Identifying Use of Knowledge Translation Theory in Applied Ergonomic Research

By
Mahdis Aziziderouei

A thesis
presented to Lakehead University
in partial fulfilment of the
thesis requirement for the degree of
Master of Science in Kinesiology

Thunder Bay, Ontario, Canada, 2020

Acknowledgement

I would like to thank my thesis supervisor, Dr. Kathryn Sinden for being an incredible mentor throughout the completion of my master's degree. During the COVID19 pandemic, many students' projects were impacted; however, Dr. Sinden did not let this set back impact the quality of my learning and my project. She supported me through every step and especially through this challenging time. This is a true testament for her amazing leadership and mentorship that guided and motivated me to strive for excellence. I am forever grateful for the unique opportunities that you have provided me. I gained many invaluable lessons, learned to be a researcher, and grew as a professional. I would like to thank my committee Dr. Sandra Dorman from Laurentian University and Dr. Paolo Sanzo from Lakehead University. Their support and valuable insights helped me throughout the research and writing process. Also, this thesis would not be possible without the support and contribution of NewGold Inc. I would like to thank them for the opportunity and involvement in this project.

A special thank you to my family, who have provided unconditional love and support throughout my master's studies. To my sister, Mana, thank you for always being by my side through good times and bad. For supporting me and encouraging me to believe in myself and making me laugh when I was going through difficult times. To my parents, thank you for being there for me and supporting me even though we were apart. To Amir, thank you for always being there for me and encouraging me to reach my potentials. My master's experience would not be the same without the love and support of you all.

Abstract

Introduction. Work-related injuries are a leading cause of physical disabilities impacting individuals' quality of life. Work-related musculoskeletal (MSK) injuries continue to impact Ontario employers costing approximately one billion dollars and resulting in two and a half million employee sick-days. The cost of medical care and return-to-work programs has also continued to increase over the past several years. In a physically demanding occupation such as mining, MSK injuries are prevalent leading to disability and lost time claims. Using knowledge translation (KT) approaches and ergonomic research, it is possible to integrate evidence and mitigate factors associated with work-related injuries. Although preliminary studies have identified the use of KT theory in applied ergonomic research, there is a general lack of understanding of the impact of using KT theory/frameworks in industrial or organizational settings to inform best practice for ergonomic interventions aimed to reduce workplace injury.

Objective. The two primary objectives of this project were to: 1) conduct a scoping review of the use of KT theory/frameworks to guide applied ergonomic research; and 2) use the findings of the scoping review to inform development of PDA@Work as a KT tool focusing on mitigating workplace musculoskeletal injury.

Method. To address objective 1, methods developed by Arksey and O'Malley (2005) and Aromataris (2017) were adapted (Appendix A) to identify and appraise relevant studies related to KT theories used in ergonomic research. The adopted scoping review strategies were described in several stages; identifying the research question, identifying relevant studied and selection criteria, appraisal of the data, and synthesis of the findings (Arksey & O'Malley, 2005). To address objective 2, findings of the scoping review were used to facilitate development of the KT tool (PDA@Work). PDA@Work is a computer application that consolidates physical demand information associated with various jobs at a local above-ground mine. Health care professionals and occupational health and safety agents were asked for feedback using the "*Interface User Feedback Questionnaire".*

Results. *Objective 1*: The scoping review of literature identified two overarching themes; i.) engaging stakeholders in the process of research and ii.) dynamic nature and limitations of applied ergonomics. The first overarching theme was further divided into three sub-themes; policy and procedure, knowledge brokering strategies, and active role. The importance of engaging stakeholders in the process of research including exchange of perspectives, understanding

expectations, and share power of decision making between all involved in the process was identified and discussed within subthemes of policy and procedure, knowledge exchange strategies, and importance of active role. The second overarching theme was further divided into two sub-themes; resources and multidimensional aspect of applied ergonomics and highlighted the importance of environmental factors impacting the ergonomic interventions. Resources that impacted efficacy of integrated approaches to facilitate applied ergonomic research included lack of time, budget, availability of experts, and production objective. The multidimensional aspect of applied ergonomics also emphasized that the relationship between humans and workplace is impacted by various factors including environmental context, social influences, and individual factors. *Objective 2*: Findings of the scoping review informed development of the PDA@Work application as a KT tool and was developed by involving and engaging stakeholders within the research process. Participants (n=15) were a purposive sample of stakeholders who use occupational physical demands information in their clinical roles. A researcher developed survey was used to identify participant feedback on utility of the PDA@Work application. 80% of participants reported PDA@Work as user friendly; 67% of participants reported that the content of the application as clear and easy to understand. 53% of the participants reported that the application would assist them for better interpreting physical demands information.

Discussion. The key findings related to the scoping review included the importance of building relationship, trust, and cooperation with stakeholders to successfully implement the ergonomic interventions. Knowledge translation facilitated the process of implementing ergonomic intervention by disseminating the intervention, evaluating, and incorporating organizational policy, procedure, and context within the research. The key findings from developing PDA@Work included increasing data accessibility and remote connectivity to facilitate interpretation of physical demands information. The integration of technology in practice provide a platform to share information and better understanding of information. Improving communication between stakeholders is anticipated to lead to change of attitude, policy, and procedural changes within the company. Overall, using an integrated KT approach is efficient in applied ergonomic research as it facilitates stakeholder engagement, efficiently tailor's knowledge for relevant context of the occupational setting and helps to map the intervention.

Table of Contents

List of Tables

List of Figures

Introduction

The mining industry is dangerous with many of the occupational tasks being arduous and physically demanding. The National Mining Association reported employment statistics of miners which was about 14 million in 2015 representing 1% of the global workforce. Mine workers are at high risk of workplace injuries and fatalities which accounts for 8% of global workplace injuries and fatalities (Legault, Clement, Kenny, Hardcastle, & Keller, 2017). The Association of Workers Compensation Boards of Canada reported lost time claims due to physical injuries in mine workers totaled 2,071 in 2018; injuries were specifically associated with musculoskeletal (MSK) injuries (Legault et al., 2017).

The mining sector has been identified as a high physically demanding occupation highlighting the importance of developing strategies to mitigate occupational hazards to decrease the work-related injuries, improve productivity, and increase safety of workers (Schwabe & Godwin, 2017). The Ontario mining sector reported employing 22,437 miners in 2018 and 4% of those workers reported work-related MSK injuries that were attributed to lack of sleep, fatigue, overexertion, and distractions in the following year (Workplace Safety & Insurance Board, 2019). The MSK injuries resulted in 40% of the lost time in the Ontario mining industry further demonstrating the burden of MSK injuries (i.e., lower back and shoulder injuries; CCOHS, 2014; OSHA, n.d.). Mine workers perform work in a dynamic environment that requires strenuous activities, including carrying heavy loads and operating heavy machinery (Employment & Social Development Canada, n.d.; Occupational Health Clinics for Ontario Workers Inc., 2018). For instance, mechanics and equipment operators perform manual handling of heavy equipment during their shift. Being able to perform these highly demanding tasks requires mine workers to maintain healthy body strength and mind towards reducing risk factors associated with physical

injury and fatigue. These high levels of physical activities combined with required alertness and vigilance increase the risk of physical injuries such as MSK disorders and development of fatigue (Butlewski, Dahlke, Drzewiecka, & Pacholski, 2015; CROSH, 2016). Thus, understanding the physical demands of tasks/jobs is important.

A physical demand analysis (PDA) is an ergonomic tool describing cognitive, environmental, and physical aspects that employees are exposed in their workplace (Snyder, Krauss, Chen, Finlinson, & Huang, 2008). The PDA document provides information on force, frequency, manual handling, and environmental factors of tasks that is used internally (i.e., human resources, employees) and externally (i.e., health care professionals, insurance agents; Snyder et al., 2008). The PDA is widely used in the field of ergonomics as part of ergonomic solutions to mitigate work-related injuries. This document provides information on the nature and demands of work tasks as a reference for researchers and workers; the PDA reports on the cognitive, sensory, physical, and environmental demands of jobs which is essential for injury management and prevention (Sinden & MacDermid, 2014). This information helps health care professionals to provide accurate treatment plans based on the employee's tasks and accommodate them for task adjustment and modifications for return-to-work successfully (Snyder et al., 2008). The integration and impacts of tools such as PDAs on reducing impacts of risk factors associated with work injury requires further empirical exploration. One approach is to consider the use of theory such as knowledge translation theory where stakeholders are engaged in the research process, to identify key components associated with effective ergonomic solutions.

The primary focus of ergonomic and occupational health and safety research has been to mitigate work-related injuries and increase work-place safety (Cole et al., 2009; Loisel et al.,

2005). To navigate the research and anticipate the wide spectrum of jobs and its demands, ergonomics and knowledge translation (KT) have been used as an approach and process to strategize a better understanding of the dynamic nature of workplace environment (Cole et al., 2009; Loisel et al., 2005). The dynamic nature refers to workplace context (i.e., fast pace) and culture impacted by human factors (i.e., job-satisfaction, safety procedure). These studies usually implemented knowledge translation frameworks, models, and theories to guide and anticipate the workplace context and culture (Sinden & MacDermid, 2014). A knowledge translation approach provided a guideline to facilitate the process of engaging stakeholders, implementing an intervention, exchanging knowledge, and educating "end-users" (Sinden & MacDermid, 2014).

There is a lack of understanding about the evidence-based strategical approach to mitigate work-related injuries such as MSK injury in high physical demanding jobs. For instance, the application of research findings into practice usually has been slow or unsuccessful (Employment & Social Development Canada, n.d.; Occupational Health Clinics for Ontario Workers Inc., 2018). As such, there is a need to identify strategies that can be used to facilitate uptake of evidence-based strategies that can be used effectively by stakeholders to mitigate MSK injuries although, there is preliminary evidence suggesting that KT theory/frameworks have been informing applied ergonomic research. Mitigating the gap between evidence to practice is necessary by reviewing KT theory/framework/model application in ergonomic research and understanding the impact of using KT theory in industrial or organizational settings. A key component considered in using KT theory / frameworks is the role of stakeholders in developing and implementing evidence-based solutions in occupational contexts.

Stakeholder Involvement

Stakeholders are defined as parties involved in a process with a mutual and single goal. Their involvement and vested interest in the successful implementation of a policy, project, and solutions are important and necessary (Freeman, 1984). In a company or organization, there are multiple stakeholders (i.e., departments, employee, managers, and shareholders). Each of these parties have a specific purpose and goal and their cooperation and collaboration is deemed necessary for achieving objectives (Freeman, 1984). Stakeholders impact and influence organizational process, policy, and instructions. Stakeholders can have direct employment (i.e., managers, employee, supervisors) within the company or indirect engagement (i.e., insurance, contractors, practitioners) (Freeman, 1984).

The stakeholders involved in the current project included the research team and research partner, NewGold Inc. at Rainy River site in Fort Francis. The research partner included occupational health and safety department, management, and registered nurse situated at the mine site.

Mining-Specific Musculoskeletal Injury data

Musculoskeletal injury symptoms have been assessed in various mines globally including Finland, Russia, Norway, and Sweden (Burström et al., 2017). Due to various type of physical demanding tasks, studies were aimed to determine the type and prevalence of MSK injuries among heavy equipment operators and non-operators (Burström et al., 2017). Participants were asked about their previous MSK injuries through the administration of the Nordic MSK Questionnaire (NMQ) and Risk of Occupational Vibration Injuries Questionnaire (ROVIQ). In addition, anthropometric measures and personal attributes were collected, as well as the duration of work tasks (Burström et al., 2017). The results showed a high prevalence of lower back and

shoulder pain in heavy equipment operators in Finland, Russia, Norway, and Sweden (Burström et al., 2017). This study did not explore the impact of sex, sleep quality, and shift work (night versus day shift) on MSK injury risks and prevalence amongst drivers (Burström et al., 2017).

Carlisle and Parker (2014) addressed the psychological and physiological impacts on MSK injuries among workers in an Australian coal mine. This study aimed to understand the prevalence of a MSK condition and its relationship with psychological stressors and workplace hazards in equipment operators and manual workers. They obtained data about MSK injuries (i.e., neck and lower back injuries) through the NMQ and measured their psychological distress using the Kessler K6 questionnaire (Burström et al., 2017; Crawford, 2007; Tang, Li, & Huang, 2016). Low back injuries, the most prevalent MSK injury among heavy equipment operators, had a positive correlation with psychological distress; meaning workers experiencing high levels of anxiety, depression, and stress were more likely to experience a low back injury. It was difficult to compare findings amongst participants, when their daily tasks were different and other factors such as sleep quality and shift work (i.e., night/day shift and rotating shifts) were not taken into account to understand the prevalence of MSK injury risks (Carlisle & Parker, 2014). The role of stakeholders and use of theory to guide the intervention was also not clearly identified.

Mitigating of Musculoskeletal Injury in the Workplace

As mentioned previously, musculoskeletal (MSK) injuries are the primary cause of workplace lost-time-injury (Murray et al., 2013; Roberts, Sim, Black, & Smith, 2015). The most common workplace injuries impact soft tissues, muscles, bones, and tendons (Kumar, 2001). This type of injury limits individuals' ability to perform physical activities, including work practices and daily life. Musculoskeletal injuries could occur gradually (i.e., overtime) or suddenly (i.e., acute). Tendinopathy and ligament sprains are often due to repetitive movements

using a specific body part over a long period of time. Sudden damage is often due to abrupt changes in posture and/or handling loads when performing work tasks (Kumar, 2001). Individuals who performed work in awkward positions, handle heavy materials and perform repetitive movements are at increased risk of experiencing MSK injuries (Middlesworth, 2019). Symptoms associate with MSK injuries may include pain, swelling, and numbness and the intensity of the symptoms varies depending on the severity of the injury. Work-related MSK injury risks predominantly increase when individuals perform repetitive movements, sustain awkward positions, and apply forces for a long period of time (Legault et al., 2017; Swaen, van Amelsvoort, Bultmann, & Kant, 2003; Yu, Chen, & Long, 2017). To mitigate work-related MSK injuries, ergonomic assessments and KT strategies have been widely used to identify risk factors and to provide practical recommendations to reduce risk of work-related injuries (Stein, 2006). Ergonomics is the science of refining the design of products to optimize them for human use (Bridger, 2003). Poorly designed work process or products introduces hazards into a workplace. Ergonomics considers both psychological and physiological aspects of work design to increase worker performance and safety; this includes considering individual capabilities and limitations (Middlesworth, 2019; Stein, 2006). Figure 1 shows the ergonomic and individual factors leading to MSK injuries in the workplace. Therefore, applying ergonomics guided by KT strategies in the workplace is often seen as a process in which hazards and possible injuries identified and prevented to protect the worker's health and safety in the workplace (Middlesworth, 2019; Stein, 2006).

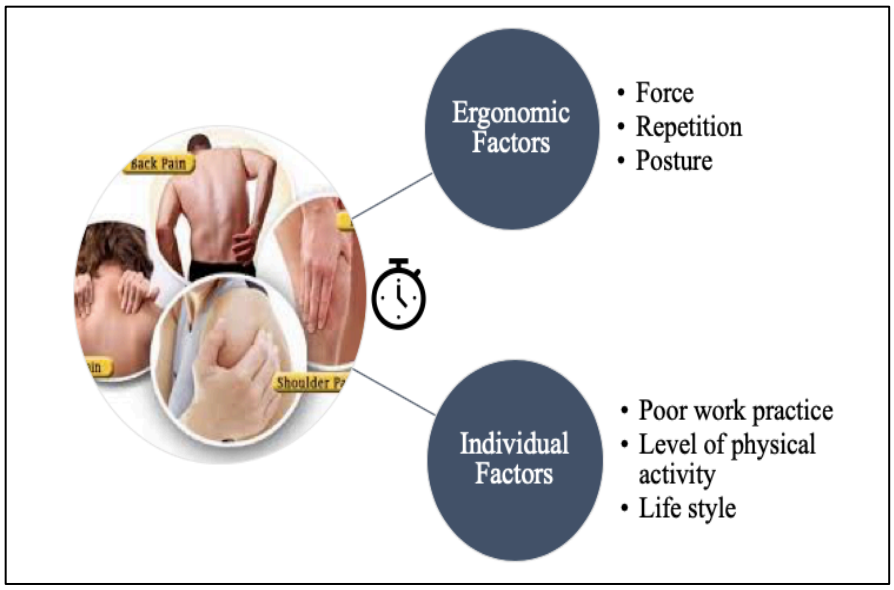


Figure 1. Summary of ergonomic and individual risk factors leading to MSK injuries. Adapted from *How to Establish an Ergonomics Program*, by M. Middlesworth, 2019, Retrieved from https://ergo-plus.com/musculoskeletal-disorders-msd/.

Knowledge Translation

Knowledge translation is an essential element to assist in mitigating the gap of moving research evidence into practice (Collisson et al., 2011). The Canadian Institutes of Health Research (CIHR) defines KT as a complex system of engaging researchers and knowledge users to provide effective solutions, products, and health care services(CIHR, 2016). Knowledge translation is a combination of knowledge inquiry, dissemination, and exchange (Collisson et al., 2011). Throughout decades of research, KT research has followed different paradigms for inquiring, disseminating, and exchanging knowledge (Nowotny, Scott, & Gibbons, 2003). One of the traditional ways of exchanging knowledge is a simple interaction between researchers and society (Nowotny et al., 2003). In recent years, KT research has aimed and focused on public health and employee's safety in industries addressing health problems, increasing quality of life, and introducing innovations (i.e., tools, technology). Knowledge translation's current paradigm is focused on inquiring information by engaging stakeholders (i.e., end-users, employers,

government) and different disciplines to account for different perspectives and introduce new tools and technologies (Nowotny et al., 2003). In general, the dynamic nature of workplaces such as the mining industry requires a guided framework that is adaptable to the pace of the workplace. KT provides guided approaches and paradigms for assessing the ergonomic challenges and understanding applied ergonomics (Steinfeld, D'Souza, & White, 2014).

Elements of Knowledge Translation

Knowledge translation is comprised of four elements: synthesis, dissemination, exchange, and ethical application (figure 2; CIHR, n.d.; McGowan, 2017).

Synthesis. This element focuses on examining the available research content, extent, and range of knowledge (Arksey & O'Malley, 2005). Evaluating the value of available studies and providing a narrative and description of findings are components of knowledge synthesis. Analytically evaluating the nature and relevance of findings combined with appraising the quality of studies provides researchers with a better understanding of the available evidence for the topic (Arksey & O'Malley, 2005).

Dissemination. Application of interventions and findings involves multilayer steps such as identifying "end-users", relevance and tailoring to match the context (McGowan, 2017). Dissemination could be providing educational briefings or executive summaries, engaging policy makers, developing tools for "end-users" (McGowan, 2017). This element requires evaluation and feedback from stakeholders to increase the applicability and appropriateness of the dissemination strategies for the intended change or challenge (McGowan, 2017).

Exchange. One of the important parts of the KT strategy is the involvement of the stakeholders (i.e., knowledge users) and researchers (Mitton, Adair, McKenzie, Patten, & Perry, 2007). The engagement of stakeholders leads to a better understanding of the workplace context

and culture to provide relevant and appropriate learning opportunities for knowledge users and researchers. The collaboration helps the process of planning, developing, disseminating, and applying the findings (Mitton et al., 2007).

Ethical Application. The important component of KT and study dissemination or intervention is that it must follow ethical principles and social values (Graham et al., 2006). There are regulatory frameworks that researchers must legally follow to protect the "end-users" and researchers (Graham et al., 2006).

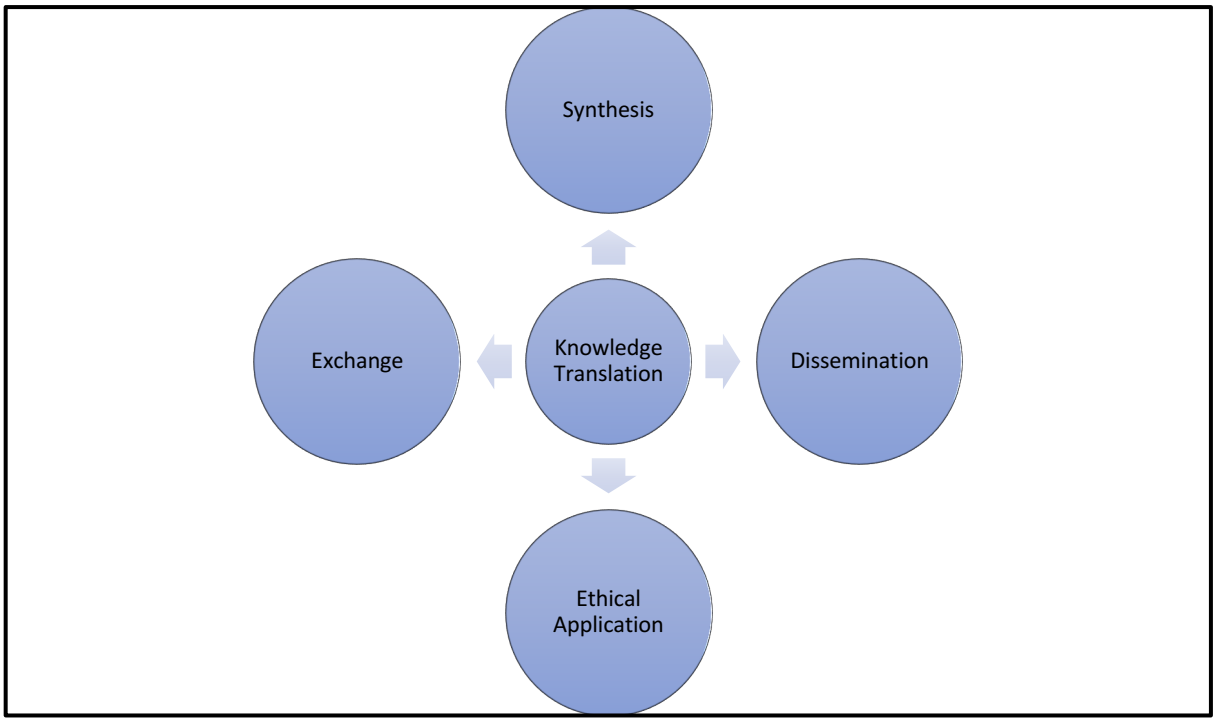


Figure 2. This graph shows the four elements of Knowledge Translation. Adapted from *Canadian Institute of Health Research (CIHR).* Retrieved from https://cihr-irsc.gc.ca/e/193.html .

Knowledge Translation Approaches

End of Grant Knowledge Translation. This approach is widely used by researchers; the implemented and developed knowledge by researchers is shared with "end-users" (CIHR, 2016). Dissemination of research findings is carefully tailored based on the stakeholders' expectations and concerns. Understanding the target audience needs and concerns requires the broad synthesis of studies and tailored solutions related to the context of the task (Grimshaw, Eccles, Lavis, Hill, & Squires, 2012). A variety of tools are used for tending the concerns of end-users such as workshops, educational surveys, executive summaries, technology, and employing knowledge brokers (CIHR, 2016; Grimshaw et al., 2012). Assessment of the workplace culture, environment, and demands complimented by implementing an appropriate KT strategy could close the gap of knowledge to action (Graham et al., 2018; Grimshaw et al., 2012). There are five elements compromising the End-of-Grant KT including objective, audience, strategies, expertise, and resources. These elements are used for improving the occupational health and safety of the community in the mining industry. Focusing on the resources and audience, the message is tailored based on the evidence found in research ("An End-of-Grant Knowledge Translation Casebook," n.d.; Graham et al., 2018; MacDermid, Miller, & Gross, 2013). This strategy leads to building connections and increased cooperation with stakeholders. Also, addressing stakeholders' expectations and concerns not only positively impacts building connections, trust, and promoting the evidence, and closing the knowledge gap but also leads to lowering injury risks and increasing job securities ("An End-of-Grant Knowledge Translation Casebook," n.d.).

Integrated Knowledge Translation. This approach focuses on the engagement of the stakeholders in the entire process of planning and implementation of research (Gagliardi, Berta, Kothari, Boyko, & Urquhart, 2016). Another name for this approach is "collaborative research"

or “co-production of knowledge”. The engagement of knowledge users within the process from the initial planning stages increases the relevancy and applicability of the findings (Gagliardi et al., 2016). These findings are relevant to the context, therefore, both stakeholders and researchers benefit from the exchange (Gagliardi et al., 2016). Using Integrated KT has become popular in applied ergonomic research. Engaging stakeholders in industry in the research process has shown to increase the success of ergonomic interventions leading to integrate the findings into decision-making process and policy modifications (Graham et al., 2018). These types of studies tended to have a greater impact on changing attitudes, building relationships, providing more research opportunities, and influencing policies (Graham et al., 2018).

Knowledge Translation and Evidence-Based Practice

There is a growing interest in using evidence-based practice to improve or change policy and practice (Grimshaw et al., 2012). Meanwhile, the decision of integrating research evidence is a complex process. There are many barriers to implementing evidence-based practice such as time, relevancy, resources, and means of transferring knowledge (Glegg, Livingstone, & Montgomery, 2016). There is a volume of research highlighting barriers for mitigating evidence into practice; these barriers includes lack of time within a fast pace workplace setting with production objective and lack of effective knowledge transfer tools/approaches (Fineout-Overholt & Melnyk, 2005). As mentioned previously, implementation of research evidence leads to policy and procedural change/modification. Accounting for different stakeholders involved in the process of policy change is important and requires vigorous planning, expertise, and evaluation (Davies, Walker, & Grimshaw, 2010). Knowledge translation elements (i.e., implementation, synthesis, dissemination, evaluation) provides a platform to account for the involvement of stakeholders. Consequently, using KT strategies and frameworks are the best

available resource for moving evidence to practice step-by-step and providing guidelines on assessment and evaluation (Grimshaw et al., 2012).

CIHR provides a good illustration (figure 3) of how KT strategies could help the process of evidence-to-practice process at every stage of research process (CIHR, 2016; Corrigan & Shapiro, 2010). Knowledge translation approach has important elements to integrate evidence into practice by using the framework or model ensuring the success, practicality, evaluation, and relevance of the evidence (MacDermid et al., 2013). This Canadian funding agency describes how KT increases the interactions, communications, and effectiveness of research. Principles that KT uses in planning and developing a research question include dissemination, implementation, publication, generalizability of findings, and assessing the impacts of findings (CIHR, 2016; Corrigan & Shapiro, 2010). Successful implementation of evidence depends on the practical and reasonable translation of knowledge; this process is crucial for the implementation and dissemination of evidence into practice (Ehrensberger-Dow, 2019). Also, the importance of building a relationship with stakeholders (i.e., employer, employee, and researchers) has also been identified as a critical step in this process. Building relationships and trust among researchers and stakeholders increases engagement and quality of dissemination of intervention guided by KT approaches (Fishman, Penuel, Allen, Cheng, & Sabelli, 2013). Building relationships leads to better communication helping the researcher identify expectations and understand the context and culture of the organization (Fishman et al., 2013; Schabracq, Winnubst, & Cooper, 2003). For instance, new guidelines for New Zealand related to natural hazards and disaster management were developed by environmental and KT researchers with the cooperation of government, policy makers, and business owners. Combining the perspective of researchers and stakeholders showed promising results to understand the impact of natural

disasters through surveys and interviews (Thompson, Owen, Lindsay, Leonard, & Cronin, 2017). Interprofessional communication and assembling a working group comprised of experts emboldened the relevancy and practicality for the dissemination process (Thompson et al., 2017). To implement evidence and close the gap with practice, it is important to draft a plan focusing on the stakeholders (researchers, government, policy makers, and business owners), environment, and context.

Franche et al. (2005) studied the stakeholders' roles in a context of return to work program to implement shared decision-making process within the program. Collaboration and communication were two important factors for a successful return-to-work and decrease in absenteeism among workers (Franche, Baril, Shaw, Nicholas, & Loisel, 2005). The facilitation of cooperation between stakeholders was important for a successful implementation of sharing power to employees to decide their course of treatment within return-to-work program. The study drafted a detailed map on engagement of stakeholders and deliberated on finding common grounds and setting time during the planning phase to involve stakeholders. Managers, supervisors, and company's decision makers were involved in the initial stages of drafting, planning, and implementation while insurance agents, practitioners, and employees were involved in the later stages to reduce the conflict of interests between the departments which accounted for concerns, expectations, and satisfaction of all parties involved in the return to work program (Franche et al., 2005; Murray et al., 2013). Engaging stakeholders in the initial phase of planning was important to account for different expectations and setting mutual objectives (i.e., modifying procedural manual). Following the integrated KT model and participatory ergonomic framework, the researchers were able to implement changes to the return-to-work program (Ehrensberger-Dow, 2019; Franche et al., 2005).

A common frustration among health practitioners or occupational health and safety agents was the lack of disseminating knowledge into practice that was relevant or practical to be used in their field (Buckle, 2011). This process is timely and requires engagement of multiple stakeholders for changing policy, procedure, drafting guidelines, and implementation. The one important factor related to this issue was the lack of focus on current ergonomic practice, factors (i.e., time, budget, experts) impacting the policy or decision-making process, and the role of stakeholders (Buckle, 2011; Soklaridis, Ammendolia, & Cassidy, 2010).

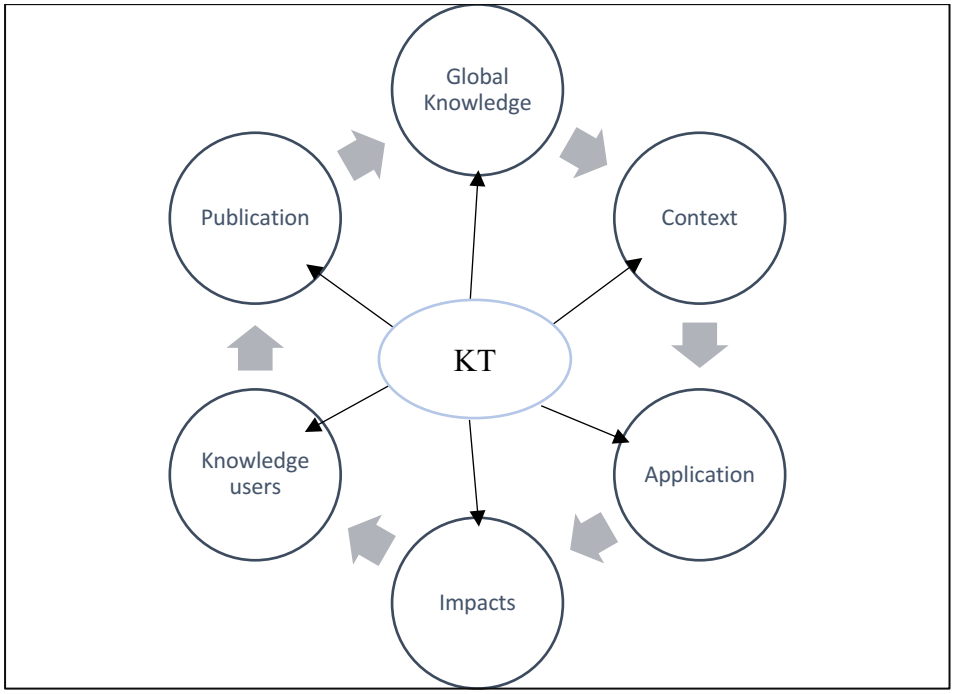


Figure 3. This figure shows how the proposed CIHR KT model/theory/framework is applied in every step of the research process. Adapted from *CIHR*. Retrieved from https://cihr-irsc.gc.ca/e/193.html.

Ergonomic Research

Ergonomics is the science of interaction between humans and machines and the environment (Bridger, 2003). Understanding the science of human performance/behavior in their workplace and their interaction with their environment is directly impacted by the designs and demands of the job (Bridger, 2003). To mitigate work-related MSK injuries, ergonomic assessments are widely used to identify risk factors and provide practical adjustments to reduce injury risks (Stein, 2006). One of the elements of ergonomic science is refining the design of products to optimize them for human use (Bridger, 2003). Poorly designed work process or products introduces hazards into a workplace, therefore applying ergonomics in the workplace is often seen as a process in which hazards and possible injuries can be prevented (Stein, 2006). Ergonomics provides tools for protecting the worker's health and safety in the workplace by examining their work space, posture, physical demands, and environmental factors (Middlesworth, 2019; Stein, 2006). One of the widely used ergonomic tool is the physical demands analysis (PDA) (Sinden & MacDermid, 2014). Physical demand analysis document is used as an ergonomic assessment containing the psychological/cognitive demand, physical demand, and environmental conditions of job/task (Snyder et al., 2008).

There has been extensive research on mitigating the injury risks to increase occupational health and safety. Using the available evidence in the context of workplace such as mine industry requires effective and efficient application and implementation process (Straus, Tetroe, & Graham, 2011). To operationalize a change based on evidence found in research, there should be a strategy that could assess, conduct, conceptualize, disseminate, and evaluate the implemented intervention/change (Graham et al., 2006). Knowledge translation strategies has these criteria (i.e., assessment, conceptualization, dissemination, and evaluation) to map, operationalize, and

conduct an ergonomic solution. Using KT strategies in applied ergonomic research environments has shown promising outcomes toward closing the gap between research and applied ergonomics in the practice/field (Graham et al., 2018; Straus et al., 2011). For instance, in a poultry processing plant, stakeholders such as ergonomists, KT expert, plant management, and employees participated in an integrated KT study to lower the risk of physical injuries (Antle et al., 2008). After assessing the injury risks using ergonomic tools (i.e., PDA, work environment), the researcher conducted training sessions for employees to promote the use of personal protective equipment. This intervention implemented by involving supervisors and managers to ensure the implementation of ergonomic intervention leading to behavioral change (increasing safety and decreasing hand injuries; Antle et al., 2018)

Dynamic Relationship between Applied Ergonomics and Knowledge Translation Theory

Knowledge translation is used in health research as a guide or framework for dissemination and development of tools to mitigate an ergonomic challenge, health promotion, and preventative measure (Glegg et al., 2016). Knowledge translation theory and frameworks are used as a guided approach for ergonomic research to observe and understand. Theory and framework are abstract and enables researchers to compare findings of research and account for multi-dimensional aspects of workplace environment (Kawulich, 2009). Thus, theory is interrelated with research on many levels; interconnecting the data to other studies, approaching a real-world challenge, and connecting the findings to other studies. One of the challenges in the health care system is the volume of information and managing the information flow which are time consuming and challenging to make information readily accessible. Although it has become easier to make the information accessible using online apps and websites, the management of online information and providing support has brought its own challenges (Roland, Spurr, &

Cabrera, 2017). Roland et al. (2017) discussed the challenge of brokering and managing knowledge on a large scale. The study focused on the impact of online-based platform/media for users accessing medical education. The flow and management of information were different in an online platform with benefits and concerns; the benefits included remote connectivity, saving time, and accessibility. The concerns were the accuracy and management of information (Roland et al., 2017). This study highlighted the need for KT approach for managing online information as the technology era has greatly impacted medical education.

There have been studies on developing tools to mitigate MSK injuries and illnesses. One of the Canadian frontier organizations developing occupationally relevant health and safety tools is the Centre for Research in Occupational Safety and Health (CROSH). CROSH has been known for developing KT tools to improve occupational health and safety in the workplace. Using technology to improve safety in the workplace and lowering the risk of injuries and accidents has been one of the missions of this institution. Dr. Alison Godwin and her team integrated technology for improving the training of heavy machinery operators (CROSH, 2017). For instance, in construction sites with heavy traffic of large, sizable machines, there was a higher chance of accidents and near misses (van der Molen et al., 2018). There was a report in 2017 stating that MSK injuries on construction sites were at a rate of 31 individuals out of 10,000 workers (van der Molen et al., 2018). CROSH has been able to integrate a virtual reality technology to train operators and workers on the blind spots of heavy machines and informed both operators and workers on the blind spots and potential dangers (CROSH, 2017). Brokering the knowledge on the dangers and providing a tool that maximized the experience of trainees on the real on-site dangers lowered MSK injury risks and provide ergonomic solutions (CROSH, 2017).

Another example of using KT theory in applied ergonomics was a study on the facilitation of Physical Demand Analysis (PDA) development for firefighters. The PDA was a document pertaining to important information regarding a task including environmental factors, cognitive demands, and physical demands (Snyder et al., 2008). Sinden & MacDermid (2014) explored the use of Knowledge-to-Action (KTA) framework to develop PDA for injury management and return-to-work planning in firefighters. The KTA framework had two components of knowledge inquiry and action (Sinden & MacDermid, 2014); this framework facilitated the use of knowledge found in research to be used by different types of stakeholders (i.e., practitioners, policymakers, researchers, managers). The KTA framework for firefighters provided a stage to develop the PDA document in a physically demanding job (Sinden & MacDermid, 2014). The dynamic interactions between multiple stakeholders (i.e., occupational therapists, physicians, management, and ergonomists) with different perspectives was required for developing the PDA (Sinden & MacDermid, 2014). As mentioned in Sinden and MacDermid (2014), there were multiple players with different roles within a context of occupational injury that should have been taken into account (i.e., managers, occupational safety and health agents, disability management, case manager, and employee). For instance, the implementation of a return-to-work program in multiple cities in Denmark displayed the impact of the roles of practitioners, employers, employees, and insurance agents on the quality of the process (Aust et al., 2015). The process of return-to-work after the employee's injury required all stakeholders to coordinate and cooperate for a successful implementation process. Denmark's disability management departments believed that encouragement, early assessment, and providing platforms for cooperation between stakeholders would help successfully implement a national return to work program (Aust et al., 2015). This finding was supported by using KT strategies

which used two sickness benefit frameworks and ordinary sickness benefit management models within the occupational health and safety of the Denmark government (Aust et al., 2015).

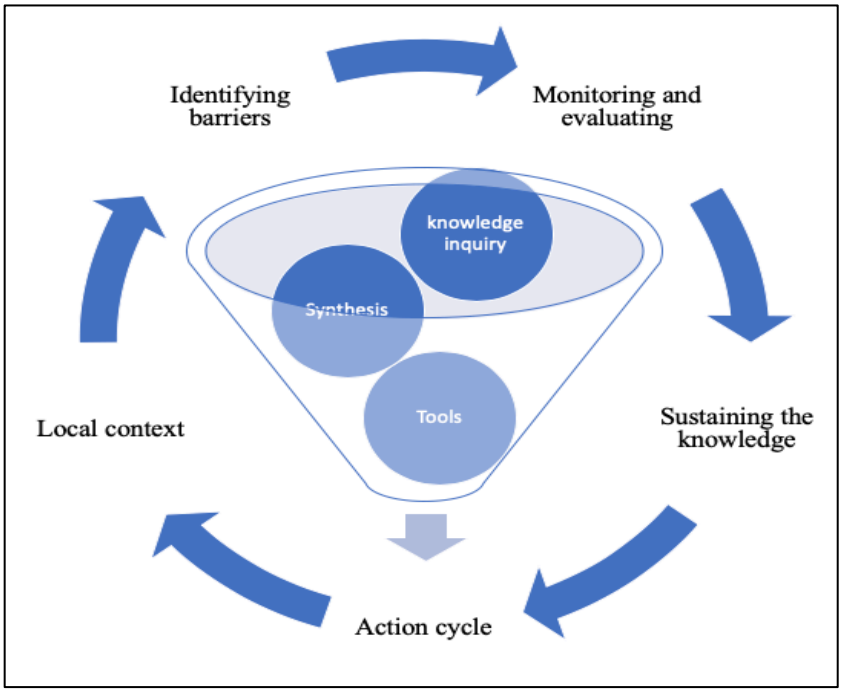


Figure 4. This figure shows the elements of KTA framework. Adapted from "Lost in Knowledge Translation: Time for a Map?", by Graham, I. D., Logan, J., Harrison, M. B., Straus, S. E., Tetroe, J., Caswell, W., & Robinson, N. (2006), *The Journal of Continuing Education in the Health Professions*, 26(1). Retrived from https://doi.org/10.1002/chp.47.

Understanding workplace dynamics within a framework or theory helps the process of assessment and evaluation. This step is important for the implementation of a policy, changing behavior, and implementing new tools or protection plans for occupational safety and health of employees. Knowledge translation strategies provide an abstract world view that helps scientists/researchers to understand the challenges and take appropriate actions. The link between hypothesis and observation within the applied research and real-world is accomplished using KT strategies.

Although there have been several studies that used KT theory in applied ergonomics, this field requires further research and use of KT theory or framework. A broad range of knowledge inquiry is required to inform occupational health and safety solutions focusing on context, end-users, and culture of workplace. Using various theoretical platforms to inform the development of evidence-based occupational health and safety solutions have been used in several studies, however, the key components that can be used to inform change and facilitate successful clinical and ergonomic outcomes remains unknown. Conducting a scoping review of the literature will help to identify how theory informs applied ergonomics research and furthermore, may identify key components that will inform effective ergonomic research aimed to prevent workplace injury and illnesses.

Problem Statement

There is a paucity of studies on use of theories/framework/models of KT to guide ergonomic and occupational health and safety research. Understanding the KT strategies used to mitigate work-related injuries (i.e., MSK injuries) requires knowledge synthesis and gathering available research in this area. There is no single solution to tackle work-related injuries. Knowledge translation strategies provide guidelines in conducting research; however, there is a gap in mapping the use of these strategies within applied ergonomics in industrial or organizational settings. Gathering the available research guided by KT frameworks and/or models and/or theories is vital in providing a better picture of the impact of KT strategies within applied ergonomic research and tool development. Consequently, this project has two primary overarching objectives:

1. To conduct a scoping review that examined the findings of applied ergonomic research using KT theory/framework/model to implement ergonomic solutions.
2. To use preliminary findings of the scoping review to develop a KT tool that can be used by employers to guide evidence-based injury prevention solutions and mitigate MSK injury.

Methodology for Scoping Review of Literature

The study protocol followed the Arksey and O'Malley (2005) and Aromataris (2017) scoping review method (Appendix A). This method was used for identifying relevant studies related to KT theories used in ergonomic research. The adopted scoping review strategy was described in several stages; identifying the research question, identifying relevant studies and selection criteria, appraisal of the data, and synthesis of the findings (Arksey & O'Malley, 2005).

Identifying the Research Question

The scoping review explored the use of KT framework/theory/models in ergonomic research within industrial or organizational setting. The main purpose of this search was to gather the available published studies that implemented ergonomic solutions using KT strategies as a mitigation of work-related injuries/illnesses risks for workers/employees. The research question identifies is as follow; What are the findings in the literature related to using KT theory/framework/model to implement ergonomic solutions?

Identifying Relevant Studies and Search Strategies

An initial scoping review of the literature was conducted to identify studies focusing on KT strategies implemented for ergonomic solutions or investigation within industry or organizations to identify or mitigate work-related injuries. The search was conducted using ProQuest, PubMed, and Google Scholar to find articles between 2000-2019. These bibliography databases were searched using enclosed phrases using quotes (i.e., Knowledge Translation) to include the Medical Subject Heading to map the potentially relevant articles (Appendix B). The search protocol included KT theory/framework/model and ergonomic research, and KT theory interventions. The search protocols were designed by the student researcher after consultation with the university librarian and extensive reviews on scoping review methods. The protocols

were verified by two experts (KES, SS). The search protocol used for this scoping review contained keywords such as “Knowledge Translation”, “Knowledge Translation Theory”, and “Ergonomic Research” in the search engines (i.e., PubMed and ProQuest). Since this area of research was broad and a variety of synonyms were used in studies for KT, we used a variety of words in the search engines. The search protocols equation that we used were as follow: KT theory; ergonomic context; exclusions criteria. The first step of the search protocol included searching databases for KT frameworks using the strings of wordings such as (“Knowledge to action framework” OR “Knowledge-to-action-framework” OR “KTA”). The researcher added “behavioral change model” OR “Knowledge translation theory” to the previous subject headings; the search was then focused on the context of ergonomic using strings of synonyms such as ((Ergonomic* OR (Human factor*) OR (Industrial Hygiene) OR (Occupational health & safety) OR (Applied Ergonomics)). The search protocol for each search engines is shown in Appendix B.

The student researcher and second reviewer (SS) identified articles independently and shared the results within an excel sheet for final review following the exclusion and inclusion criteria. The studies were merged, and duplicated studies were excluded using EndNote referencing manager software and entered into an Excel spreadsheet. The inclusion and exclusion criteria were as follow:

1. Knowledge translation theories should be implemented in the study.
2. The articles should report on the dissemination of KT theories/framework/model for ergonomic challenges within an organization or industry.
3. The non-English articles were excluded.
4. Book chapters, dissertations, and conference abstracts were excluded.

The non-English articles were excluded due to limited English translational resources. Conference abstracts were excluded due to preliminary and abstract report of the study and unavailability of the context of the research explaining the implementation of KT strategies within the context of applied ergonomics research. Lastly, the chosen articles were reviewed by the student researcher for key features of KT theories, tenets, relevance to the research, and context.

Data Appraisal

The articles were appraised using the quality assessment tool developed by Hawker, Payne, Kerr, Hardey, and Powell (2002). Their assessment tool enabled assessment of studies based on their clear description within their title, abstract, introduction, method, sampling, data analysis, bias, findings and transferability, and study implications within the practice to assign four criteria: “good”, “fair”, “poor”, and “very poor” (Hawker et al., 2002). For reporting the findings, each criterion was assigned with a numerical score: 1 point (very poor), 2 points (poor), 3 points (fair), and 4 points (good; Appendix C). The assigned numerical scores produced a sum scores range from 9 to 36 points (Lorenc et al., 2014). Study author (MA) and second reviewer (SS) conducted the appraisal of studies independently. Upon disagreeing on scoring of the studies, the reviewers discussed the disagreement and if they did not reach an agreement, a third reviewer (KES) asked to review the study in question.

Synthesis. The study findings were presented using tables and figures and KT frameworks/models/theories, context, and sample characteristics were highlighted. The qualitative assessment developed by Hawker et al (2002) result presented in a table featuring the study qualities based on numeric scores.

Findings of the Scoping Review of the Literature

The initial search strategy found a total of 1,628 articles after duplicated studies were removed (Appendix A). After initial review of the articles based on the inclusion and exclusion criteria, 14 articles were identified to be included in the scoping review. Following the thematic analysis, studies were synthesized to identify two overarching themes. The synthesized themes in the studies were as follows: 1.) **Engaging stakeholders to build relationships and identifying their expectations; and** 2.) **Dynamic nature and limitations of applied ergonomics**. The first theme was further divided into three sub themes; policy and procedure, knowledge brokering strategies, and active role. The second theme further divided into two sub-themes; resources and multidimensional aspects of applied ergonomics. These sub-themes discussed critical factors that accounted as limiting factors influencing the success of ergonomic solutions and engagement of stakeholders. These critical factors were financial resources, workload, availability of experts and workforce, and production objective. Also, the data were appraised by the author and second reviewer (SS; Appendix D).

Theme #1: Stakeholders' Engagement in the Research Process and Identifying their expectations

Engaging stakeholders was an overarching theme that was found in majority of the reviewed studies. Integrated KT model was widely used as a strategy to engage stakeholders in ergonomic research. These studies either included the stakeholders in the research process or through meetings and cooperation to identify the expectations of stakeholders. Knowledge translation theories/frameworks oriented the applied ergonomic research to map and strategize every step. This step by step strategy helped with implementation of the ergonomic solutions in the workplace; the important component for a successful implementation strategy was

engagement of the stakeholders (Antle et al., 2011; Aust et al., 2015; Tappin, Vitalis, & Bentley, 2016). The studies further highlighted that KT theories and frameworks were an important approach in the success of the intervention and finding of a long-term solution. It has been found that in a dynamic environment of workplace identifying expectations and sharing power between stakeholders, researchers, and end-users had a positive impact on the dissemination of an ergonomic solution (Sinden & MacDermid, 2014). The "dynamic nature" was a phrase used to define the nature of work in industry. Dynamic represented a fast pace and high volume workplace (Chimamise et al., 2013); for instance, in an on the ground mining context, there were heavy traffic of heavy machinery and labour workers on the field. Every employee had production goals and expected tasks to complete by the latter definition the mine classified as a dynamic workplace (Chimamise et al., 2013). Implementation of an intervention in this context needed cooperation of stakeholders, identifying expectations, dissemination of the intervention, evaluation, identifying barriers, addressing the limitations, and modifying the intervention based on the context (Antle et al., 2011; Aust et al., 2015; Tappin et al., 2016). These complex systems required a frame to address each step; KT strategies helped to map the steps and implement the strategies in a dynamic environment such as in the mine (Chimamise et al., 2013).

Despite finding evidence through research on risk factors of MSK injuries, there has not been any improvement on mitigating the work-related injuries. Antle et al. (2011) believed that ergonomic solutions were not enough for mitigating the work-related injuries; this matter needed participation among all relevant members (i.e., employers, practitioners, claim managers, case managers, and occupational health and safety agents). Ergonomic solutions required a mutual effort (participatory ergonomics) to decrease the risk of injuries in the workplace; another important characteristic for a successful ergonomic solution was the participation of the

organization (Antle et al., 2011). Understanding the organizational culture, context, and structure for the implementation of the ergonomic solutions were important. At the time of a work-related injuries, a cascade of process and actions started that required a collaboration and cooperation of different departments (Antle et al., 2011; Coutu et al., 2015; Sinden & MacDermid, 2014). Encouraging the participation of stakeholders in an ergonomic solution led to higher participation of employees and increasing job security (Labrecque, Coutu, Durand, Fassier, & Loisel, 2016).

Stakeholders effective engagement depended on the trust, addressing expectations, departmental agendas, and overall concerns (Aust et al., 2015; Vermeulen, Anema, Schellart, Van Mechelen, & Van Der Beek, 2009). Each of these requirements impacted the success of ergonomic intervention and stakeholders' motivation and investment during the research process. An effective communication among stakeholders (i.e., senior management, employees, and supervisors) and researchers was a foundation for a successful implementation of intervention leading to relevant outcomes, context appropriate, and potential long-term solution. (Sinden & MacDermid, 2014; Tappin et al., 2016). Facilitating the meetings and planning was deemed difficult for an effective involvement of all stakeholders. The attitude and receptiveness of the organization and its stakeholders depended on building relationships through meetings, successfully facilitating the discussion, and mapping the strategy details were important keys for successful engagement of stakeholders (Labrecque et al., 2016; Sinden & MacDermid, 2014).

The engagement of stakeholders further divided into three sub-themes showing the impact of on intervention and implementation process; organizational policy and procedure impacted the stakeholder's engagement, knowledge brokering strategy, and active role.

Organizational Policy and Procedure Impacting Stakeholders Engagement

Engaging stakeholders in different departments of an organization was difficult and often impacted the outcome. Different departments or stakeholders abided by different policies, priority, and procedures which impacted their engagement and expectations. These differences complicated the engagement of the stakeholders for the implementation of the interventions (Rothmore, Karnon, & Aylward, 2013; Tappin et al., 2016). Integrating KT theories (i.e., behavioral change method, iKT, participatory framework, dynamic knowledge transfer model) in applied ergonomic research helped in drafting new policies, modification of existing procedures, and developing new policies. The KT elements were important aspect of the studies for dissemination, implementation, and evaluation of the ergonomic solutions (Aust et al., 2015; Vermeulen et al., 2009).

Stakeholders were the pertinent members for enforcing policies and procedures in a workplace; their trust, collaboration with each other, and cooperation with researchers would increase the success of the interventions and possible long-term solutions to improve health and the safety of employees. Lack of communication between researchers and stakeholders and not addressing different expectations of stakeholders involved in the research process led to unsuccessful return-to-work process (Aust et al., 2015). Aiming to evaluate the Danish national return-to-work program in different cities required communication and collaboration between organizations in different cities. This program aimed to evaluate the process of implementation of a nation-wide policy to improve workers return-to-work process and decrease the confusion and increase the health and safety of all workers in Denmark (Aust et al., 2015). Although specific KT strategies were not identified; the study was included as it followed an iKT model in which the stakeholders were engaged in the process of research (Aust et al., 2015). All return-to-

work stakeholders (i.e., insurance, government, employee, and practitioners) were involved in this study; as this project showed, return-to-work programs required multi-dimensional aspects that required the expertise, cooperation, and engagement of stakeholders. In the implementation of the program, different stakeholders' policies and procedures had different barriers and facilitators which impacted the program implementation. Aust et al. (2015) discussed how integrating a working group within a government to manage the stakeholders across different cities would result in a better implementation of the Denmark national return-to-work program. The working group would be able to identify the different procedural and policies in each city and provide a plan for nation-wide implementation of the program (Aust et al., 2015). The first step was to minimize the barriers by providing a solution or policies that adopted the organizational process with the program and increase the communication between stakeholders through the working group (Aust et al., 2015).

In another study, the researcher aimed to implement a participatory return-to-work program that protected temporary employees (Vermeulen et al., 2009). Cooperation of the stakeholders (i.e., employee, return-to-work coordinator, and occupational health and safety agents) played key roles in the successful implementation of a successful program that protected these vulnerable employees. Engaging stakeholders including the return-to-work coordinator, human resources, practitioners, and case managers and providing platforms for their cooperation was key for making changes and safe work environment (Vermeulen et al., 2009). Adopting the *"attitude-social influence-self-efficacy (ASE)"* model used for engaging the stakeholders and implementation of the program. This model was chosen since workplace injuries and disability are often believed to have a negative connotation on individuals and the people around them (Vermeulen et al., 2009). The ASE model chose to change the attitude of stakeholders that were

responsible for implementation of the return to work program. The social influence and attitude impacted on the success of the return-to-work program. Engaging stakeholders was pertinent for implementation of the ergonomic intervention guided by the ASE framework. This framework helped the implementation of the change in attitude and smoother process of return-to-work plan (Vermeulen et al., 2009).

Knowledge Brokering Strategies

Knowledge brokering has shown to be a significant factor in change in organization leading to implementing and developing policies (Antle et al., 2011; Sorensen et al., 2017). A key role of knowledge brokering was to implement evidence-based knowledge in policy and procedure of organizations/companies/industries. For a successful knowledge brokering of evidence, tailoring message based on knowledge users, appropriateness of the ergonomic solutions based on organizational context, and relevancy to workplace culture were important (Gross & Lowe, 2009; Haynes et al., 2018; Sorensen et al., 2017). Integrating the stakeholders (i.e., employers, managers, and occupational health and safety agents) in the process of knowledge brokering provided a unique opportunity to account for organizational culture, context, and procedures (Sorensen et al., 2017). Using experienced and influential knowledge brokers (i.e., ergonomists, registered kinesiologists, expert knowledge translators) was important for presenting the evidence or mapping the intervention plans for stakeholders (Gross & Lowe, 2009; Labrecque et al., 2016).

The knowledge brokering strategies (i.e., visual arts, executive summaries, workshops) were important for successful engagement of stakeholders (Gross & Lowe, 2009; Haynes et al., 2018). Knowledge brokering is defined as producing information, knowledge, and evidence to end-users leading to building relationships and promoting the engagement of the stakeholders

(Haynes et al., 2018). These knowledge brokering strategies had a positive impact on the ergonomic intervention aiming for injury prevention in the workplace and brokering knowledge to health practitioners. Gross and Lowe (2009) investigated the impact of KT and the exchange model in brokering knowledge regarding workplace physical injury prevention strategies for physical therapists. The study developed a guideline for disability management of workplace injuries for physical therapists. The role of stakeholders involved in the research process led to the successful dissemination of the KT tool by providing a platform to share information, expectations, connections, and communication (Gross & Lowe, 2009). Experienced physical therapists in the field provided perspective and information on framing information and guiding the development of the tool tailored for the role of physical therapists in care of worker's injury prevention (Gross & Lowe, 2009). Using experienced and well-known practitioners and educators in this field for developing the KT tool provided a platform for understanding expectations of practitioners and patients; also, engaging the stakeholders at this level led to building connections and platforms for further discussions and increasing the cooperation of practitioners in using the KT tool in their practice (Gross & Lowe, 2009). Also, using creative ways such as the visual arts (i.e., pictures, diagrams, and drawings) to broker the knowledge on work disability prevention showed a promising outcome (Labrecque et al., 2016). Stakeholders were more engaged in the meetings. These meetings were attended by a large pool of attendees with different backgrounds (i.e., human resources, occupational health and safety agents, supervisors, and engineers). This kind of knowledge brokering was difficult due to the need of delivering the message to the various end-users with different backgrounds; however, it was embraced and hoped to be used as a training tool (Labrecque et al., 2016). The strength of having stakeholders with different backgrounds helped to understand different perspectives and

feedback that provided the researcher to develop a strategy that was more relevant to end-users. Facilitating these meetings were difficult in the sense of timing, planning, and facilitating discussions; however, the perspectives and expertise of attendees overcame this difficulty for the implementation of the visual art training intervention (Coutu et al., 2015; Labrecque et al., 2016).

Active Role

Review of studies identified that not only stakeholder involvement critical to successful development and implementation of applied ergonomic strategies, but also ensuring that the stakeholders have an active role in the research process. For example, Antle et al. (2011) evaluated the process of knowledge transfer of evidence-based ergonomic solution in a knife sharpening and steeling program at a poultry processing plant. The role of stakeholders in the implementation of ergonomic intervention was deemed necessary and important (Antle et al., 2011). At the dissemination stage of the KT strategy, managers, supervisors, and employee's cooperation directly impacted the outcome. Managers and supervisors as decision making bodies of an organization had ability to implement changes to procedures and encourage engagement of employees to follow the ergonomic interventions (Antle et al., 2011). A key finding was that active engagement by key stakeholders was critical to the successful implementation of the ergonomic solutions (i.e., training sessions and use of personal protective equipment). Participatory ergonomics was used in a poultry processing plant in an effort to reduce hand injuries. The participation of employees and employers increased the communication and commitment of all stakeholders to follow ergonomic solutions following the dynamic KT model. This model provided a platform to guide the intervention in two perspectives: interaction between stakeholders and the transfer of knowledge (Antle et al., 2011). This showed that providing a platform for stakeholders to have active roles in the implementation of training

sessions and providing information on the use of personal protective equipment (gloves) led to a decrease in hand injuries. Engagement of stakeholders was a key element in the dissemination of this ergonomic intervention. In another study, the use of participatory ergonomics and actively engaging stakeholders led to a successful implementation of MSK injury interventions (Tappin et al., 2016). Engagement of stakeholders across New Zealand meat processing industries showed positive outcomes in the development and implementation of MSK injury intervention (Tappin et al., 2016). The success of intervention strategies was directly related to giving stakeholders active roles in the dissemination of the intervention. The knowledge brokers (researchers) provided training workshops and designing the MSK preventative guide for specific tasks; the stakeholders provided expertise and experience in this process which increased their motivation and cooperation (Tappin et al., 2016). In another study, building relationships and collaboration with stakeholders were highlighted for the development of the PDA document for firefighters. Sinden and MacDermid (2014) used the KTA framework to build a PDA document that was relevant and operationalized for firefighters. Bringing the partners in the research process provided a platform for understanding the expectations and needs of the stakeholders (Sinden & MacDermid, 2014). Thus, regular meetings with stakeholders were conducted to share information and perspectives. Building trust, collaboration and partnerships with stakeholders in research led to more relevant findings based on stakeholder's expectations (Sinden & MacDermid, 2014). The importance of stakeholders' active role was highlighted in the Sinden and MacDermid (2014) study which showed that the lack of cooperation and willingness of stakeholders participation in the intervention would impact the outcomes (Rothmore et al., 2013). Musculoskeletal injury prevention has been a priority in the industry to prevent absenteeism and disability in employees. Different expectations and concerns of departments

played as barriers for developing a practical MSK injury prevention plan; these barriers led to the lack of active participation of stakeholders and collaboration. For instance, Rothmore et al. (2013) discussed the process of behavioral change required for mitigating the MSK injury risks in the workplace. Although this was the main concern for industries, engaging stakeholders in this ergonomic challenge was difficult. Some supervisors believed that the main reason for the unsuccessful implementation of the MSK injury prevention plan was lack of support from senior managements and employees resistance to behavioral change (Rothmore et al., 2013). This finding suggested that the active role of stakeholders was critical for the successful implementation of ergonomic solutions in the organization/industry.

One of the important stakeholders impacted the most in occupational injuries were the employees (Coutu et al., 2015). Providing a platform to engage stakeholders for preventative measures or ergonomic interventions was deemed important. During injuries, employees interacted with return-to-work coordinators and physicians (Coutu et al., 2015). During this time, employees felt powerless in the process which impacted the outcomes of the return-to-work and recovery. Coutu et al. (2015) believed giving power to employees in their care (i.e., providing information and the right to make decisions) significantly impacted the partnership between the healthcare providers and injured workers.

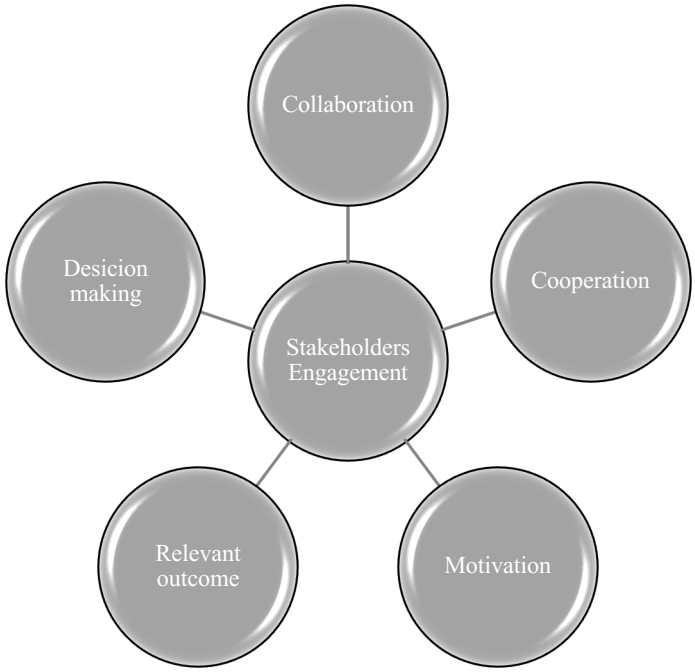


Figure 5. The summary of the impact of stakeholder's engagement in the research process based on the findings of scoping review.

Theme #2: Dynamic Nature and Limitations of Applied Ergonomics

Applied ergonomics had a dynamic nature which increased the challenges faced by researchers to tackle the issues and provide a long-term solution (Haynes et al., 2018; Tappin et al., 2016). It was difficult to account for both organizational context and culture combined with human factors and social influences in a design or organizational structure. These characteristics of applied ergonomics provided a dynamic circumstance leading to limitations and barriers for successful intervention strategies and facilitation of knowledge exchange (Gainforth, Latimer-Cheung, Athanasopoulos, Moore, & Ginis, 2014; Pickett et al., 2010; Tappin et al., 2016). Elements of KT theories and frameworks helped to identify these barriers during the operationalizing of the ergonomic solutions. When stakeholders engaged in the process of the research, researchers were able to seek their perspectives to evaluate and provide feedback. In this process, critical factors impacting the ergonomic intervention were identified (i.e.,

production objective, workload, time, budget, and experts/work force; Antle et al., 2011; Coutu et al., 2015; Haynes et al., 2018). This overarching theme divided into two sub-themes; resources and multidimensional aspect of applied ergonomics.

Resources

The priority of organizations/industries were productivity, production objectives, and competitiveness in the market; there were critical factors that limited the degree of success in the implementation of ergonomic solutions guided by KT strategies (Antle et al., 2011; Aust et al., 2015; Haynes et al., 2018). Knowledge translation theories and frameworks guided the application of ergonomic solutions and facilitated the discussion with all stakeholders for finding a mutual objective. Being aware of the differences and impact of resources in the success of ergonomic research outcome helped the facilitation of meetings and addressing the concerns raised by the different stakeholders (Gainforth et al., 2014; Pickett et al., 2010). Two of the critical limiting factors were time and money (Haynes et al., 2018). These major limiting factors in industries such as mining led to the lack of interest in the implementation of a sun safety exposure intervention in a workplace. Occupational health and safety departments priority were not focused on these issues as launching the intervention needed time and money to revise an action plan or resources to launch a new program (Haynes et al., 2018). To implement and develop a policy change and guideline, several steps were required; expert deliberation, feedback, revision, training, implement, and evaluate. These processes were time consuming and at times faced with resistance of stakeholders; these resistance were due to high volume of workloads and production goals (Antle et al., 2011; Aust et al., 2015; Haynes et al., 2018). Also, the budget for safety and health issues in a scale of an industry with more than 1,000 employees at risk raised another limitation for spending priority. Haynes et al. (2018) study pointed to

spending priorities that focused more on traditional practices and physical injuries despite recent evidence-based studies highlighting the impact of other injuries such as skin damage due to sun exposures. In addition, the lack of cooperation and collaboration between departments linked to the lack of time and resources (i.e., experts, workforce) for the implementation of a new policy and training (Haynes et al., 2018).

Multidimensional Aspect of Applied Ergonomics

Applied ergonomics is a multidimensional science that considers the relation of human and work spaces in different contexts; environment, social, and individuals (Coutu et al., 2015; Gainforth et al., 2014). For instance, Coutu et al. (2015) aimed to promote empowering injured workers in their treatment and providing opportunities for decision making. Empowering injured workers improved their access to treatment and return-to-work process. The realities of access to treatment include many aspects such as social influence (i.e., job security) and financial status. The study did not consider the aspects which directly could impact the return-to-work success and workers rehabilitation time (Coutu et al., 2015).

Several studies mentioned that *"no one approach fits all"*; which suggests that a multi-disciplinary strategy was needed to provide a relevant and appropriate solution for each industry based on their needs and tasks to mitigate work-related injury risks (Antle et al., 2011; Aust et al., 2015; Pickett et al., 2010). Musculoskeletal injury rates in Saskatchewan farmers were high; a study aimed to use population health theory to map the injury risks as a mitigating step toward decreasing the injuries (Pickett et al., 2010). Population health theory is defined as an approach for improving population health by considering various factors in the process. For instance, this theory aimed to guide the mitigating MSK injuries of Saskatchewan farmers initiative by considering various factors (i.e., tasks, time, socioeconomic status, and physical demands).

Pickett et al (2010) studied the tasks, duration of each tasks, socioeconomic status, physical demands, and environmental factors. These factors were important to compare with the rate of injuries, treatment duration, and successful return-to-work process. Pickett et al. (2010) found that population health theory was not sufficient to address a multi-dimensional aspect of MSK injuries in farmers. There were other factors that impacted the farmers MSK injuries such as weather, equipment, and available resources (Pickett et al., 2010). Consequently, structuring the research within multiple KT theory and frameworks would benefit the research in finding a relevant and long-term ergonomic solution (Pickett et al., 2010). Another study demonstrated the limitations of KT theory for the implementation of a tool within a work context. The introduction of new KT tools tended to face resistance and unwillingness from stakeholders (Gainforth et al., 2014). The diffusion of innovation theory helped the introduction of the online communication system and knowledge brokering easier; however, validation of the tool deemed difficult (Gainforth et al., 2014; Rogers, 1995). The theory only considered the interpersonal experiences rather than considering the impact of both interpersonal and external communications (Gainforth et al., 2014). Interpersonal communications were referring to communications within the organization's employees and external communications were referring to communications with contractors and third-party individuals outside of the organization. Theory and frameworks have been known as an abstract concept which had an ability to be used to generalize the findings of the research and connect to other studies (Kawulich, 2009). The limitations that KT theories and frameworks faced in these studies were the adoptability of them to the dynamic nature of the industry. These limitations as suggested by the studies could be remedied by the development of KT strategies or using multiple KT strategies at once.

Summary of the Findings of the Scoping Review of Literature

The studies in this scoping review had two overarching themes: 1.) the importance of stakeholders' engagement in the research process; and 2.) the dynamic nature and limitations of applied ergonomics. The first theme, engagement of stakeholders in the research process, further divided into three sub-themes; policy and procedure, knowledge brokering strategies, and active role. The first theme discusses the importance of cooperation and collaboration for relevant outcomes and increasing motivation in research participation (Antle et al., 2011; Sinden & MacDermid, 2014). Thus, this theme highlighted the significant role of stakeholders at all levels in the success of the intervention and implementation of the ergonomic solutions. Besides time and money, lack of cooperation and collaboration of stakeholders rooted back to the lack of resources such as workload of occupational health and safety departments and competition within the organization (Rothmore et al., 2013).

The second theme, dynamic nature and limitations of applied ergonomics further divided into sub-themes; resources and multidimensional aspect of applied ergonomics. These sub-themes discussed the limitations impacting the intervention and implementation process. Time and money were important factors impacting the long-term interventions, behavioral change, and implementation of new policies (Haynes et al., 2018). Lack of resources (i.e., manpower, experts) impacted the development of policies and lack of time and money limited the success of implementation of ergonomic solutions (i.e., mitigating MSK injury prevention and skin-damage due to sun-exposure; Gainforth et al., 2014; Haynes et al., 2018; Pickett et al., 2010). Also, KT strategies sometimes were unable to capture factors impacting MSK injury prevention intervention or KT tool development processes (Gainforth et al., 2014). For instance, population health theory failed to map the risk factors and impact of MSK injuries in Saskatchewan farmers.

Methodology for PDA@Work App Development

Rationale

The following project built on the results of the scoping review of literature on KT theory/framework/models implementation in applied ergonomic research. The previous work identified that using KT theory to guide applied ergonomic research was beneficial particularly in developing an injury prevention tool. The KT tool, PDA@Work, development built on the results of the scoping review particularly, the use of stakeholders in developing evidence-based tools to facilitate knowledge dissemination.

Study Approach

An integrated knowledge translation model and Knowledge-to-Action framework were used as the theoretical framework to guide the process for engaging stakeholders in identifying expectations and using their perspective and feedback for the development of the PDA@Work application (Graham et al., 2018, 2006). This tool was developed as a way to facilitate knowledge transfer about quantifying job demands to prevent MSK injury risks in mine workers. Understanding the characteristics of job demands such as environmental, cognitive, and physical factors helped to implement safety measures within the workplace and practitioners to develop a relevant treatment plan (Snyder et al., 2008). The PDD documents were an important ergonomic document describing the job demands and as an injury prevention tool (Holtermann et al., 2010; Soklaridis et al., 2010). The KTA framework and foundational principles of integrated knowledge translation (iKT) facilitated the cooperation and engagement of practitioners, management, occupational health and safety departments, and employees (figure 5; Graham et al., 2018, 2006). At each stage of developing the PDA@Work application, KTA framework used as a guideline for inquiring knowledge to gather feedback for assessment and evaluation of the

tool.

PDA@Work Development Protocol

Five distinct steps were used in the design of the PDA@Work app including stakeholders meeting, identifying main concerns, preliminary pilot data examination, web-based application development, and evaluation.

Stakeholders Meeting

A series of three in-person stakeholder meetings were conducted which included research team members, occupational health and safety agents, and the registered nurse working on site. The meetings were held from May 2018 to September 2019. The meetings were aimed to understand the health and safety needs of the team and to discuss potential solutions. The research team has been in contact with a local mine, NewGold Inc. at the Rainy River site for the past two years.

Identifying Main Concerns

The concerns were related to the lack of understanding of job demands and absenteeism due to MSK injuries of operators. Also, stakeholders usually neglected to consider the multi-dimensional aspect of tasks that were documented in the PDA documents; the research partners were eager for a solution to inform their employees, supervisors, nurses, and operators of the job demands and description of the tasks. As the occupational health and safety agent stated in one of the meetings, *"the first thing that would help reduce the risk of injuries is informing the employees and understanding the potential risks in their jobs and workplace."*

A priority identified by the team was tailoring of various knowledge sources related to the physical demands of occupations at the mine. Tailoring of knowledge is an important construct

in the KTA Framework and involves organization, synthesis, and understanding of the information.

Preliminary Pilot Data Examination

The preliminary concerns of the health and safety of the mine workers were discussed, and a preliminary summary Excel spreadsheet for the PDD documents of the mine were prepared and sent to research partner for further discussion. The occupational health and safety manager and registered nurse reviewed the document and deliberated with two supervisors. They asked for a rearrangement and format of information to present and facilitate access to significant data.

Web-based Application Development

Upon receiving the feedback, modifications were made to the documents including color coding and re-arrangement and formatting of the data based on physical demands, manual handling, and postures. At this stage, the need for information accessibility through technology was raised by the research team which led to the decision of developing a web-based physical demands analysis application - PDA@Work. Figure 6 below displayed the step by step process of the PDA@Work application development. The web application was developed using Microsoft© Visual Studio 2017 and Notepad++ software as local hosts to write the algorithm and logic for the application. The programming language used for developing the PDA@Work platform included JavaScript®, Bootstrap, C-sharp™ (C#™), Cascading Style Sheet™ (CSS™), and HyperText Markup Language™ (HTML ™). Plesk Web Host was used as a server data centre to enable release of the application to a virtual cloud space and allow commercial access to users. The link to the application designed as www.PDAWork.ca.

Evaluation

After developing the application, the research team decided to use purposive sampling to

seek feedback about the application utility and feasibility. Feedback was sought from occupational therapists, kinesiologists, physical therapists, and occupational health and safety agents who were practicing in Ontario, Canada. An email was devised and sent to eligible participants via the research team containing information about the application and a link to the User Interface Feedback Questionnaire for "PDA@Work Application" (Appendix E). The questionnaire was distributed through email and via phone to a targeted sample based on the researchers' network. The User Feedback Interface Questionnaire is a researcher developed questionnaire that used a 5-point Likert-scale designed to determine participants' experience using the PDA@Work application (Appendix E). Questions were designed specifically to ask about the utility of the app relevant to their area of expertise and practice. The questions focused on application user-friendliness, navigations between webforms, content presentation, impact of the application in understanding the physical demand of jobs, and integration of the application in practice.

Data Analysis

The data were collected using a Google form. Descriptive analysis demonstrated the overall participant responses regarding the utility of the app using median and interquartile range (IQR).

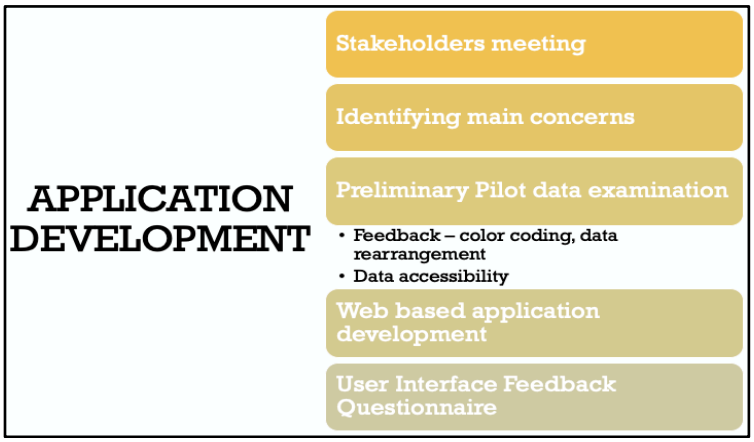


Figure 6. The step-by-step process of KT tool development.

Result: PDA@Work App Development

This project used purposive sampling. Fifteen participants who working as occupational therapy, kinesiology, physical therapy, and occupational health and safety agents in Ontario, Canada were contacted. Participants provided general feedback through a Google form, email, and via phone. The user feedback interface questionnaire had five questions. The results of the responses to the survey are discussed separately.

Utility of Application

Overall 15 participants responded to the questionnaire. 84% of responses indicated that the application was easy to use (Mdn=4; IQR=1; figure 12). The majority of the participants' responses reflected heavily toward somewhat agree and strongly agree (12 out of 15) on their positive experience with the utility of the application. A total of 20% (3 out of 15 participants) of the responses indicated that they were neutral (neither agree or disagree). Some of the comments provided by the participants denoted their position toward the application as undecided. Figure 7 shows the visual contribution of responses to the first question of the survey stating "I was able to use the application easily.

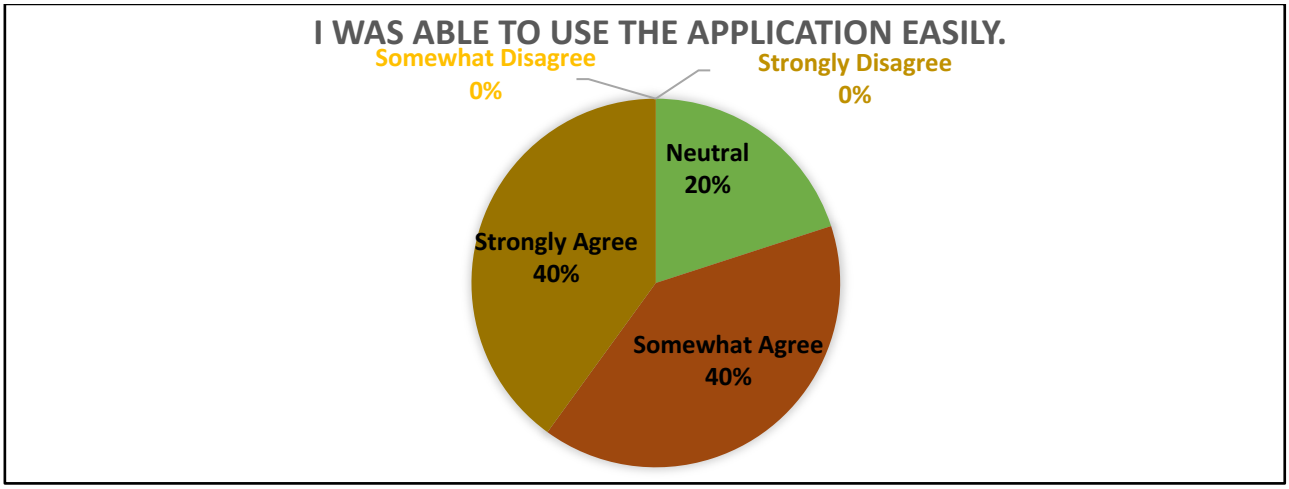


Figure 7. Pie chart showing the percentage of participants' response to the statement "I was able to use the application easily."

Navigation Utility

Overall 91% of participants reported that navigation bars on the screen were readable and easy to access (Mdn=5; IQR=1; figure 12). The majority of the participants' responses reflected heavily toward somewhat agree and strongly agree (14 out of 15). One participant (7%) reported to somewhat disagree with application navigation bar accessibility (figure 8). No further comment was provided on the reasoning for reporting "somewhat disagree" for this question. Some of the comments denoted participants' position stating the need for improvement on navigation within the application by providing "back bottoms" and "menu bar" to navigate better between the web forms. It was highlighted that menu bar available in each section saves time to find the information easily. One of the participants stated, "the application design was customized easily to the screen and the tables designed to pin-point the label columns and rows to follow the information".

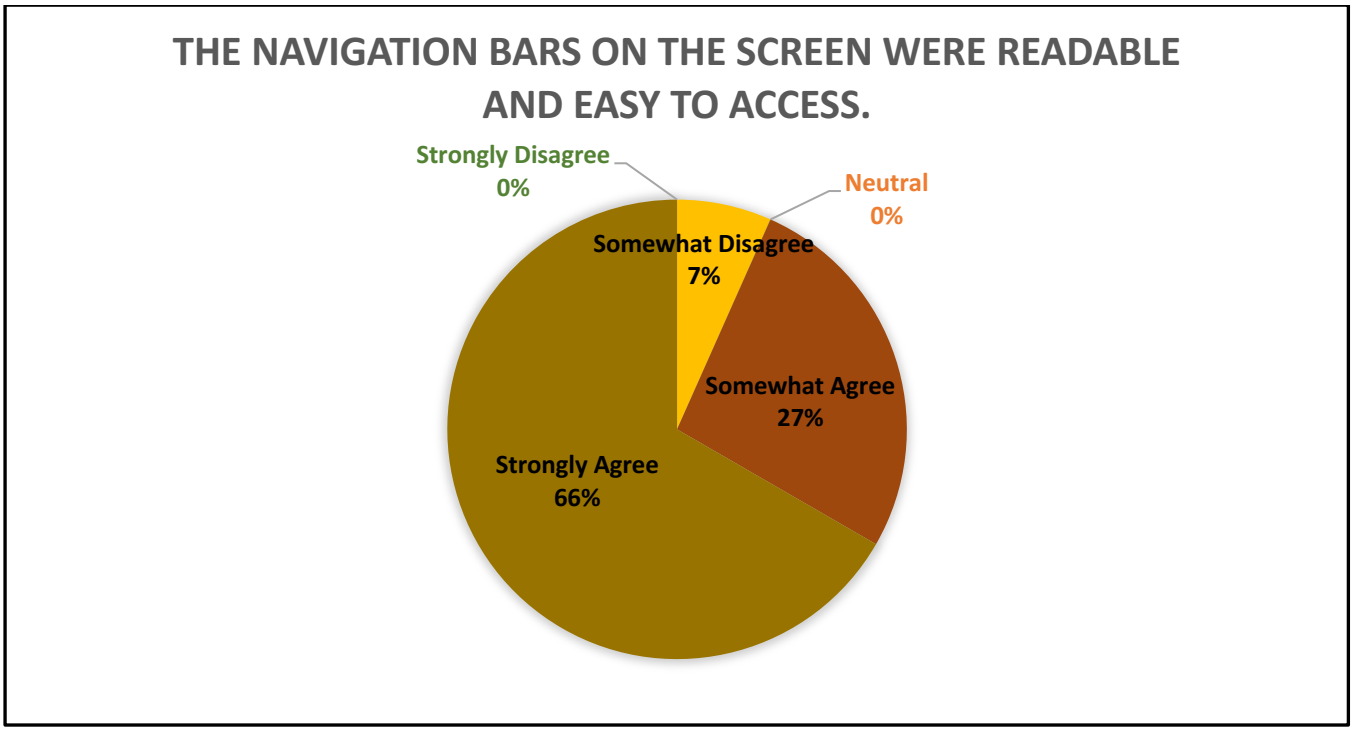


Figure 8. Pie chart showing the percentage of participants' response to the statement "the navigation bars on the screen were readable and easy to access."

Content Presentation

Overall 80% of participants responses reported that the PDA@Work application content was clear and easy to understand (Mdn=4; IQR=2; figure 12). The majority of participants' responses were reflected heavily toward somewhat agree and strongly agree (10 out of 15) with the content of the application being easy and clear to understand. A total of 27% (4 out of 15) of participants' response indicated a neutral position (neither agree or disagree; figure 9). Participants indicated in their feedback that providing a search option to look for the specific information would decrease the time for information inquiring about a specific job description. Also, one participant suggested to categorize jobs based on physical labour; for instance, separating the manual labour and office jobs. In the perspective of a practitioner, understanding the physical demand of the job is the first stage of diagnosis or planning the care for patients.

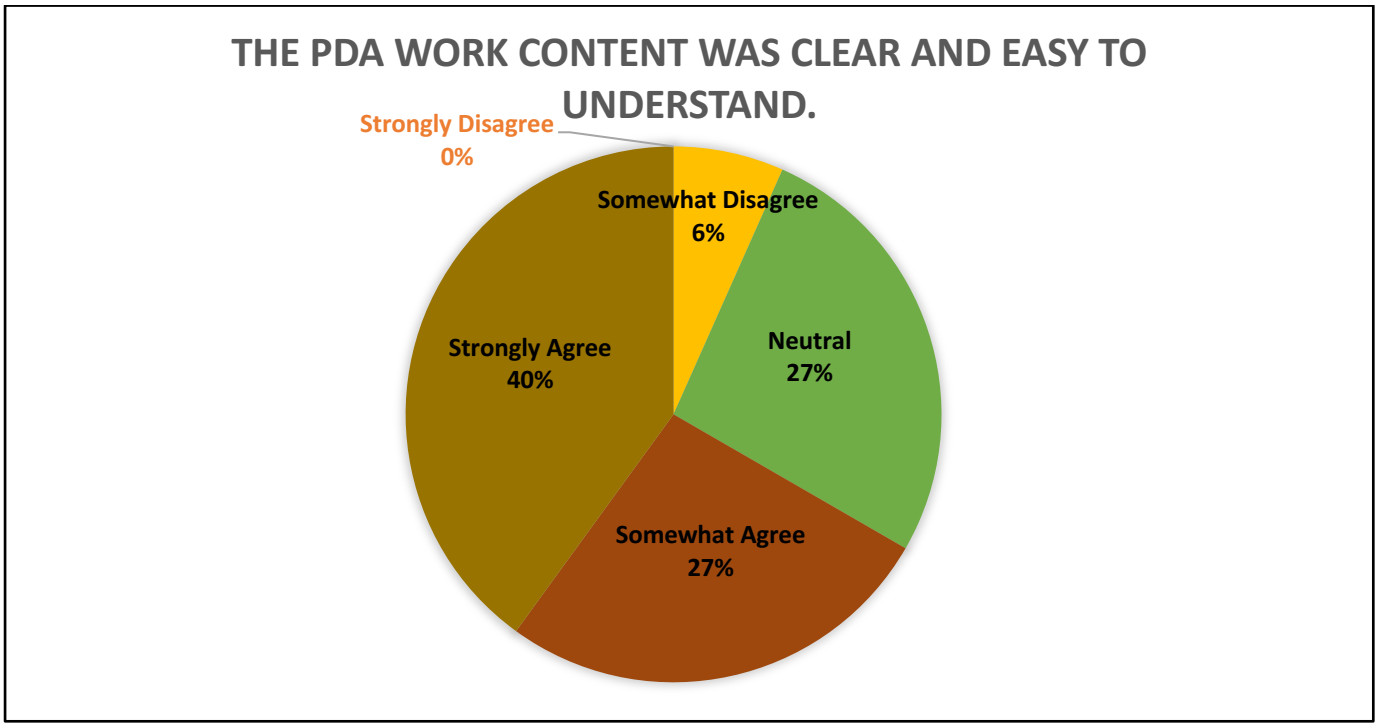


Figure 9. Pie chart showing the percentage of participants' response to the statement "the PDA@Work application content was clear and easy to understand."

Physical Demand Interpretation

Overall responses indicated that 71% of participants agreed that PDA@Work provided a solution for better interpretation of physical demands information of the tasks (Mdn= 4; IQR=1; figure 12). More than half of participants' responses (8 out of 15) were heavily reflected toward somewhat agreeing (5 out of 15) and strongly agreeing (3 out of 15) on utility of the application for interpreting information (figure 10). One of the participants stated, "being able to access the data with a click of a bottom would save them a lot of time during patients visit to understand their task and environment of workplace and reduce the use of papers". Also, 33% (5 out of 15) of participants' responses indicated a neutral position. Some of the participants emphasized that workplace injuries and planning a successful patient care and return to work program were a multi-dimensional subject. Participants suggested a system of communication should be embedded within the application to promote cooperation and communication between the stakeholders and patients to be able to fully interpret physical demands.

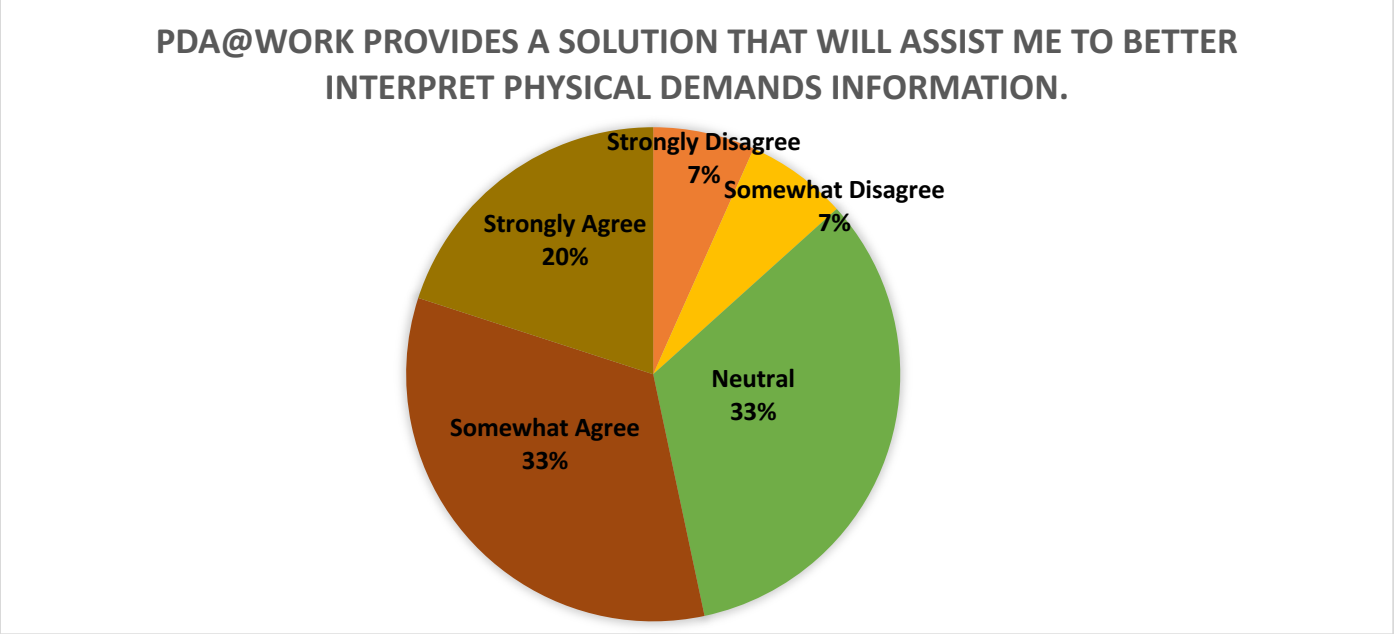


Figure 10. Pie chart showing the percentage of participants' response to the statement "the PDA@Work provides a solution assisting to better interpret physical demands information."

Integration of Technology in Practice

Overall responses indicated that 79% of participants reported a willingness to use the PDA@Work in their practice (Mdn= 4; IQR= 0.5; figure 12). The majority of participants reflected heavily toward somewhat agree and strongly agree (12 out of 15) with the integration of the PDA@Work in their practice. Only one participant (7%) indicated a neutral opinion and 13% (2 out of 15) indicated somewhat disagree with integration of PDA@Work in their practice (figure 11). One of the participants stated, *"the recommendation for task modifications depends on a case by case basis and organizational needs, policy, and procedures."* Another participant with more than 12 years of experience as an occupational therapist stated, *"Two of the important factors leading to practitioners to resist for integration of technology in their practice are time and money; there is not enough time to learn and integrate technology effectively and making sure the information is updated."*

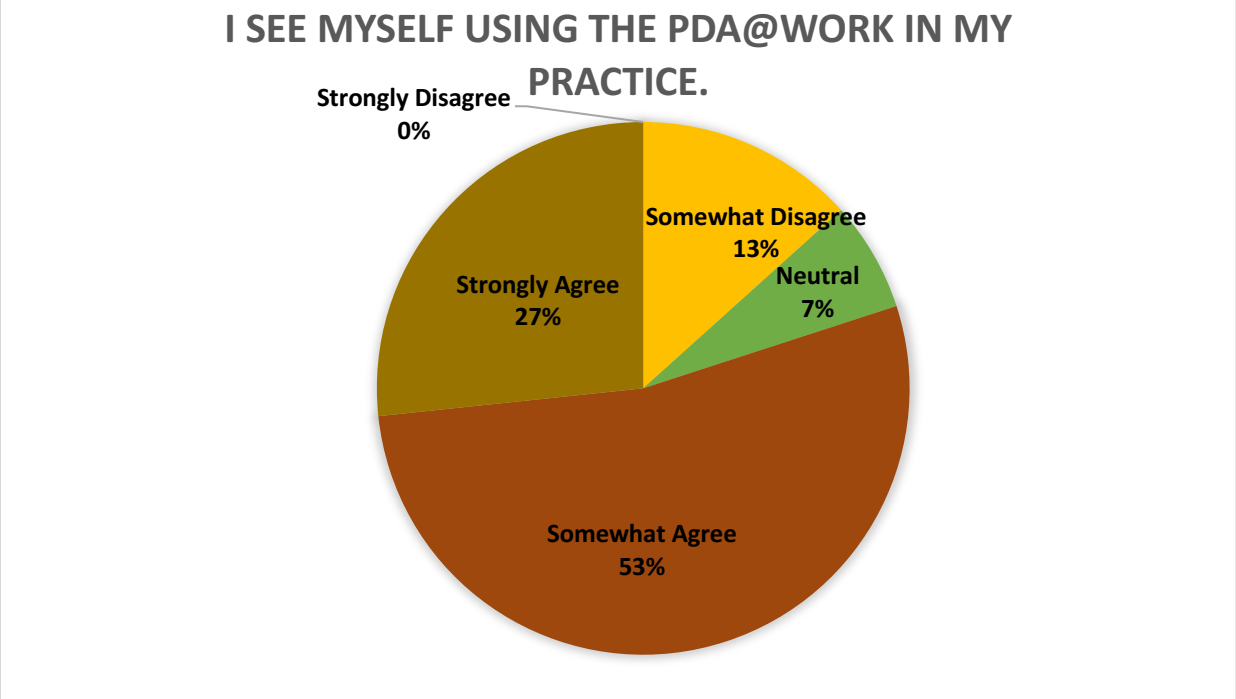


Figure 11. Pie chart showing the percentage of participants' response to the statement "I see myself using the PDA@Work in my Practice."

Summary of the Findings for the PDA@Work App Development

Overall the participants indicated that the application was easy to use (84%; Mdn=4; IQR=1) and navigation bars were readable and easy to access (90.67%; Mdn=5; IQR=1). The participants also reflected heavily on agreeing on the PDA@Work. Content presentation was clear and easy to understand (80%; Mdn=4; IQR=2). A total of 71% of participants indicated that PDA@Work would assist them to better interpret the physical demands information (Mdn=4; IQR=1). Lastly, participants reported that they are willing to integrate the application in their practice (78%; Mdn=4; IQR=0.5).

The majority of participants commented on the embedding a communication platform between stakeholders to improve the care plan for patients and understand the physical demands of the tasks. Further comments indicated that communication and collaboration between the stakeholders believed to increase the chance of return-to-work and quality of care for injured workers. Also, understanding the workplace culture, policy, and procedure would greatly help to deduce on the task demands and environmental demands that workers experienced on a daily basis.

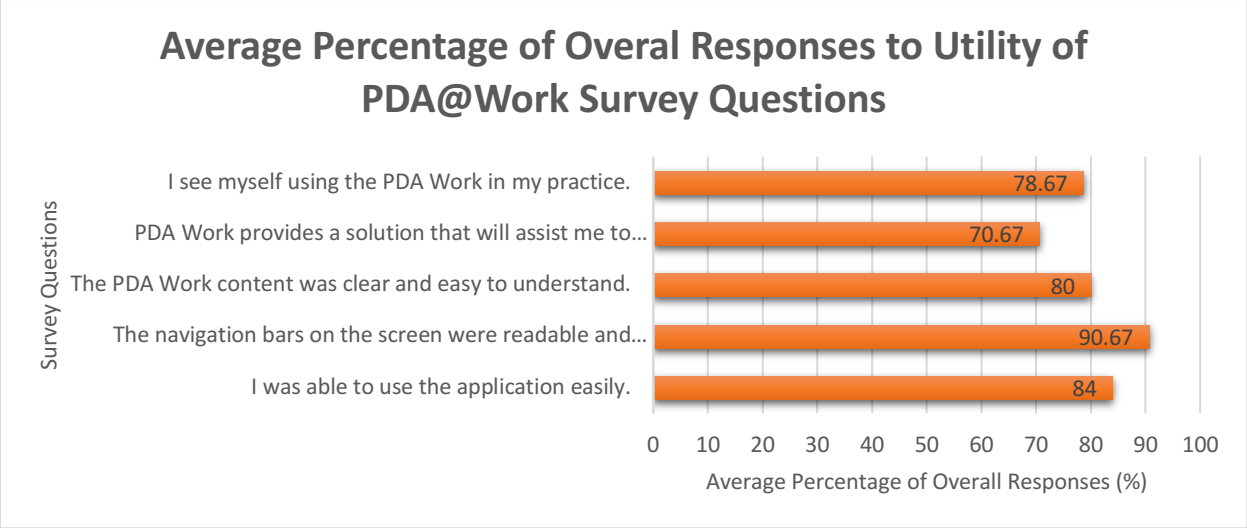


Figure 12. Overall average percentage of responses to utility of PDA@Work survey questions.

Discussion

Overall, this thesis work identified that KT was important in applied ergonomic research, particularly identifying stakeholder priorities and engaging stakeholders in solutions designed to reduce physical injury risks. Objective one was a scoping review of the implementation of KT theories in applied ergonomics and led to a scheme of how engagement of stakeholders was important for the implementation and development of ergonomic interventions and long-term solutions. The findings of objective one provided the foundation for approaching objective two, developing the PDA@Work application to assist individuals' needing to access information on PDD documents. The first theme of the scoping review of the literature, engaging stakeholders in the process of research, was used to build and approach the research partner, New Gold Inc. The research partner was actively involved in the design and development of the application and the research team implemented their feedback and concerns within the design and presentation of the information.

The scoping review of the literature found two overarching themes; engaging stakeholders in the process of research and dynamic nature and the limitations of applied ergonomics. The first theme further divided into three sub-themes including policy and procedure, knowledge brokering strategies, and active role. The second theme further divided into two sub-themes including resources and multidimensional aspect of applied ergonomics. Engaging stakeholders has been identified as an important factor for the successful implementation of ergonomic interventions (Antle et al., 2011; Tappin et al., 2016). Providing the platform for stakeholders to explain their expectations and engage them in the process of research showed better outcomes with potential long-term interventions (Vermeulen et al., 2009). Stakeholders impacted many aspects of interventions as decision makers (policy and

procedures); also, stakeholders were more receptive for knowledge brokering strategies when they were given an active role in the research process (Aust et al., 2015; Vermeulen et al., 2009). Their motivation and investment in the project led to an easier and smoother implementation process and encouraging employees to follow the interventions (Coutu et al., 2015; Labrecque et al., 2016). This integrated KT strategy provided a unique opportunity for researchers to build trust and relationships which positively impacted the outcomes. Thus, potential partnerships for future studies would be built upon the trust and cooperation of researchers and stakeholders (Aust et al., 2015). These findings aligned with the findings of studies on interactive research strategies for managing workplace injuries and stakeholders as key players in enforcing change within an organization (Felekoglu & Ozmehmet Tasan, 2020; Kumar Sahu & Sahu, 2016). Felekoglu et al. (2020) highlighted the importance of engaging stakeholders from management, decision makers, and supervisors for tackling the workplace injuries. In addition, the role of end-users was important in the successful implementation of the interventions; for instance, Coutu et al. (2015) study showed the importance of empowering workers to engage in their treatment process and making decisions increased the success of the intervention. These findings aligned with Stansfield and South (2018); highlighting the role of end-users (community) in policy changes and providing a platform for making decisions for their health. The involvement and active role of the community helped to integrate successful policy changes and using evidence in practice (Stansfield & South, 2018). Although, there were positive impacts of stakeholders engagement, this process might bring some challenges. Bebbington et al. (2007) discussed that lack of facilitating meetings with a broad range of stakeholders with different backgrounds, expertise, and expectations impacted the implementation of ergonomic solutions and at times complicated the process. For instance, in research meeting every stakeholders' expectations and

opinion would be difficult; if the stakeholders opinion or expectation would not be implemented, the trust and cooperation between researchers and stakeholders may have been negatively impacted (Bebbington, Brown, Frame, & Thomson, 2007).

In industries, there were many barriers to manage the cooperation of all stakeholders such as time, money, and resources (Haynes et al., 2018; Tappin et al., 2016). For instance, the occupational health and safety department was focused more on MSK injury risks rather than the sun exposure risks of employees (Haynes et al., 2018). Also, implementing a new guideline for sun exposure needed time and assigning resources (i.e., experts, employees) for devising the document and implementation planning (i.e., training sessions, workshops). Thus, it was difficult to find a solution without the cooperation of this department (Haynes et al., 2018). Another limiting factor in applied ergonomics research was financial resources; departments had their own priority and objective with a limited budget. This led to a competitive environment between the departments that impacted on the implementation of the ergonomic intervention and outcome of the implementation of KT strategies (Pickett et al., 2010). For instance, Sinden & MacDermid (2014) stated the difficulties of facilitation of meeting with multiple stakeholders due to scheduling plans and different expectation of stakeholders. Knowledge translation theories and frameworks provided a structure for research and investigating the problem to find relevant and practical solutions; however, KT theories/frameworks were unable to account for all aspects leading to physical injuries and factors impacting the return-to-work process (Pickett et al., 2010). The phrase “no one approach fits-all” explained the need to develop multi-dimensional KT theories and frameworks or using multiple theories and frameworks to tackle the applied ergonomic challenges (Gainforth et al., 2014; Pickett et al., 2010).

Integrating Technology into Practice

The KTA framework can be divided into two stages of knowledge inquiry and action (Graham & Tetroe, 2007; Graham et al., 2006). The integration of evidence in practice fell under the action stage of KTA for objective two; we applied the findings of the scoping review following the KTA approach and used the knowledge inquired from the scoping review to move forward with the KT tool development. The engagement of stakeholders in the development of the PDA@Work application helped to understand their perspective and concerns within the design. The findings of the scoping review aligned with Esmail et al. (2018); the study aimed to identify the important characteristics and foundations for the integration of technology in the workplace context. Trust, cooperation, and collaboration of stakeholders were important for successful transition of technology into the organizational/practitioners work context (Esmail, Hanson, Holroyd-Leduc, Niven, & Clement, 2018). The scoping review also showed that engaging stakeholders within research with an active role had great benefits for research and building partnership to close the evidence-to-practice gap. The application was preliminarily released to a purposive sample of experts (i.e., occupational therapist, physical therapist, kinesiologist, and occupational health and safety agent). Their feedback and evaluation of the application were important for assessing the application relevancy and practicality.

Developing the PDA web-based application guided by integrated KT model and KTA framework. Stakeholders were involved in the preliminary stages for understanding their concerns and expectations. This stage was important for building trust and cooperation to move forward to the project. The meetings used as a discussion and deliberation approach between researcher and research partner for feedback and building trust and cooperation. A preliminary summary of PDA document was provided to stakeholders in the second meeting for feedback.

The document was later revised, and color coded with the re-arranged data. After these revisions, a web-based application developed *PDA@WORK* and released to 15 experts (occupational therapists, physical therapists, kinesiologists, and occupational health and safety agent) for feedback and evaluation. Overall, 12 (80%) of the participants were willing to use the PDA@Work in their practice and 8 (53%) of the participants reported that this application had the potential to assist them for better interpreting physical demands of tasks. The iKT and KTA framework provided a guided structure for this project application development process. Providing a platform for research partners and researchers to take an active role and sharing power of decision making in the process of brokering the knowledge in the practice. One of the important aspects of developing a web-based application was to provide a solution for the limitations of applied ergonomic research (i.e., resources and multidisciplinary aspect of applied ergonomics). The application provided information based on job categories which did not need a training session and funding for integration and introduction to end-users.

Effectiveness of Knowledge Translation in Applied Ergonomics

Knowledge translation has operated as an approach for mitigating MSK injuries using evidence-based research and implementation of ergonomic solutions (Al Zoubi, Menon, Mayo, & Bussières, 2018). This field has shown to have comprehensive and successful impacts in applying findings of research in practice (i.e., organizational and health care contexts). One of the important steps for applying evidence-based findings in practice was using knowledge brokers and knowledge transfer strategies. As mentioned in Gross and Lowe (2009) and Antle et al. (2011), knowledge transfer approaches such as visual arts, training and educational sessions, and workshops were an important step for applying evidence in practice and informing end-users. Solely educational sessions which were not practiced and followed by senior stakeholders

(i.e., managers and supervisors) showed no improvement or positive outcome for mitigating the MSK injury risks (Peter et al., 2015). These findings were not aligned with our findings although it has highlighted the importance of engagement and cooperation of stakeholders for implementing procedural change and a long-term ergonomic solution (Al Zoubi et al., 2018).

Knowledge translation is an important component for brokering knowledge to "end users" and closing the gap of evidence to practice (Ehrensberger-Dow, 2019). The translation of research in a real work context is a multi-dimensional system. There are many departments, organizations, and individuals involved that require communication, management, and cooperation (Ehrensberger-Dow, 2019). In the context of a workplace, there are many factors aside from different stakeholders that play a role in ergonomic hygiene of workers; environmental factors, physical factors, psychological factors (Bridger, 2003). Ergonomic research has been able to delve to some extent into environmental and physical factors; however, psychological factors have been recently within the spotlight and require more research (Tang et al., 2016). There is a collaborative relationship between KT theory and framework with research; these strategies provide guidelines and frameworks to conduct research and understand the findings using theories to generalize to a real-world situation (Gagliardi et al., 2016; Kawulich, 2009). In the industrial setting, there are time pressures and production goals per day; providing a relevant and practical ergonomic solution for occupational injuries through research should account for the needs and context of the workplace. Knowledge translation theory and frameworks help ergonomic research to implement strategies based on a guided or framed direction; also, KT strategies have the ability to be used alongside other frameworks or modified/adjusted based on the context (Rothmore et al., 2013; Strifler et al., 2018). As mentioned previously, providing an active role for stakeholders in research and using KT

theories to guide the research help the evidence to be translated based on the organizational need with the cooperation of stakeholders and provide a relevant long-term solution (Ehrensberger-Dow, 2019).

Limitations

There were limited studies available on using KT strategies in applied ergonomics and the implementation of the interventions. Depending on the workplace, there are many aspects that should be considered during ergonomic research. The limitations of this project were the available studies on the topic, compatibility of KT strategies to include all potential factors impacting the intervention, and the lack of gender studies in ergonomic research.

As mentioned in Pickett et al. (2010), the KT theory used in their studies failed to explain the MSK injuries; this was due to the multi-dimensional aspect of the MSK injury as it needed to include social, environmental, and physical factors. In addition, pursuing the answers to the ergonomic challenge (i.e., work-related injuries) needed to account for multiple factors (environment, job description, psychological aspects; Karsh, 2006). Knowledge translation theories and frameworks combined to align together tackling this multi-dimensional ergonomic challenge. This could lead to a favorable outcome and practical findings that mitigate the MSK injury risks in workplaces (Karsh, 2006).

Traditionally, MSK injuries were only related to posture and manual handling; however, ergonomic research has shown that both physical and psychological factors were important as MSK injury risk factors. An industrial workplace designed to meet a production limit which increases the pace of the tasks and increase the injury risks. For instance, improving the understanding of mining workers' responsibilities and task performances is anticipated to assist in developing strategies that will mitigate the risks factors they encounter. The unpredictability

of the environment in which mine workers operate highlights the attention to variables that could be targeted towards decreasing MSK injuries and fatigue; for example, working shift work, sleep quality, fatigue, and MSK injury risks. Also, knowing the potential risks impacting miner's health and safety helped to highlight the importance of using KT frameworks and theories. As these strategies were abstracted in their definition but provided a guideline in approaching the ergonomic problem, assessing the risks, implementing interventions, evaluating the outcome, and modifying based on the feedback. Another factor that has been neglected was the impact of injuries based on gender. For instance, mining has historically been a male-dominated occupation, there is a paucity of research on how female mine workers are affected by MSK injury. In the mining industry, female workers represent 16% of the workforce in Canada (Bhandari, 2014). There are clear biological differences between females and males such as physiological strength and psychological differences, and social pressures (Koch and Walker, 2010). Dr. Côté, Assistant Professor and Chair of Kinesiology and Physical Education Department at McGill University presented her studies at the PREMUS conference in 2016. She stated that "*Women compensate for their weaker strength by engaging muscles at levels that are close to their maximum capacity. This increases their risk of muscle overload among women, leading to a higher risk of injury."*

Over the past two decades, there has been a surge in female employment in the mining industry; however, there is still important neglect towards considering the role of a female mine worker and gender diversity in equipment designs including understanding fatigue and injuries in this population (Bhandari, 2014). As Dr. Côté stated, it is important to consider the differences of female and male workers by focusing on how female workers are differently affected by workplace safety and culture and physical injuries (Bhandari, 2014).

Recently, hiring female workers in the mining industry encouraged scientists to investigate whether women are affected differently in workplace environments compared to their male counterparts and to identify impacts on their physical health. For instance, in the Australian mining industry, the equipment was maintained and used more competently in the mines with female operators compared to male mining workers (Koch & Walker, 2010; Bhandari, 2014). Also, Matthew Bruneau, mine shift supervisor for more than 15 years at New Gold Inc, stated that "*female haul truck drivers are the best operators; they have fewer incidences and mistakes throughout the time I worked here."* Despite the positive impact of female operators or mine workers, the lack of gender- and sex-specific ergonomic solutions for safety and occupational health is evident. Ergonomics is an interaction between a machine and an individual and it has been oriented on lowering work-related injuries; however, gender and sex are two constructs that have not been fully studied in this field (Bridger, 2003; Habib & Messing, 2012). Research and society have neglected female roles and are still grounded in the preconception that women work or engage in tasks that are safer (i.e., low risk, low manual handling) than males. This preconception has led to ignoring the change in female employment in arduous jobs such as operating heavy machinery in the mining industry (Messing, 1999). Obtaining data on how female workers are impacted by fatigue and MSK injuries is anticipated to improve the understanding of barriers to their full participation and safety in the field. In the mining industry, there are various tasks associated with physically demanding jobs including the operation of excavators, truck drivers, and manual underground laborers. Adapting the KTA framework in this context, there is a need for inquiring knowledge on the impact of physical demands of tasks in the mining environment on female workers. One of the next steps moving forward to the action plan is to make PDD documents gender inclusive. Providing a description of the tasks

nature and provide more gender-inclusive modification, assessment, and interventions would be a greatly impact the injury risks.

Future Direction

This thesis work has identified the key characteristics for integration of KT theory/framework in applied ergonomics research. Following the findings of the scoping review, the PDA@Work application built upon the KT theories and findings of the objective one. The key characteristics included engagement of stakeholders in all levels of the organization and identifying barriers and limitations within a dynamic workplace. Despite these findings, there are many important research questions and technical supports that still need to address the implementation, policy changes, and evaluation for a long-term ergonomic solution. Implementing a technology within an organization needs a research initiative to address the needs of all departments and integrate internal (within company) and external (outside of company) communication platform. Based on the findings of the scoping review, using KT frameworks and theories provides a guided direction to identify and implement a feasible and applicable ergonomic strategy. The theories and frameworks provide a step by step procedure that the researcher can identify barriers and seek feedback for evaluation of the intervention.

For future research, the use of KT theories and frameworks should be assessed in ergonomic research to identify the strength and weakness of the approaches. Combining multiple KT strategy research and ergonomics could help understanding the impact of human factors and workplace context. Also, more emphasis should be placed on assessing the technology alignment with corporation design and policies. The integration of the feedback of end-users (i.e., employees) and the evaluation of the rate of injuries and incidences would be helpful in assessing the impact of the application. In addition, this application could be customized to

answer the needs of employees, health care professionals, and managers. Providing a platform to promote communication and cooperation between the stakeholders' involved in workers' injuries to reduce the time absent from work and the implementation of a successful return-to-work program. In addition, future studies should focus on the use of KT strategies in applied ergonomics. Based on the KTA framework, the research is still in the knowledge inquiry stage and for moving into an action plan there is a need for engagement of stakeholders and cooperation to mitigate MSK injury risks.

Conclusion

The study aimed to review the available literature on the use of KT theory/framework implementation in applied ergonomics and later build upon the findings of the scoping review to develop the PDA@Work application as a KT tool for mitigating MSK injury risks. The thematic analysis of the literature identified two overarching themes including the importance of engaging stakeholders in the process and dynamic nature and the limitations of applied ergonomics. The stakeholders engagement was the first theme that further divided into three sub-themes including the policy and procedure, knowledge brokering strategies, and active role. The dynamic nature and limitation of applied ergonomics identified as the second theme that further divided into two sub-themes including resources and multidimensional aspect of applied ergonomics.

The scoping review identified that increasing cooperation and building relationships benefitted the research outcome and future studies (Aust et al., 2015; Pickett et al., 2010; Sinden & MacDermid, 2014). Also, the cooperation and building relationship helped stakeholders' active participation, knowledge brokering strategies, and understanding the policy and procedures of an organization (Rothmore et al., 2013; Vermeulen et al., 2009). These key facts used in developing a KT tool for a mining company, *PDA@WORK*. This KT tool was designed to better assist individuals' who needed to access information of PDD information. The web-based application developed following the KTA framework and integrated KT approach. A sample of 15 experts (occupational therapist, physical therapist, kinesiologist, and occupational health and safety agent) asked to examine the application based on their area of expertise for further evaluation of the application. The majority of the participants indicated that the application was easy to use, and navigation bars were readable and easy to access. A total of 71% of participants indicated that the PDA@Work would assist them to better interpret the

physical demands information. Lastly, 78% of participants reported that they were willing to integrate the application into their practice.

Our findings showed that engaging stakeholders for applied ergonomic research were important for more relevant outcomes (Coutu et al., 2015; Labrecque et al., 2016). Stakeholders' involvement led to the development of a KT tool that believed to benefit health care professionals and other individuals to access information of physical demands description of the job easier. It was important to encourage active participation and facilitation of discussions to understand research partners expectations and perspective. Integrating technology in an organizational context could be beneficial to overcome applied ergonomics limitations such as the availability of resources (i.e., budget, workforce, experts, and training sessions). The limiting factors impacted the implementation process and success of ergonomic interventions. The engagement of stakeholders and providing active roles in the development process of the application encouraged the stakeholders cooperation and collaboration for future studies.

Reference

Al Zoubi, F. M., Menon, A., Mayo, N. E., & Bussières, A. E. (2018). The effectiveness of interventions designed to increase the uptake of clinical practice guidelines and best practices among musculoskeletal professionals: A systematic review. *BMC Health Services Research*. https://doi.org/10.1186/s12913-018-3253-0

An End-of-Grant Knowledge Translation Casebook. (n.d.). Retrieved July 22, 2020, from https://www.yumpu.com/en/document/view/52367735/an-end-of-grant-knowledge-translation-casebook

Antle, D. M. (2008). The role of knowledge transfer in participatory ergonomics: evaluation of a case study at a poultry processing plant.

Antle, D. M., MacKinnon, S. N., Molgaard, J., Vézina, N., Parent, R., Bornstein, S., & Leclerc, L. (2011). Understanding knowledge transfer in an ergonomics intervention at a poultry processing plant. *Work*. https://doi.org/10.3233/WOR-2011-1138

Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework. *International Journal of Social Research Methodology: Theory and Practice*, *8*(1), 19–32. https://doi.org/10.1080/1364557032000119616

Aromataris E, M. Z. (2017). *Joanna Briggs Institute Reviewer ' s Manual*. *The Joanna Briggs Institute*.

Aust, B., Nielsen, M. B. D., Grundtvig, G., Buchardt, H. L., Ferm, L., Andersen, I., … Poulsen, O. M. (2015). Implementation of the danish return-to-work program: Process evaluation of a trial in 21 danish municipalities. *Scandinavian Journal of Work, Environment and Health*. https://doi.org/10.5271/sjweh.3528

Bebbington, J., Brown, J., Frame, B., & Thomson, I. (2007). Theorizing engagement: The

potential of a critical dialogic approach. *Accounting, Auditing and Accountability Journal*. https://doi.org/10.1108/09513570710748544

Bridger, R. (2003). *Introduction to Egonomics*. *Engineering*. https://doi.org/10.4324/9780203426135

Buckle, P. (2011). 'The perfect is the enemy of the good' – ergonomics research and practice.Institute of Ergonomics and Human Factors Annual Lecture 2010. *Ergonomics*, *54*(1), 1–11. https://doi.org/10.1080/00140139.2010.542251

Burström, L., Aminoff, A., Björ, B., Mänttäri, S., Nilsson, T., Pettersson, H., … Wahlström, J. (2017). Musculoskeletal symptoms and exposure to whole-body vibration among open-pit mine workers in the Arctic. *International Journal of Occupational Medicine and Environmental Health*. https://doi.org/10.13075/ijomeh.1896.00975

BURSTRÖM, L., MÄNTTÄRI, S., NILSSON, T., AMINOFF, A., BJÖR, B., PETTERSSON, H., … WAHLSTRÖM, J. (2017). Musculoskeletal symptoms and exposure to whole-body vibration among open-pit mine workers in the Arctic. *International Journal of Occupational Medicine and Environmental Health*, *71*(4), 553–564. https://doi.org/10.13075/ijomeh.1896.00975

Butlewski, M., Dahlke, G., Drzewiecka, M., & Pacholski, L. (2015). Fatigue of Miners as a Key Factor in the Work Safety System. *Procedia Manufacturing*, *3*, 4732–4739. https://doi.org/10.1016/j.promfg.2015.07.570

Carlisle, K. N., & Parker, A. W. (2014). Psychological Distress and Pain Reporting in Australian Coal Miners. *Safety and Health at Work*, *5*(4), 203–209. https://doi.org/10.1016/j.shaw.2014.07.005

CCOHS. (2014). Work-related Musculoskeletal Disorders (WMSDs) - Risk Factors : OSH

Answers. Retrieved September 17, 2019, from https://www.ccohs.ca/oshanswers/ergonomics/risk.html

Chimamise, C., Gombe, N. T. afar., Tshimanga, M., Chadambuka, A., Shambira, G., & Chimusoro, A. (2013). Factors associated with severe occupational injuries at mining company in Zimbabwe, 2010: a cross-sectional study. *The Pan African Medical Journal*. https://doi.org/10.11604/pamj.2013.14.5.1148

CIHR. (2016). Knowledge Translation at CIHR. Retrieved July 20, 2020, from https://cihr-irsc.gc.ca/e/29418.html

Cole, D. C., Theberge, N., Dixon, S. M., Rivilis, I., Neumann, W. P., & Wells, R. (2009). Reflecting on a program of participatory ergonomics interventions: A multiple case study. *Work*, *34*(2), 161–178. https://doi.org/10.3233/WOR-2009-0914

Collisson, B. A., Benzies, K. M., Mosher, A. A., Rainey, K. J., Tanaka, S., Tracey, C., … Olson, D. M. (2011). Knowledge translation: Principles and practicalities for trainees within interdisciplinary health research teams. *Clinical and Investigative Medicine*, *34*(6). https://doi.org/10.25011/cim.v34i6.15897

Corrigan, P. W., & Shapiro, J. R. (2010). Measuring the impact of programs that challenge the public stigma of mental illness. *Clinical Psychology Review*. https://doi.org/10.1016/j.cpr.2010.06.004

Coutu, M. F., Légaré, F., Durand, M. J., Corbière, M., Stacey, D., Bainbridge, L., & Labrecque, M. E. (2015). Operationalizing a Shared Decision Making Model for Work Rehabilitation Programs: A Consensus Process. *Journal of Occupational Rehabilitation*. https://doi.org/10.1007/s10926-014-9532-7

Crawford, J. O. (2007). The Nordic Musculoskeletal Questionnaire. *Occupational Medicine*.

https://doi.org/10.1093/occmed/kqm036

CROSH. (2016). Applying Learnings from the Physiological Demands Research at the 2016 International Mine Rescue Competition (IMRC) - CROSH. Retrieved June 18, 2019, from https://crosh.ca/webinars/applying-learnings-from-the-physiological-demands-research-at-the-2016-international-mine-rescue-competition-imrc/

CROSH. (2017). Integrating Technology for Improved Line of Sight - CROSH. Retrieved August 5, 2020, from https://crosh.ca/webinars/integrating-technology-for-improved-line-of-sight/

Davies, P., Walker, A. E., & Grimshaw, J. M. (2010). A systematic review of the use of theory in the design of guideline dissemination and implementation strategies and interpretation of the results of rigorous evaluations. *Implementation Science*. https://doi.org/10.1186/1748-5908-5-14

Ehrensberger-Dow, M. (2019). Ergonomics and the translation process. *Slovo.Ru: Baltic Accent*, *10*(1), 37–51. https://doi.org/10.5922/2225-5346-2019-1-3

Employment & Social Development Canada. (n.d.). National Occupational Classification (NOC) - Canada.ca. Retrieved June 18, 2019, from https://www.canada.ca/en/employment-social-development/services/noc.html

Esmail, R., Hanson, H., Holroyd-Leduc, J., Niven, D. J., & Clement, F. (2018). Knowledge translation and health technology reassessment: Identifying synergy. *BMC Health Services Research*. https://doi.org/10.1186/s12913-018-3494-y

Felekoglu, B., & Ozmehmet Tasan, S. (2020). Interactive ergonomic risk mapping: a practical approach for visual management of workplace ergonomics. *International Journal of Occupational Safety and Ergonomics*. https://doi.org/10.1080/10803548.2020.1712127

Fineout-Overholt, E., & Melnyk, B. (2005). Building a culture of best practice. *Nurse Leader*. https://doi.org/10.1016/j.mnl.2005.09.007

Fishman, B., Penuel, W., Allen, A.-R., Cheng, B., & Sabelli, N. (2013). Design-Based Implementation Research: An Emerging Model for Transforming the Relationship of Research and Practice. *Yearbook of the National Society for the Study of Education*.

Franche, R.-L., Baril, R., Shaw, W., Nicholas, M., & Loisel, P. (2005). Workplace-Based Return-to-Work Interventions: Optimizing the Role of Stakeholders in Implementation and Research. *Journal of Occupational Rehabilitation*, *15*(4). https://doi.org/10.1007/s10926-005-8032-1

Freeman, E. R. 1984. (1984). Freeman, E.R. 1984. *Strategic Management: A Stakeholder Approach*.

Gagliardi, A. R., Berta, W., Kothari, A., Boyko, J., & Urquhart, R. (2016). Integrated knowledge translation (IKT) in health care: A scoping review. *Implementation Science*. https://doi.org/10.1186/s13012-016-0399-1

Gainforth, H. L., Latimer-Cheung, A. E., Athanasopoulos, P., Moore, S., & Ginis, K. A. M. (2014). The role of interpersonal communication in the process of knowledge mobilization within a community-based organization: A network analysis. *Implementation Science*. https://doi.org/10.1186/1748-5908-9-59

Glegg, S. M. N., Livingstone, R., & Montgomery, I. (2016). Facilitating interprofessional evidence-based practice in paediatric rehabilitation: Development, implementation and evaluation of an online toolkit for health professionals. *Disability and Rehabilitation*, *38*(4), 391–399. https://doi.org/10.3109/09638288.2015.1041616

Graham, I. D., Kothari, A., McCutcheon, C., Alvarez, G., Banner, D., Botti, M., … Tetroe, J.

(2018). Moving knowledge into action for more effective practice, programmes and policy: Protocol for a research programme on integrated knowledge translation. *Implementation Science*, *13*(1), 1–15. https://doi.org/10.1186/s13012-017-0700-y

Graham, I. D., Logan, J., Harrison, M. B., Straus, S. E., Tetroe, J., Caswell, W., & Robinson, N. (2006). Lost in knowledge translation: time for a map? *The Journal of Continuing Education in the Health Professions*. https://doi.org/10.1002/chp.47

Graham, I. D., & Tetroe, J. (2007). Some Theoretical Underpinnings of Knowledge Translation. *Academic Emergency Medicine*. https://doi.org/10.1197/j.aem.2007.07.004

Grimshaw, J. M., Eccles, M. P., Lavis, J. N., Hill, S. J., & Squires, J. E. (2012). Knowledge translation of research findings. *Implementation Science*. https://doi.org/10.1186/1748-5908-7-50

Gross, D. P., & Lowe, A. (2009). Evaluation of a knowledge translation initiative for physical therapists treating patients with work disability. *Disability and Rehabilitation*. https://doi.org/10.1080/01443610802355965

Habib, R. R., & Messing, K. (2012). Gender, women's work and ergonomics. *Ergonomics*, *55*(2), 129–132. https://doi.org/10.1080/00140139.2011.646322

Hawker, S., Payne, S., Kerr, C., Hardey, M., & Powell, J. (2002). Appraising the evidence: Reviewing disparate data systematically. *Qualitative Health Research*, *12*(9), 1284–1299. https://doi.org/10.1177/1049732302238251

Haynes, E., Kramer, D. M., Strahlendorf, P., Holness, D. L., Kushner, R., & Tenkate, T. (2018). A cross-Canada knowledge transfer and exchange workplace intervention targeting the adoption of sun safety programs and practices: Sun Safety at Work Canada. *Safety Science*. https://doi.org/10.1016/j.ssci.2017.10.013

Holtermann, A., Jørgensen, M. B., Gram, B., Christensen, J. R., Faber, A., Overgaard, K., … Søgaard, K. (2010). Worksite interventions for preventing physical deterioration among employees in job-groups with high physical work demands: Background, design and conceptual model of FINALE. *BMC Public Health*, *10*, 1–13. https://doi.org/10.1186/1471-2458-10-120

Karsh, B. T. (2006). Theories of work-related musculoskeletal disorders: Implications for ergonomic interventions. *Theoretical Issues in Ergonomics Science*. https://doi.org/10.1080/14639220512331335160

Kawulich, B. (2009). The role of theory in research. *Teaching Research Methods in the Social Sciences*, 37–47.

Kumar Sahu, J., & Sahu, M. (2016). CORPORATE ERGONOMIC RESPONSIBILITY-A tool for sustainability of Corporate Social Responsibility. *International Journal of Engineering Trends and Technology*. https://doi.org/10.14445/22315381/ijett-v41p240

Labrecque, M. E., Coutu, M. F., Durand, M. J., Fassier, J. B., & Loisel, P. (2016). Using Cartoons to Transfer Knowledge Concerning the Principles of Work Disability Prevention Among Stakeholders. *Journal of Occupational Rehabilitation*. https://doi.org/10.1007/s10926-015-9595-0

Legault, G., Clement, A., Kenny, G. P., Hardcastle, S., & Keller, N. (2017). Cognitive consequences of sleep deprivation, shiftwork, and heat exposure for underground miners. *Applied Ergonomics*, *58*, 144–150. https://doi.org/10.1016/j.apergo.2016.06.007

Loisel, P., Buchbinder, R., Hazard, R., Keller, R., Scheel, I., Van Tulder, M., & Webster, B. (2005). Prevention of work disability due to musculoskeletal disorders: The challenge of implementing evidence. In *Journal of Occupational Rehabilitation* (Vol. 15, pp. 507–524).

Springer Science and Business Media Deutschland GmbH. https://doi.org/10.1007/s10926-005-8031-2

Lorenc, T., Petticrew, M., Whitehead, M., Neary, D., Clayton, S., Wright, K., … Renton, A. (2014). Crime, fear of crime and mental health: synthesis of theory and systematic reviews of interventions and qualitative evidence. *Public Health Research*, *2*(2), 1–398. https://doi.org/10.3310/phr02020

MacDermid, J. C., Miller, J., & Gross, A. R. (2013). Knowledge Translation Tools are Emerging to Move Neck Pain Research into Practice. *The Open Orthopaedics Journal*, *7*(1), 582–593. https://doi.org/10.2174/1874325001307010582

McGowan, J. (2017). Measuring most informative titles (declarative titles) as a knowledge translation dissemination tool is possible using altmetrics. *Journal of Clinical Epidemiology*. https://doi.org/10.1016/j.jclinepi.2017.03.009

Messing, K. (1999). *Integrating gender in ergonomic analysis : strategies for transforming women's work*. European Trade Union Technical Bureau For Health And Safety (TUTB). Retrieved from https://www.etui.org/Publications2/Books/Integrating-gender-in-ergonomic-analysis

Middlesworth, M. (2019). The Definition and Causes of Musculoskeletal Disorders. Retrieved May 30, 2019, from https://ergo-plus.com/musculoskeletal-disorders-msd/

Mitton, C., Adair, C. E., McKenzie, E., Patten, S. B., & Perry, B. W. (2007). Knowledge transfer and exchange: Review and synthesis of the literature. *Milbank Quarterly*. https://doi.org/10.1111/j.1468-0009.2007.00506.x

Murray, E., Franche, R. L., Ibrahim, S., Smith, P., Carnide, N., Côté, P., … Mustard, C. (2013). Pain-related work interference is a key factor in a worker/workplace model of work absence

duration due to musculoskeletal conditions in Canadian nurses. *Journal of Occupational Rehabilitation*. https://doi.org/10.1007/s10926-012-9408-7

Nowotny, H., Scott, P., & Gibbons, M. (2003). Introduction: "Mode 2" revisited: The new production of knowledge. *Minerva*. https://doi.org/10.1023/A:1025505528250

Occupational Health Clinics for Ontario Workers Inc. (2018). Physical Demands Description (PDD). Retrieved December 5, 2018, from https://www.ohcow.on.ca/physical-demands-description-pdd.html

OSHA. (n.d.). Safety and Health Topics | Ergonomics - Identify Problems | Occupational Safety and Health Administration. Retrieved August 4, 2019, from https://www.osha.gov/SLTC/ergonomics/identifyprobs.html

Peter, W., Van Der Wees, P. J., Verhoef, J., De Jong, Z., Van Bodegom-Vos, L., Hilberdink, W. K. H. A., … Vlieland, T. P. M. V. (2015). Effectiveness of an interactive postgraduate educational intervention with patient participation on the adherence to a physiotherapy guideline for hip and knee osteoarthritis: A randomised controlled trial. *Disability and Rehabilitation*. https://doi.org/10.3109/09638288.2014.913708

Pickett, W., Hagel, L. M., Day, A. G., Day, L., Sun, X., Brison, R. J., … Dosman, J. (2010). Determinants of agricultural injury: A novel application of population health theory. *Injury Prevention*. https://doi.org/10.1136/ip.2010.026286

Roberts, M. H., Sim, M. R., Black, O., & Smith, P. (2015). Occupational injury risk among ambulance officers and paramedics compared with other healthcare workers in Victoria, Australia: Analysis of workers' compensation claims from 2003 to 2012. *Occupational and Environmental Medicine*. https://doi.org/10.1136/oemed-2014-102574

Rogers, E. M. (1995). *Diffusion of Innovations, Fourth Edition*. *Elements of Diffusion*.

Roland, D., Spurr, J., & Cabrera, D. (2017). Preliminary Evidence for the Emergence of a Health Care Online Community of Practice: Using a Netnographic Framework for Twitter Hashtag Analytics. https://doi.org/10.2196/jmir.7072

Rothmore, P., Karnon, J., & Aylward, P. (2013). Implementation of interventions to prevent musculoskeletal injury at work — lost in translation? *Physical Therapy Reviews*. https://doi.org/10.1179/1743288X13Y.0000000092

Schabracq, M., Winnubst, J. A. M., & Cooper, C. L. (2003). *The handbook of work and health psychology*. J. Wiley & Sons. Retrieved from https://www.wiley.com/en-us/The+Handbook+of+Work+and+Health+Psychology%2C+2nd+Edition-p-9780470855836

Schwabe, N., & Godwin, A. (2017). Implications of articulating machinery on operator line of sight and efficacy of camera based proximity detection systems. *Safety*. https://doi.org/10.3390/safety3030017

Sinden, K., MacDermid, J., Buckman, S., Davis, B., Matthews, T., & Viola, C. (2013). A qualitative study on the experiences of female firefighters. *Work*, *45*(1), 97–105. https://doi.org/10.3233/WOR-121549

Sinden, K., & MacDermid, J. C. (2014). Does the knowledge-to-action (KTA) framework facilitate physical demands analysis development for firefighter injury management and return-to-work planning? *Journal of Occupational Rehabilitation*. https://doi.org/10.1007/s10926-013-9442-0

Snyder, L. A., Krauss, A. D., Chen, P. Y., Finlinson, S., & Huang, Y. H. (2008). Occupational safety: Application of the job demand-control-support model. *Accident Analysis and Prevention*. https://doi.org/10.1016/j.aap.2008.06.008

Soklaridis, S., Ammendolia, C., & Cassidy, D. (2010). Looking upstream to understand low back pain and return to work: Psychosocial factors as the product of system issues. *Social Science and Medicine*, *71*(9), 1557–1566. https://doi.org/10.1016/j.socscimed.2010.08.017

Sorensen, G., Nagler, E. M., Pawar, P., Gupta, P. C., Pednekar, M. S., & Wagner, G. R. (2017). Lost in translation: The challenge of adapting integrated approaches for worker health and safety for low-and middle-income countries. *PLoS ONE*. https://doi.org/10.1371/journal.pone.0182607

Stansfield, J., & South, J. (2018). A knowledge translation project on community-centred approaches in public health. In *Journal of Public Health (United Kingdom)*. https://doi.org/10.1093/pubmed/fdx147

Stein, F. (2006). *Occupational therapy and ergonomics : applying ergonomic prinicples to everyday occupation in the home and at work*. Whurr Publishers. Retrieved from http://eds.b.ebscohost.com.ezproxy.lakeheadu.ca/eds/detail/detail?vid=2&sid=534bc336-ac81-4b3a-9278-77c383cab83b%40pdc-v-sessmgr02&bdata=JnNpdGU9ZWRzLWxpdmUmc2NvcGU9c2l0ZQ%3D%3D#AN=lul.568916&db=cat00833a

Steinfeld, E., D'Souza, C., & White, J. (2014). Developing evidence-based standards: A case study in knowledge translation. In *Assistive Technology Research Series* (Vol. 35, pp. 89–98). IOS Press. https://doi.org/10.3233/978-1-61499-403-9-89

Straus, S. E., Tetroe, J. M., & Graham, I. D. (2011). Knowledge translation is the use of knowledge in health care decision making. *Journal of Clinical Epidemiology*. https://doi.org/10.1016/j.jclinepi.2009.08.016

Strifler, L., Cardoso, R., McGowan, J., Cogo, E., Nincic, V., Khan, P. A., … Straus, S. E. (2018).

Scoping review identifies significant number of knowledge translation theories, models, and frameworks with limited use. *Journal of Clinical Epidemiology*, *100*, 92–102. https://doi.org/10.1016/j.jclinepi.2018.04.008

Swaen, G. M. H., van Amelsvoort, L. G. P. M., Bultmann, U., & Kant, I. J. (2003). Fatigue as a risk factor for being injured in an occupational accident: results from the Maastricht Cohort Study. *Occupational and Environmental Medicine*. https://doi.org/10.1136/oem.60.suppl_1.i88

Tang, F. C., Li, R. H., & Huang, S. L. (2016). The association between job-related psychosocial factors and prolonged fatigue among industrial employees in Taiwan. *PLoS ONE*, *11*(3), 1–13. https://doi.org/10.1371/journal.pone.0150429

Tappin, D. C., Vitalis, A., & Bentley, T. A. (2016). The application of an industry level participatory ergonomics approach in developing MSD interventions. *Applied Ergonomics*. https://doi.org/10.1016/j.apergo.2015.07.007

Thompson, M. A., Owen, S., Lindsay, J. M., Leonard, G. S., & Cronin, S. J. (2017). Scientist and stakeholder perspectives of transdisciplinary research: Early attitudes, expectations, and tensions. *Environmental Science and Policy*, *74*, 30–39. https://doi.org/10.1016/j.envsci.2017.04.006

van der Molen, H. F., Basnet, P., Hoonakker, P. L. T., Lehtola, M. M., Lappalainen, J., Frings-Dresen, M. H. W., … Verbeek, J. H. (2018). Interventions to prevent injuries in construction workers. *Cochrane Database of Systematic Reviews*, *2018*(2). https://doi.org/10.1002/14651858.CD006251.pub4

Vermeulen, S. J., Anema, J. R., Schellart, A. J. M., Van Mechelen, W., & Van Der Beek, A. J. (2009). Intervention mapping for development of a participatory return-to-work intervention

for temporary agency workers and unemployed workers sick-listed due to musculoskeletal disorders. *BMC Public Health*. https://doi.org/10.1186/1471-2458-9-216

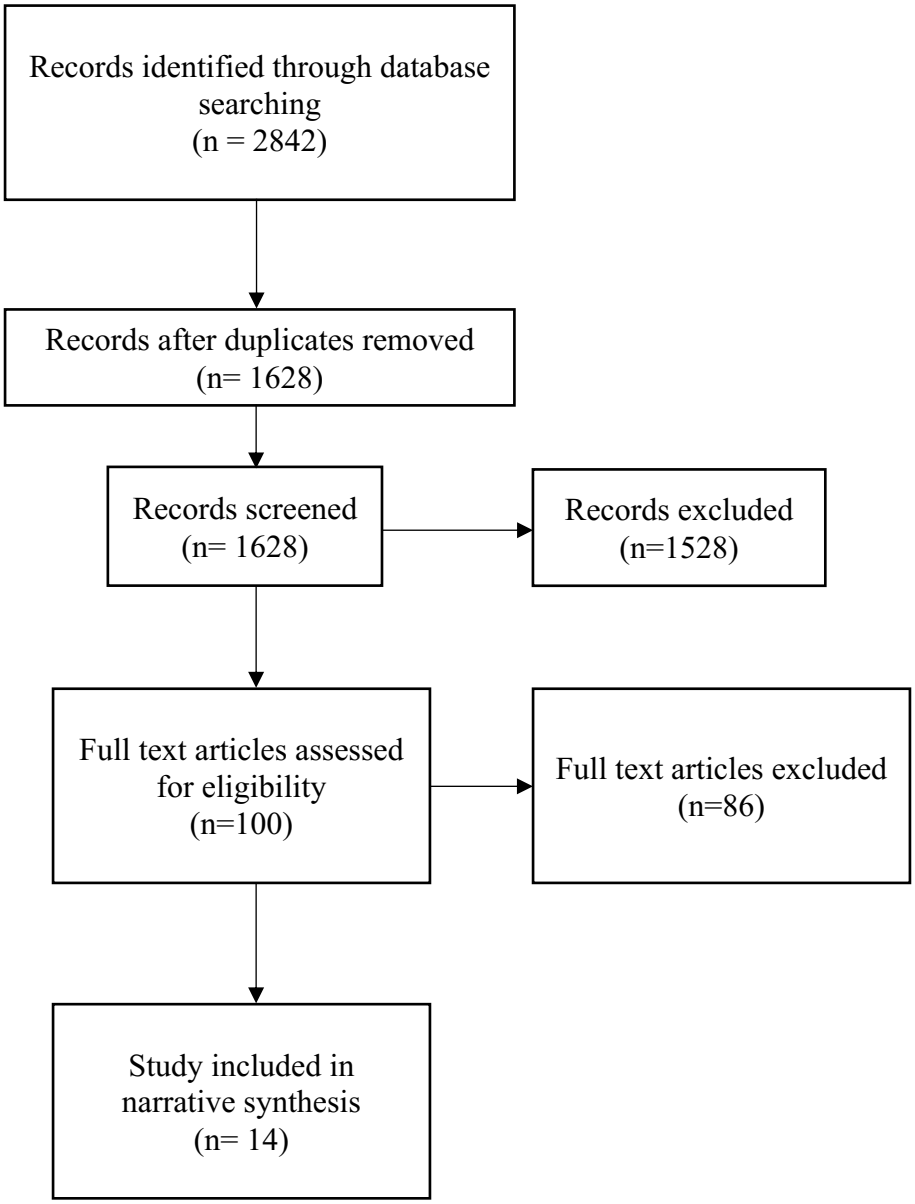
Workplace Safety & Insurance Board. (2019). Mining Statistics | Workplace Safety North. Retrieved October 29, 2019, from https://www.workplacesafetynorth.ca/resources/mining-statistics

Yu, H., Chen, H., & Long, R. (2017). Mental fatigue, cognitive bias and safety paradox in chinese coal mines. *Resources Policy*, *52*(March 2016), 165–172. https://doi.org/10.1016/j.resourpol.2017.02.005

Other Consideration

This project originally was tended to explore the Musculoskeletal injury risks and fatigue in female and male mine workers in the on the ground mining context. The data collection was scheduled for March 2020; however, due to COVID19, the project has to be pivoted and virtually completed to fulfil the master's thesis requirement. I do not believe that the circumstances of the pandemic affected the quality of this work, but it impacted the approach and planning. This project was planned and prepared in April 2020 with the support of my supervisor Dr. Kathryn Sinden.

Appendix A: Study Protocol Methodology: Objective One



Study design for reviewing the studies using Arksey & O'Malley (2005) method.

Appendix B: Search Protocols Methodology: Objective One

Database	Subject Headings & Keywords
PubMed	Search: **("Knowledge Translation" OR "KT") AND (("Ergonomic*") OR (Industrial Hygiene) OR (Applied Ergonomic*) OR ("Occupational health")) AND (("model") OR (Theor*) OR (Concept*) OR (framework*))** (("Knowledge Translation"[All Fields] OR "KT"[All Fields]) AND ((("ergonomic*"[All Fields] OR ((("Occupational health"[MeSH Terms] OR ("occupational"[All Fields] AND "health"[All Fields])) OR "Occupational health"[All Fields]) OR ("industrial"[All Fields] AND "hygiene"[All Fields])) OR "industrial hygiene"[All Fields])) OR ((("applied"[All Fields] OR "applies"[All Fields]) OR "applying"[All Fields]) AND "ergonomic*"[All Fields])) OR "Occupational health"[All Fields])) AND ((("model"[All Fields] OR "theor*"[All Fields]) OR "concept*"[All Fields]) OR "framework*"[All Fields]) **Translations** **Industrial Hygiene:** "occupational health"[MeSH Terms] OR ("occupational"[All Fields] AND "health"[All Fields]) OR "occupational health"[All Fields] OR ("industrial"[All Fields] AND "hygiene"[All Fields]) OR "industrial hygiene"[All Fields] **Applied:** "applied"[All Fields] OR "applies"[All Fields] OR "applying"[All Fields]
ProQuest	(("Knowledge Translation") AND (("Ergonomic" OR "Ergonomics" OR (Ergonomic*)) OR (Industrial Hygiene) OR (Applied Ergonomic*) OR ("Occupational health")) AND (("model" OR (Theor*) OR (Concept*) OR (framework*)) OR (Knowledge Translation Theory)))
Google Scholar	(("Knowledge Translation") AND (("Ergonomic" OR "Ergonomics" OR (Ergonomic*)) OR (Industrial Hygiene) OR (Applied Ergonomic*) OR ("Occupational health")) AND (("model" OR (Theor*) OR (Concept*) OR (framework*)) OR (Knowledge Translation Theory))) Knowledge translation theory in Applied Ergonomics Frameworks and theory in Ergonomics

Appendix C: Data Appraisal Tool

The qualitative study appraisal tool

Answer to the questions below using the pointing system of good (4), fair (3), poor (2), very poor (1). The maximum and minimum score for studies are 36 and 9 respectively. The overall scores can be assigned as follow; A (30-36), B (23-29), C (15-22), D (9-14). This tool was adapted from Hawker et al. (2002) for appraising qualitative studies.

1. Did the abstract and title provide a clear description of the study?
2. Did Introduction and aims stated clearly and provided an extensive literature review?
3. Were the method and data collection chosen appropriately and explained?
4. Was the sampling of participants appropriate for the study?
5. Did the data analysis describe appropriately?
6. Were the ethics and bias discussed in the study?
7. Did the result section explain appropriately?
8. Was the study findings generalizable and transferable?
9. Were the implications of the study explained?

Table 1.

Characteristics of studies (n=14) that used KT strategies in Applied Ergonomic research.

AUTHOR (YEAR)	STUDY LOCATION	STUDY DESIGN	SAMPLE	KT THEORY/MODEL/FRAMEWORK	FINDINGS
ROTHMORE ET AL. (2013)	Australia	Intervention	OHS practitioners	Behavior Change method	Improving the implementations of evidence-based findings in practice and engaging OHS practitioners within the process are keys for successful behavioral change.
SINDEN ET AL. (2014)	Canada	Qualitative	Firefighters	Knowledge to Action model	KTA helped to develop effective PDA and facilitation of the Knowledge synthesis. Also, the study suggested modifications to KTA to enhance the process.
GROSS ET AL. (2009)	Canada	Qualitative	Physical Therapists	Knowledge Translation and Exchange (KTE)	Successful rehabilitation of injured workers was interrelated with PT initiative with KTE model.
ANTLE ET AL. (2011)	Canada	Case Study	Industry workers (Poultry Processing Plant)	Dynamic Knowledge Transfer Model	KT model used to identify the obstacles in lowering the risk of MSK injury. The key element that identify as an obstacle was lack of participation in implementation of ergonomic strategy.
ROBERTSON ET AL. (2009)	United States	Longitudinal field intervention	Office Workers	Theory of Change	Understanding the environmental factors impacting the workers had a great impact on behavioral change and decreasing the MSK injury risks.
TAPPIN ET AL. (2016)	New Zealand	Qualitative	Industry Workers (Meat Processing Plants)	Participatory Ergonomic Framework	The key element for success was the initiative among stakeholders and participation in MSK intervention within the industry practices.
GAINFORTH ET AL. (2014)	Canada	Cross Sectional	MSK Injured workers (general)	Diffusion of Innovation Theory	Interpersonal communications using a technology helped increasing the physical activity behaviors among individuals with MSK injuries.
VERMEULEN ET AL. (2009)	Dutch	Qualitative	Vulnerable workers (temporary & Unemployed)	Attitude-Social influence-self-Efficacy (ASE) model	A structured RTW program framed within a KT theory could aim to decrease the vulnerability of temporary and unemployed workers. Assembling stakeholders such as labour experts, employers, and RTW coordinators would help to mitigate the situation.
AUST ET AL. (2015)	Denmark	Qualitative & Quantitative	RTW Program in Danish municipalities	Integrated Knowledge translation (not mentioned specifically in the study)	Environmental and geographical factors affected the Danish RTW program implementations. The suggestion for assembling a successful interdisciplinary RTW teams was dependent on stakeholder's engagement in the process.
COUTU ET AL. (2015)	Canada	Qualitative	Workers suffering from MSK injury	Program Process Theory	Providing a shared decision-making framework for workers suffering from injuries to be involved in their care. This gave the workers the power and increased their participation and believed to have positive impact on successful return to work.
HAYNES ET AL. (2018)	Canada	Qualitative	Outdoor workers	Social Constructionism Theory (SCT)	Using the SCT as a framework to apply interventions to engage stakeholders and give priority to sun exposure as an occupational hazard for outdoor workers showed promising implications on emphasizing evidence-based findings and applying it in workplace.
PICKETT ET AL. (2010)	Canada	Qualitative	Saskatchewan Farmers	Population Health Theory	Population health theory was not enough to tackle a multi-dimensional aspect of MSK injuries in farmers. Consequently, structuring the research within multiple KT theory and frameworks would benefit the research in finding a relevant and long-term ergonomic solution.
LABRECQUE ET AL. (2016)	Canada	Qualitative	Work disability agents	Integrated Knowledge translation	Using visual arts to broker the knowledge on work disability prevention showed a promising outcome. Stakeholders were more engaged in the meetings. These meetings attended by a large pool of attendees with different background. This type of knowledge brokering was hard as it needed to deliver the message to different type of end-users with different backgrounds.
SORENSEN ET AL. (2017)	India	Qualitative	Manufacturing worksite	Participatory Framework	Taking into account the organizational policies and budget was important for implementation strategies to be successful. Addressing a tabaco control in the worksite led to decrease in use of cigarettes by workers. Engagement of the stakeholders were limited by the organizational policies, production demands, and competing priorities.

Table 2.

Description of quality assessment of studies (n=14) of using KT strategies in Applied Ergonomics.

Study	Abstract/title.	Introduction/aim	Data collection	Sampling	Analysis	Ethics/bias	Results	Generability	Implications	Total	Grade
Rothmore et al. (2013)	3	2	2	1	2	2	3	2	2	19	C
Sinden et al. (2014)	4	3	4	4	3	3	4	4	4	33	A
Gross et al. (2009)	3	3	2	3	3	3	3	2	2	24	B
Antle et al. (2011)	2	2	2	3	2	1	2	3	2	19	C
Robertson et al. (2009)	3	4	3	3	2	1	3	2	3	24	B
Tappin et al. (2016)	2	3	3	3	3	1	3	3	3	24	B
Gainforth et al. (2014)	2	2	3	2	3	2	2	2	2	20	C
Aust et al. (2015)	3	2	4	3	3	3	3	4	1	26	B
Vermeulen et al. (2009)	3	4	4	3	2	3	3	4	4	30	A
Haynes et al. (2018)	4	4	3	2	3	2	3	3	3	27	B
Pickett et al. (2010)	3	3	4	4	3	2	3	3	3	28	B
Coutu et al. (2015)	3	4	3	3	3	2	3	2	3	26	B
Labrecque et al. (2016)	3	3	3	2	3	3	3	2	3	25	B
Sorensen et al. (2017)	3	4	4	3	3	3	4	4	3	31	A

Appendix E: User Interface Feedback Questionnaire

User Interface Feedback Questionnaire for "PDA @ Work Application"

PDA@Work is an application designed to better assist individuals' who need to access information on physical Demand Description of a job.

Please select the option that best describes your opinion on the PDA@Work's feasibility and utility as it applied in your own work.

1. I was able to use the application easily.

Strongly Disagree 1 2 3 4 5 Strongly Agree

2. The navigation bars on the screen were readable and easy to access.

Strongly Disagree 1 2 3 4 5 Strongly Agree

3. The PDA@Work content was clear and easy to understand.

Strongly Disagree 1 2 3 4 5 Strongly Agree

4. PDA@Work provides a solution that will assist me to better interpret physical demands information.

Strongly Disagree 1 2 3 4 5 Strongly Agree

5. I see myself using the PDA@Work in my practice.

Strongly Disagree 1 2 3 4 5 Strongly Agree

.

6. Do you have any other comments/ concerns about the PDA at Work Application features?

Appendix E: Email Correspondence to Potential Participants

Subject: **Survey about Web-based Application of Physical Demand Description**

Email Content:

"I am hoping that you can complete a brief survey about the PDA@Work application that was developed during my Master's. The PDA@Work application has been designed to better assist individuals' who need to access information on job physical demands information. I am hoping that you can provide your opinion on the PDA@Work's feasibility and utility as it applies in your own work.
You can access the application via this link: www.PDAWork.ca
This website is designed as a prototype for phone and tablet screens originally, but it can be customized to the laptop as well. We recommend you to use your phone to use this web-based application. After your visit to the website, please kindly fill out a short survey by clicking below:
User Interface Feedback Questionnaire for "PDA@Work"

If you have any questions or concerns, please do not hesitate to contact me."