwardly. These findings highlight the importance of early career interventions and targeted safety measures for younger dental professionals.

Differences within the dental workforce

The dental workforce includes dentists, dental assistants, dental hygienists, nurses and therapists, dental technologists and technicians, as well as denturists, all of whom play a crucial role in public health and well-being, by maintaining oral health (Kapila, 2021). Dentists work in static, awkward postures for extended periods during intricate procedures, which increases their risk of neck, shoulder, and lower back disorders (Kumar et al., 2013). In our study, 4.3% of the injury claims were filed by dentists, while 95.7% were filed by dental hygienists, assistants, and denturists. There is a notable discrepancy in the reporting of musculoskeletal disorders among dental professionals. While dentists demonstrate a lower claim rate compared to assistants and hygienists, this difference persists even when considering that only 25% of dentists are covered by CNESST, as opposed to higher coverage rates among other roles. This suggests that beyond coverage rates, factors like professional autonomy, job security, and specific task-related risks contribute to underreporting among dentists. This discrepancy may also be attributed to the nature of their roles, with dentists often working independently and thus being more reluctant to report injuries. They might also choose not to report injuries to avoid the administrative burden or to prevent raising concerns with patients or insurers, particularly in cases where an injury may seem minor but could still impact their ability to perform effectively. This behavior is influenced by their professional autonomy, which allows them to make independent decisions, but may also lead to underreporting of injuries due to concerns about reputation or financial stability (Shannon et al., 2001). Dental assistants not only support dentists by managing materials and handling equipment, but they also play a key role in patient care and clinic management. This exposes them musculoskeletal disorders due to repetitive motions and awkward postures, as well as potential chemical exposure from disinfectants and dental materials. Hygienists, primarily focused on preventive oral care, frequently engage in scaling and root planing, which places strain on their wrists and hands. The repetitive nature of their tasks and static postures contributes significantly to MSDs (Johnson & Kanji, 2016). Reporting behaviors vary across these roles. Assistants and hygienists, typically employed by dentists, may hesitate to report injuries to avoid disrupting clinic operations. On the other hand, dental technicians and denturists, often working in labs,

are exposed to upper back, neck, and eye strain from precision tasks. Technicians employed in structured environments may be more likely to report injuries, especially when they have access to benefits and workplace protections. However, those working as contractors or in smaller labs may underreport MSDs due to job insecurity and lack of occupational health coverage. By considering the distinct roles and environments, it becomes clear that employment status, job security, and the type of work significantly impact injury reporting behaviors across these professions.

Body Parts at Risk

The study identified shoulders, wrists, back, neck, fingers, and hands as the most vulnerable body parts for MSDs among dental professionals. Studies, such as those by (Hayes et al., 2009) found that neck and shoulder pain is prevalent in up to 60-70% of dental professionals and this is exacerbated by inadequate ergonomic training or poorly adjusted seating and equipment. A study by (Valachi & Valachi, 2005) identified that back pain is a leading cause of disability among dental professionals. Over the years, ergonomic handpieces and instruments have been designed to minimize the required force during treatment. For example, (Dong et al., 2005) highlighted that hand instruments with flexible or rotating heads decrease the strain on fingers and wrists by allowing for more natural movements during scaling and drilling. Additionally, AI-driven personalized intervention strategies offer tailored feedback to each practitioner. For example, advanced machine learning algorithms can more accurately analyze posture data and movement patterns over time to predict potential injury risks. These systems can track real-time body dynamics, detecting subtle deviations that may lead to musculoskeletal disorders. This allows for targeted interventions, such as personalized posture correction exercises, ergonomic adjustments, or workflow modifications, all designed to prevent injury before symptoms manifest. Adjustable dental stools, magnification loupes, and improved patient positioning have been shown to reduce spinal strain and upper extremity fatigue. Workload modifications, such as rotational task assignments and micro-break scheduling, may further mitigate chronic strain among dental professionals (Rose-Ange Proteau, 2009). Furthermore, AI models can adapt to the user's behavior, continuously refining recommendations as more data is collected, ensuring a proactive approach to maintaining long-term health in dental professionals (Niehaus et al., 2022). The following table 2 summarizes the strength of evidence for the relationship between various risk factors and MSDs across different body areas. Based on existing literature by Coggon et al. (2013), as well as more recent systematic reviews and epidemiological studies,

the table categorizes risk factors into those with strong, reasonable, or insufficient evidence. This classification accounts for both biomechanical (e.g., repetitive movements, awkward postures, force exertion) and psychosocial risk factors (e.g., high psychological demands, low decision-making autonomy, workplace harassment), which have been increasingly recognized as significant contributors to WMSDs.

Table 2- Strength of Evidence for Relationship to MSDs by Body Area and Risk Factors

Body Area	**Strong Evidence**	**Reasonable Evidence**	**Insufficient Evidence**
Back and Neck	None	• Psychosocial factors • Smoking • Gender • Posture • Comorbidity • Heavy physical work	• Lifting • Sedentarism • Older age • High BMI
Lower Back	None	• Awkward postures • Heavy physical work • Psychosocial factors	• Smoking • High BMI • Comorbidity • Gender
Upper Limbs: Shoulder	None	• Repetitive work • Heavy physical work • Psychosocial factors	• Older age • High BMI • Sedentarism
Upper Limbs: Elbow/Forearm	None	• Awkward postures • Comorbidity • Repetitive work	• Older age • Sedentarism
Upper Limbs: Wrist/Hand	None	• Prolonged computer work • Heavy physical work • High BMI • Female gender	• Awkward posture • Repetitive work • Smoking
Lower Limbs: Non-specific MSDs	None	• Comorbidity • Psychosocial factors • Smoking	• High BMI
Lower Limbs: Hip	None	• Heavy physical work • Repetitive work	• Lifting
Lower Limbs: Knee	None	• Awkward postures • Lifting • Heavy physical work	• Smoking • Comorbidity • Psychological distress • High BMI

Use of Compensation Claims Data

The use of compensation claims data in Quebec, similar to other provinces and high-income countries, has proven to be a reliable source of occupational injury statistics. As mentioned, in Quebec, compensation claims are managed by the CNESST, which verifies the work-relatedness of injuries before granting compensation. This approach is mirrored in occupational health studies, where using administrative compensation databases ensures that only verified cases are included. However, while these databases offer a standardized collection of injury

information, they are not without limitations. Workers' compensation data are subject to underreporting, as not all work-related injuries are reported or accepted as compensable cases. Factors such as employer reporting practices, worker reluctance due to fear of job loss or stigma, and administrative hurdles can all contribute to gaps in the data (Utterback et al., 2012).

In countries like the United States, the Occupational Safety and Health Administration (OSHA) plays a similar role in tracking occupational injuries, while in Europe, organizations like Eurostat collect data from national compensation schemes to assess trends across industries. The standardization of injury data, coupled with medical verification, enhances the reliability of such systems for analyzing trends over time. MSDs are consistently among the most common types of work-related injuries in high-income countries, particularly in physically demanding professions like healthcare, construction, and dentistry (European Agency for Safety and Health at Work, 2019).

Over time, trends in compensation claims for MSDs have evolved, reflecting changes in both workplace practices and healthcare systems. For example, from the early 2000s to the present, many high-income countries such as Canada have seen a decline in claims for injuries such as MSDs across many industries, likely due to improvements in workplace ergonomics, safety training, and the integration of technology that reduces physical strain (Mustard et al., 2015). In the dental profession, specifically, the implementation of ergonomic designs for chairs, instruments, and workstations may have contributed to the reduction in certain MSD claims (Bethany Valachi, 2008).

The financial implications of compensation claims are significant, as MSDs often lead to costly treatment, prolonged recovery periods, and lost productivity. In high-income countries, compensating for musculoskeletal disorders (MSDs) places a significant financial burden on employers and compensation boards. The costs associated with these claims run into billions. For instance, in the United States, MSDs account for one-third of all workers' compensation costs, with direct costs estimated at $20 billion annually. When factoring in indirect costs, such as lost productivity and additional operational expenses, the total burden can rise to between $45-54 billion per year (Hanifa et al., 2023).

The use of compensation claims data remains invaluable for identifying trends in workplace injuries and developing targeted interventions. The data collected allows occupational health authorities to pinpoint industries and occupations at high risk for MSDs, such as dentistry, and to tailor safety regulations accordingly. Furthermore, the data can be used to track the

effectiveness of interventions over time, such as the introduction of ergonomic training programs or new workplace safety standards. This feedback loop between data collection and policy development is critical for reducing injury rates and ensuring the health and safety of workers across various sectors.

However, there are limitations to relying solely on compensation claims data. In Quebec and other provinces, self-employed workers, such as many dentists and denturists, are not required to contribute to the provincial compensation fund, meaning their injuries are often underreported. In some cases, small clinic workers may also hesitate to file claims due to financial pressures or concerns about job security (Cloutier et al., 2019). In addition, compensation boards in different countries may have varying definitions and thresholds for compensable injuries, making international comparisons of MSD incidence rates more challenging (EU-OSHA, 2020). Despite these limitations, compensation claims data remain a robust tool for understanding occupational health risks, particularly in regulated industries like dentistry.

Technological Innovations

The integration of advanced technologies such as robotics and artificial intelligence (AI) has the potential to revolutionize the dental profession by reducing the physical strain that contributes to MSDs (El-Helaly, 2024). One promising development is the use of robotic-assisted surgery in dental procedures, which can enhance precision and reduce the physical demands on the dentist. For example, robotic systems like Yomi®—the first FDA-cleared robotic device for dental implant surgery—allow dentists to perform procedures with improved accuracy while reducing the need for repetitive (Cepolina & Razzoli, 2024).

In addition, AI-powered tools are being developed to monitor and improve posture during dental procedures. Wearable sensors integrated with AI algorithms can provide real-time feedback on posture and movements, alerting dentists when they are adopting positions that may lead to strain or injury (El-Helaly, 2024).

3.2. Strengths and Limitations

A significant strength of our research using a claims database is the requirement that a health professional verify both the injury and its work-relatedness before any claims are approved. This approach reduces the risk of reporting bias, a common limitation in studies that rely on self-reported surveys, where injuries may be under- or over-reported depending on the

respondent's perception. By using verified claims data, our study objectively captures the occupational health risks specific to dental professionals, offering a more reliable portrayal of injury trends. This method is particularly important for assessing disparities in musculoskeletal disorder rates based on sex, occupation, and age, which can inform the development of targeted interventions. For example, female dental hygienists may experience higher rates of MSDs in the wrist and hands, while male dentists may report more lower back issues due to prolonged standing. These verified disparities emphasize the need to consider worker demographics when designing safer and more comfortable work environments for dental professionals. Additionally, the use of multiple data sources—combining Census data and Labor Force Survey (LFS) data—enhances the accuracy of our findings. The Census provides comprehensive demographic data every five years, offering a detailed snapshot of the workforce, while the LFS offers more frequent updates on workforce changes but has a smaller sample size. By interpolating these datasets, we created a continuous estimation of worker populations over time, allowing for a more nuanced understanding of MSD incidence rates.

Despite these strengths, our study has some noteworthy limitations. First, the study population consists only of employed workers covered by the Quebec compensation board (CNESST), which does not represent the entire population of dental workers in Quebec. A significant proportion of dental professionals, such as dentists and denturists, are self-employed. In Quebec, up to 25% of the 5900 practicing dentists and 85% of denturists are self-employed. Although self-employed workers have the option to voluntarily contribute to the provincial compensation fund to obtain coverage, this is not mandatory. As a result, our claims data may underestimate the true burden of MSDs, particularly among self-employed workers who may choose not to participate in the compensation system. Furthermore, underreporting of claims, especially in small clinics, is a known issue in dental practice, where some workers may be reluctant to file claims due to financial pressures or fear of repercussions (Lippel, 2012). These further limits the comprehensiveness of our data, as injuries in small or independent clinics may go unreported, resulting in underestimated injury rates.

Another limitation is the potential for claims rejection, where not all submitted claims are accepted by the compensation board. This may exclude certain legitimate cases from the analysis, again underestimating the true incidence of MSDs in the dental workforce. Moreover, our study does not calculate injury rates based on the number of working hours or full-time equivalents (FTEs), which would provide a more precise measure of occupational risk. Instead,

rates are based on overall worker counts, which may skew the data by not accounting for part-time or casual workers who have less exposure to ergonomic risks.

Lastly, until 2020, the CNESST used the 1971 National Occupation Classification system, which grouped dental assistants, hygienists, and technicians together, making it impossible to analyze profession-specific hazards. This classification system's lack of granularity limits the accuracy of identifying and addressing specific risks associated with each dental profession. For instance, dental assistants may face more repetitive hand movements, while hygienists could have more posture-related issues. The inability to separate these professions in the data precludes detailed analysis of these unique occupational risks, reducing the overall precision of the study's findings.

These limitations suggest that our estimates likely understate the true risk of musculoskeletal disorders in the dental profession and highlight areas where future research could improve, such as including self-employed workers and considering the number of working hours to better capture the full extent of workplace-related MSDs.

3.3. Future Research

Future research should aim to capture data on self-employed dental professionals, such as dentists and denturists, who may not be represented in CNESST claims data. This would provide a more comprehensive view of MSD incidence across the entire dental workforce. To address the limitations of the National Occupation Classification system, future studies should focus on collecting data that distinguishes between different dental professions, such as dental assistants, hygienists, and technicians. A more granular classification system will allow for a clearer understanding of specific occupational hazards and ergonomic risks faced by each group.

Further future research should consider interventions targeting both psychosocial and biomechanical risks in high-strain occupations like dentistry. S. R. Stock et al. (2018) found that work organization changes, such as adjusted task pacing and job rotation, can alleviate MSD risks by providing sufficient recovery time and reducing repetitive strain. Applying these principles to dental work could yield valuable insights into designing effective prevention programs.

Full-Time Equivalents (FTEs)

Future studies should calculate injury rates based on FTEs or hours worked to provide a more precise measure of occupational risk. This would account for part-time and casual workers who may have less exposure to ergonomic risks, allowing for more accurate comparisons across various working conditions.

Underreporting

Research could focus on investigating the extent of underreporting and rejected claims, particularly in small or independent clinics. Surveys or interviews with dental professionals could provide insight into the barriers to reporting workplace injuries and help identify strategies to encourage more comprehensive claim submissions.

Longitudinal Studies for Long-Term Impact

To better understand the long-term effects of MSDs on dental professionals, future research could benefit from longitudinal studies that follow workers over time. These studies could capture changes in MSD rates as ergonomic practices and technologies evolve, providing insight into the effectiveness of interventions and identifying persistent risk factors.

Chapter 4: Conclusion

This thesis focused on occupational hazards particularly MSDs in Quebec's dental workforce, with significant injury rates among the dental workforce that involve repetitive movements and sustained postures, especially in occupations such as dental hygienists and assistants. Findings from this thesis are informative and provide relevant knowledge on the topic which is useful, particularly for prioritizing and targeting future prevention efforts.

This information could support public health practitioners and policymakers in developing ergonomic prevention programs or perhaps incorporate knowledge on this topic in dental teaching curriculums and also benefit researchers aiming to conduct prevention-focused intervention studies on MSDs within the workforce.

We used appropriate multivariate analysis methods to estimate the demographic risk factors associated with filing claims. Our findings indicate that a significant number of MSD claims could be attributed to specific personal risk factors, which, if mitigated, may have reduced the occurrence of these claims. Nevertheless, they must be interpreted by considering the available data used, particularly the variables included in the analyses and the limitations of the statistical methods used. Finally, it should be noted that, despite the consideration of adjustment factors, the analyses may, in some cases, have led to an under- or over-estimation of the number of attributable cases.

Given the established burden of MSDs, this study suggests an urgent need for policy adjustments and ergonomic interventions. Enhanced use of adaptive equipment, such as loupes and adjustable seating, along with routine breaks and exercise for posture management, can also help mitigate long-term MSD risks.

This study highlights the need to rethink the approach to occupational health in dentistry. By embedding ergonomic principles into dental professionals' initial training and everyday work routines, and enhancing workplace support for ergonomic well-being, dental practices can help mitigate the physical strain on practitioners. These changes not only benefit individual dental workers but are also vital for maintaining a healthy and productive workforce over time.

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Appendices

5.1. Appendix 1 – Methodology

5.1.1. Study design

This study employs an observational, cross-sectional design focused on claims data filed by dental workers in Quebec over a 15-year period from 2005 to 2019. The research examines each claim as an independent occurrence rather than following individual workers over time. By considering claims data instead of individual claimants, this approach enables a portrait of the types and frequencies of injuries, providing insights into occupational health burdens in this workforce.

5.1.2. Data source and population

We utilized the administrative data maintained by Commission des normes de l'équité de la santé et de la sécurité du travail (CNESST) for the years 2005 to 2019. The CNESST database includes claims for injuries and illnesses and was accessed via an agreement between the Institut de recherche Robert-Sauvé en Santé et en Sécurité du Travail (IRSST) and the CNESST. The database comprised information on claimant occupations, classified under the 1971 Canadian Descriptive Classification of Occupations (Bureau Fédéral de la Statistique, 1971b). Under this classification, dental workers fall into one of two occupation codes: 3113—Dentists, and 3157—Dental hygienists, dental assistants, and technicians. The CNESST database included individual demographic characteristics (e.g., age and sex), year of injury, injury description, and the affected body part (coded according to the Canadian Standard Association Z795-03). The total workforce information for Quebec was obtained from the Statistics Canada and Labor Force Survey database (explained further below). The study included only Quebec residents and excluded self-employed workers not covered by the provincial workers' compensation board. The study population comprised dental workers aged 16 to 80 years who had filed workplace-related injury or illness claims between 2005 and 2019.

5.1.3. Ethical considerations

The research was approved by the Research Ethics Board of McGill University (IRB Internal Study Number: A03-E11-23B). This study accessed data through the CNESST under strict confidentiality agreements. A key document involved in this process was the CNESST Confidentiality Agreement (attached in the Appendix 3). As part of the research at the IRSST, I committed to upholding the confidentiality of all data provided by CNESST. This agreement ensures that the CNESST data is used solely for research purposes, remains anonymized, and is

accessible only to authorized individuals, with no personal identifying information disclosed in any reports or publications.

Data Maturity

In occupational health studies, particularly with data from administrative sources like CNESST, there's often a lag between the filing of a claim and its validation in the database, necessitating a "data maturity period." IRSST research typically applies a three-year period to allow sufficient time for claims to be processed and verified within CNESST, ensuring the data captures a representative and stable sample of closed case files. This period helps smooth out potential inconsistencies caused by pending claims or complex cases, allowing the data to more accurately reflect injury rates, compensation periods, and costs related to specific occupational injuries, including those most severe or likely to have extended compensation needs (Lebeau et al., 2020).

Estimation of Total Worker Populations

To accurately calculate claim rates, it is essential to determine the total number of employed dental workers each year, as this serves as the denominator in rate calculations. This ensures that we can account for variations in the workforce size and provide accurate, representative rates of claims across time periods. The total number of employed dental workers per year (denominator) was estimated using Statistics Canada's Census of Population data (from 2006, 2011, 2016, and 2021) and Labour Force Survey data (LFS 2005-2019) (Statistics Canada, 2024b; Statistiques Canada, 2022). While the Census provides detailed demographic and employment data every five years, it does not capture workforce information for the years in between. To fill in these gaps, we used the LFS, which provides annual updates on employment statistics, but lacks the detailed distribution of workers in every occupation. To estimate total worker populations for intercensal years, linear interpolations were applied for the years between census data years (2006, 2011, 2016, 2021), with the line's slope adjusted for each year according to LFS data on healthcare workers.

The Census of Population is a comprehensive survey conducted by Statistics Canada every five years, with the most recent surveys taking place in the years 2006, 2011, 2016, and 2021 (Statistics Canada, 2024c). This census gathers extensive demographic, social, and economic data on the entire population of Canada. Among other questions, it asks respondents about their occupation, industry, employment status, and other job-related characteristics. Given the broad

scope of the census, it captures detailed employment data across various professions, including dental workers, providing a reliable snapshot of the workforce in these specific years. The Census typically covers nearly 100% of the population, ensuring that the occupational and demographic data is representative of the Canadian labor force (Statistique Canada, 2022). On the other hand, the Labour Force Survey (LFS) is conducted monthly and provides more frequent updates on employment trends. It captures data on labour market participation, employment, unemployment rates, and occupation types, though it doesn't offer the same level of occupational detail as the Census. The LFS uses a sample of households (about 56,000), covering approximately 97% of the Canadian population aged 15 and older, but it may not fully capture smaller occupational groups like dental workers with the same precision as the Census (Statistics Canada, 2024a). In our analysis, the Census was used to provide snapshots of the total number of dental workers in the years it was conducted. To fill in the gaps between these years, we utilized LFS data, which offers annual employment statistics. By applying linear interpolation between Census years and adjusting for annual employment changes indicated by the LFS, we estimated the total number of dental workers for the intercensal years.

5.1.4. Statistical analysis

Descriptive Analysis

For descriptive analyses, claims were stratified according to occupation, sex, age, and site of injury. Workers were divided into six age groups. The annual MSD claim rates were calculated by dividing the yearly MSD claims by the number of employed dental workers for that year. Similarly, the claim rate for each type of MSD was calculated by dividing the number of yearly claims for each type of MSD by the total number of employed dental workers for that year. According to the following formula, these claim rates were expressed per 1000 employed workers. It is assumed that all employed dental workers are covered by the provincial compensation board, ensuring comprehensive representation in the dataset:

$$Claim\ Rate = \frac{Number\ of\ MSD\ Claims\ (per\ year)}{Total\ employed\ dental\ workers\ (per\ year)} \times 1000.$$

Additionally, we calculated frequencies for claims based on the affected body part, providing further insights into the distribution of MSDs by injury site. Statistical analyses were completed using Stata 18.0 (StataCorp LLC, Texas).

Negative Binomial Regression Analysis

Negative binomial regression (NBR) models were used to estimate the claim rate ratio (RR) with 95% confidence intervals (CIs) and to compare different demographic groups (Schober & Vetter, 2021). The negative binomial regression (NBR) is a generalization of the Poisson model, primarily used for modelling count data, mainly when the data exhibits overdispersion, with the variance exceeding the mean. This model allowed for random variability in the data, making it more suitable for our analysis than the simpler Poisson model. NBR is widely used in claims analysis, particularly in the insurance and healthcare sectors, where the frequency of claims often demonstrates overdispersion due to variability in the underlying population. For example, claims can vary depending on factors such as age, occupation, and exposure to specific occupational hazards (in our case MSDs), making NBR ideal for modeling this variability. By accounting for overdispersion, NBR improves the accuracy of the rate ratio estimates, providing more reliable insights into which demographic or occupational groups are at higher risk for claims. This method also allows for flexibility in interpreting claim frequencies, offering a better fit for complex datasets typical in occupational injury claims analysis (Faroughi et al., 2023).

Claim counts were analyzed using a Negative Binomial Regression (NBR) model, which was chosen for its suitability in handling over-dispersed count data—common in claim count datasets. In this model, the number of claims served as the dependent variable, while sex, age group, and occupation were included as independent variables. This approach allowed us to examine the influence of each demographic factor on claim rates. The model was designed to be parsimonious, meaning it included the fewest variables necessary to capture the primary patterns and trends in the data, minimizing complexity while preserving explanatory power.
To adjust for differences in group sizes within the workforce, an offset for the number of employed dental workers in each demographic category was incorporated. This adjustment allowed the analysis to focus on relative differences in claim rates rather than raw counts, ensuring the comparisons remained valid across varying group sizes.

In addition to analyzing demographic factors, NBR models were applied to assess general trends in claim rates over the 15-year period, with the year as an independent variable and the claim rate as the dependent variable. To control for changes in the worker population over time, the total number of dental workers was used as an exposure variable. This approach provided

a standardized rate over time, accounting for shifts in workforce size and allowing for a clear analysis of how claim rates have evolved independently of workforce growth or shrinkage.
To ensure we selected the most suitable and parsimonious model, a systematic approach was taken, beginning with bivariate models. Each independent variable—such as sex, age group, occupation, and year—was tested individually to assess its significance in explaining variation in claim rates. Variables demonstrating a significant relationship were then included in a multivariate model.

Using stepwise regression methods, we tested various model configurations, adding or removing variables iteratively based on their significance and contribution to model fit. This selection process was guided by metrics like the Akaike Information Criterion (AIC) and the model's R-squared values, both of which help in balancing explanatory power with simplicity. By comparing these values across models, we identified the configuration that minimized unnecessary complexity without compromising interpretability.

The final model included sex, age group, and occupation as independent variables, with an offset for the number of employed dental workers in each category. This offset allowed us to adjust for varying workforce sizes across demographic groups, ensuring the focus remained on differences in claim rates rather than group size. Additionally, to analyze claim rate trends over the 15-year period, year was included as an independent variable, with the workforce size serving as the exposure variable. This approach enabled us to account for changes in the dental workforce population over time, providing a clearer perspective on how claim rates have evolved within the context of the profession.

Model Specification

The regression model was specified as follows:

```
nbreg num_claims i.sex i.age_group i.CCDP4, exposure(workers) irr
```

In this specification, the variables are as follows:

`num_claims` represents the count of claims;

`i.sex`, `i.age_group`, and `i.CCDP4` are categorical variables indicating sex, age group, and occupational classification, respectively;

the `exposure(workers)` term includes the total workforce as an offset to model the rate of claims per worker;

`irr` means "incidence rate ratio." By specifying irr, the regression outputs interpret the coefficients as incidence rate ratios rather than raw coefficients, making the results more interpretable for count data models like negative binomial regression.

This approach allowed us to report incidence rate ratios (IRRs), which quantified the association between each demographic group and the likelihood of a claim, adjusting for the size of the worker population in each group. The model's structure ensured the focus remained on claim rates rather than absolute claim counts, providing a comparison across demographic subgroups.

Sensitivity Analysis

Sensitivity analyses were conducted to assess the robustness of the model, particularly regarding the impact of outliers. One such analysis involved removing a data point from a claimant aged 16, allowing us to confirm that this outlier did not substantially affect the overall results. The study focused on dental workforce members aged 16 to 80 who received compensation for workplace-related injuries or illnesses between 2005 and 2019. From the CNESST dataset, 2,230 claims were initially identified, but one claim was excluded due to the worker being under 18. This exclusion left a total of 2,229 claims for analysis, spanning the 15-year period. The dataset was complete, with no missing observations. With the methodological framework in place, the following chapter presents the manuscript detailing the study's findings and their implications.

5.2. Appendix 2 - Ethical Approval

McGill | Faculty of Medicine and Health Sciences | Faculté de médecine et des sciences de la santé

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March 24, 2023

Dr. Elham Emami
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Info-Ed (eRAP) File Number: **23-01-094** **(IRB Internal Study Number:** **A03-E11-23B)**

Study/Protocol Title: *Occupational Hazards in Dentistry: An Analysis of Quebec Compensation Claims*

Principal Investigator: Elham Emami

Student Investigator : Tisha Prakash

Sponsor Name (if applicable):

Dear Dr./Professor Emami,

Thank you for submitting the above-referenced study for an ethics review, on behalf of your Master's student.

As this study involves no more than minimal risk, and in accordance with Articles 2.9 and 6.12 of the 2nd Edition of the Canadian Tri-Council Policy Statement of Ethical Conduct for Research Involving Humans (TCPS 2) and U.S. Title 45 CFR 46, Section 110 (b), paragraph (1), we are pleased to inform you that a delegated review was conducted and ethics approval for the study was provided on March 24, 2023. **The ethics certificate is valid until March 23, 2024**. The study proposal will be presented for corroborative approval at the next meeting of the Institutional Review Board.

The following documents were reviewed and approved:

- Initial ethics submission dated February 20, 2023
- Study protocol, IRB dated February 20, 2023

The Faculty of Medicine Institutional Review Board (IRB) is a registered University IRB working under the published guidelines of the Tri-Council Policy Statement 2, in compliance with the *Cadre de reference ministériel pour la recherche avec des participants humains* (MSSS, 2020), and the Food and Drugs Act (17 June 2001); and acts in accordance with the U.S. Code of Federal Regulations that govern research on human subjects (**FWA 00004545**). The IRB working procedures are consistent with internationally accepted principles of good clinical practice.

1

The Principal Investigator is required to immediately notify the Institutional Review Board Office, via amendment or progress report, of:

- Any significant changes to the research project and the reason for that change, including an indication of ethical implications (if any)
- Serious Adverse Effects experienced by participants and the action taken to address those effects
- Any other unforeseen events or unanticipated developments that merit notification
- The inability of the Principal Investigator to continue in her/his role, or any other change in research personnel involved in the project
- A delay of more than 12 months in the commencement of the research project, and
- Termination or closure of the research project.

The Principal Investigator is required to submit an annual progress report (continuing review application) on the anniversary of the date of the initial approval (or see the date of expiration).

The Faculty of Medicine IRB may conduct an audit of the research project at any time.

If the research project involves multiple study sites, the Principal Investigator is required to report all IRB approvals and approved study documents to the appropriate Research Ethics Office (REO) or delegated authority for the participating study sites. Appropriate authorization from each study site must be obtained before the study recruitment and/or testing can begin at that site. Research funds linked to this research project may be withheld and/or the study data may be revoked if the Principal Investigator fails to comply with this requirement. A copy of the study site authorization should be submitted the IRB Office.

It is the Principal Investigator's responsibility to ensure that all researchers associated with this project are aware of the conditions of approval and which documents have been approved.

The McGill IRB wishes you and your colleagues every success in your research.

Best regards,

Roberta Palmour, PhD
Chair
Institutional Review Board

cc: Associate Dean, Research (Medicine)
A03-E11-23B / 23-01-094

5.3. Appendix 3 - Déclaration de confidentialité

ANNEXE B

DÉCLARATION DE CONFIDENTIALITÉ

Je, Tisha Prakash, m'engage à respecter la confidentialité des renseignements dont j'aurai eu connaissance dans l'exercice de mes fonctions reliées à la recherche, à l'Institut de recherche Robert-Sauvé en santé et sécurité du travail (IRSST). Plus particulièrement, je m'engage à :

- Utiliser les renseignements émanant de la Commission des normes, de l'équité, de la santé et de la sécurité du travail (CNESST) uniquement pour les fins de la mission de l'IRSST, accomplie en vertu de mandats confiés par la CNESST;
- Ne pas tenter de reconstituer des renseignements personnels dans le but d'identifier les personnes visées par une étude;
- Ne permettre l'accès aux renseignements émanant de la CNESST qu'aux seules personnes ayant signé le présent formulaire;
- Ne pas identifier les personnes visées par une étude dans les rapports ou publications s'y rapportant.

Signé à Montréal, Quebec

ce 15 Novembre 2022

Signature

*** Retourner à :**
Commission des normes, de l'équité, de la santé et de la sécurité du travail
a/s de Me Stéphane Larouche
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