Age-related differences in work outcomes: Developing a better understanding of variations in return-to-work, wage-replacement and retirement outcomes using better methods and data

by

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A thesis submitted in conformity with the requirements
for the degree of Doctor of Philosophy in Epidemiology

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2020

Abstract

Background: Age-related differences in work outcomes, such as return-to-work after work injury (RTW) and early labour market exit, are of renewed interest because they can impact organizational planning and worker well-being. Yet, age-related variations in work outcomes have yet to be fully understood. While existing data sources often do not contain items specifically intended to measure other age dimensions (e.g., functional, psychosocial, organizational, life-stage), they can contain items that could be used to assess these dimensions. If age dimensions could be assessed using existing data sources, which also contain relevant work outcomes, this can provide a feasible and efficient approach to examine the relationships between chronological age, age dimensions and outcomes of interest in existing large samples.

Objectives: 1) Better understand the overall association between chronological age and wage-replacement duration, RTW and retirement expectations; 2) demonstrate a methodological approach that could be used to create indices of age dimensions using existing data sources; 3) examine the extent to which each age dimension explains the overall relationship between chronological age and work outcomes.

Methods: This research used a combination of survey and administrative data collected from samples of working-age individuals across Canada and Australia. Regression and path models examined the overall relationship between chronological age and work outcomes, and the proportion mediated via age dimensions.

Results: Older versus younger age was associated with greater wage-replacement duration, non-RTW and earlier retirement expectations. Differences in wage-replacement duration and non-RTW also varied as a function of follow-up time. Path models found that 25-30% of the overall relationship between older chronological age and work outcomes was mediated through functional age, life-stage age and RTW status at earlier time points (for non-RTW) and through life-stage and organizational age (for earlier retirement expectations).

Conclusions: Findings indicate that both individual and contextual factors play a role in explaining relationships between older age and work outcomes. We derived novel measures of age dimensions using a variety of existing data sources and demonstrated the utility of an analytic approach to examine the relative contribution of age-related factors. This approach can be employed in future studies, although conceptual and measurement work needs to be refined.

Acknowledgments

First and foremost, I would like to thank Dr. Peter Smith. I am indebted to you for your endless support and encouragement over the years as you pushed me to think critically, analytically and independently. This dissertation would not be the same without your sharp, insightful comments and technical expertise. Beyond that, you have been an incredible role model for work-life balance, time management and simply getting things done. I cannot thank you enough for sharing half a decade and for constantly going above and beyond as a mentor and supervisor.

I extend my deepest appreciation and thanks to Dr. Anne Harris and Dr. Monique Gignac. You both challenged me to think beyond the numbers and statistics and truly pushed me to my limits in the most enjoyable and rewarding way. Anne, thank you for the extra time you spent giving me personal advice when I needed it. Monique, thank you for the countless hours you spent providing moral support and the best copy editing I have ever witnessed. To my committee as a whole, it has been a pleasure completing this body of work under your expert consultation.

I am indebted to Dr. Chris McLeod, who was not only a co-author but also a mentor, colleague and friend. Chris, you have supported me in so many ways over the past decade, including during many important life events. I thank you for your genuine interest in my professional growth, development and well-being. It has been a pleasure working with you on this thesis.

I would like to express my sincerest thanks to the reviewers of the proposal and dissertation. I am indebted to them for providing their expertise, feedback and challenging questions, all of which have strengthened the quality and rigor of this dissertation. A sincere thanks to my funding sources, including the Institute for Work and Health, the University of Toronto, the S. Leonard Syme Fellowship in Work and Health and the Dr. Andrea Sass-Kortsak Award. And a sincere thank you to the data stewards, mentioned throughout Chapter 4, as well as the study participants who took the time to agree to data collection and answer the surveys.

To my mentors who have guided me during this training period – Dr. Cam Mustard, thank you for providing me with sage advice and for being an example of true and compassionate leadership. To Dr. Mieke Koehoorn, who provided me with my first job and foray into this wonderful world of work and health research – thank you for the guidance, advice and mentorship. Robert, thank you for your excellent technical advice and help with data coding over the years, as well as anecdotes from your own doctoral training experiences. Suhail, I could write a whole chapter on the various ways that you've helped me. Your support and genuine friendship means so much to me and I thank you for this.

To my colleagues at IWH – thank you for the endless opportunities for intellectual growth and friendship. I especially appreciate my colleagues on the 7th floor – I can think of no better place to have spent so many long days and late nights. To the Institute, thank you for providing a positive and supportive working environment. To my colleagues at PWHS, my other training home – thank you for your friendship and technical expertise. To my instructors and cohort at DLSPH. You are an inspiring group and I thank each of you for your companionship and advice.

To my mom, dad, brother, sister, and my in-laws. Thank you for your love and support throughout the years. To my mom and dad especially, this dissertation is dedicated to you. Last, but certainly not least, to my loving wife Carolina. My motivation to push through and complete this dissertation was fueled by your love, patience and never ending companionship. I cannot thank you enough for being with me throughout this entire process and I am eternally grateful.

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Chapter 1
Introduction and Objectives

1.1 Introduction

The proportion of the labour market comprised of older-aged workers has increased in many high-income countries (1–3). Economic policies have focused on keeping older workers engaged in the labour market to retain critical skills, transfer knowledge to new and younger employees, and ensure a balanced labour supply for the coming decades (4). However, large variations in work outcomes, such as return-to-work following work injury (RTW) and early labour market exit, have been noted across chronological age groups (5–10). In this changing arena of aging and work, age-related differences in work outcomes are of renewed interest because they can impact organizational planning and potentially impact worker health and well-being (8).

Aging is a heterogeneous process that is not completely reflected by chronological age (11,12), which refers to the number of calendar years of age attained by an individual. A paper by Sterns and Doverspike (11) outlined additional age dimensions that may be relevant to work outcomes: functional, psychosocial, organizational and life-stage age. The inclusion of theoretically stronger age conceptualizations (11,12) may help to better understand factors and mechanisms that contribute to chronological age inequalities in work outcomes (13–15). However, to date, these dimensions have not been applied towards understanding age differences in RTW or retirement outcomes, in part because theoretical and data limitations make assessing and simultaneously incorporating age dimensions challenging (12,16).

The most direct way to measure the above age dimensions would be to incorporate measures using validated scales developed in previous studies. However, these measures are not always available in existing data sources that were not originally collected to directly examine age dimensions (12). These large secondary data sources or prospective cohort studies may contain relevant work outcomes for focused samples of working-age individuals, although they often contain limited direct data on age dimensions (17,18). If there are aspects of age dimensions that could be captured by existing indicators, then this would allow for the measurement of age using a broader range of data sources with relevant work outcomes where direct measures had not been collected.

1.2 Objectives

The overarching aims of this dissertation were to investigate similarities and differences in work outcomes among older versus younger workers; demonstrate a methodological approach that could be used to create indices of age dimensions using existing data sources that were not originally collected for this purpose; and to better understand whether differences in work outcomes across chronological age groups can be explained via age dimensions. **Table 1.1** provides an overview of objectives, data sources and methods used throughout the dissertation. Objectives were to:

1) Understand age differences in wage-replacement duration following work injury by focusing on variations in the relationship across different periods of follow-up time and jurisdictional contexts, using claims data from six workers' compensation systems across Canada;

2) Develop and validate a methodological approach to better understand chronological age differences in retirement expectations using underlying age dimensions (e.g., functional, psychosocial, organizational, life-stage age) and population-based data from the Canadian Longitudinal Study on Aging; and,

3) Examine the role of age dimensions in explaining the overall association between chronological age and RTW/wage-replacement duration outcomes following work injury using longitudinal survey data on injured workers in Victoria, Australia, linked with claims data.

Each study adds to the growing body of research that aims to address the underlying reasons for why older age is associated with inequalities in work outcomes by incorporating a nuanced conceptualization of age, beyond calendar years, while addressing theoretical and data limitations in operationalizing each age dimension using existing data sources that were not originally collected for this purpose. The studies extend previous work by separating the various age-related pathways (i.e., indirect effects) from the residual differences that are not due to age dimensions (i.e., remaining direct effects) using novel methodological frameworks proposed in recent studies. Prior to this dissertation, these analytic models had yet to be applied using all four age dimensions in the context of retirement outcomes and RTW following workplace injury. Finally, the studies extend previous work by examining both self-reported and administrative definitions of work outcomes within one study sample across longitudinal follow-up, while appropriately accounting for the complexity of time-varying estimates across phases of recovery.

1.3 Thesis structure

This dissertation is structured as a monograph comprised of three standalone manuscripts. Each manuscript addresses one of the three dissertation objectives. Chapter 2 presents an overview of the research literature on age, work and health. Chapter 3 presents a summary of data sources, research variables, and the analytic methods used to address each of the dissertation objectives, as well as methodological considerations that are common to each study. Chapter 4 presents the findings from three papers, formatted for submission to peer-reviewed journals. Chapter 5 presents the findings from supplementary analyses that were not included in the peer-reviewed journal submissions, but serve as a complement to the main findings. Finally, Chapter 6 provides an integrative discussion that links each of the standalone papers to the thesis objectives.

1.4 Role of the candidate

The dissertation and resulting manuscripts constitute original material to fulfil the requirements of the doctoral program. The candidate developed the research questions, designed the analytic studies and conducted the data analyses in consultation with the members of the supervisory committee. The candidate took the lead in drafting the manuscripts based on results from the analyses, in collaboration with committee members and other manuscript co-authors. This research was made possible using administrative claims data collected by Canadian workers' compensation systems (Study #1), survey data collected by the Canadian Longitudinal Study on Aging (Study #2), and longitudinal survey data collected from injured workers in Victoria, Australia (Study #3). Data for these studies were collected as part of larger, overarching research projects, with PS serving as co-investigator for Study #1 and Principal Investigator for Study #3. However, the candidate oversaw all aspects of research question development, data cleaning and analyses using the provided data extracts.

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1.6 Tables and figures

Table 1.1. Overview of objectives, data sources and methods used throughout the dissertation.

Objectives	Rationale	Data	Methods	Status
A) Understand age differences in wage-replacement duration across follow-up time; B) Quantify differences on both an absolute and relative hazard scale	The process of recovery following a work injury is complex. Previous studies have overlooked the phase-specificity of recovery and time-varying nature of RTW.	Canadian WCB claim data, six provinces, 2011-2015, n = 751,679	Survival analysis	Accepted in *J Occup Rehabil* (#JOOR-D-19-00228).
A) Develop multi-dimensional measures of age using existing survey data; B) Validate a methodological approach to better understand chronological age differences in retirement expectations	Although it is recognized that aging is more than chronological age, few measures exist to operationalize other dimensions (e.g., functional, psychosocial, organizational, life-stage age)	Canadian Longitudinal Study on Aging, 2011-2015, n = 17,938	Mediation analysis	Submitted for peer-reviewed publication.
A) Examine the association between chronological age and RTW; B) Examine the role of age dimensions in explaining these associations	Age dimensions have been validated in relation to general labour market outcomes in previous studies. However, few studies examine RTW.	Australia survey and WCB claim data, 2014-2015, n = 869	Mediation analysis	Accepted in *J Occup Environ Med* (#JOEM-S-20-00337).

WCB = Workers' Compensation Board.

Chapter 2
Background and Rationale

2.1 Changing demographic context

The proportion of the labour market comprised of older workers has increased in many high-income countries. For example, from 2008 to 2017, the proportion of Canadians aged 55 years and older in the labour force increased from 15% to 21% (1) due to an aging population coupled with improved health, an increased desire among many older adults to work longer, and policy changes to retirement and pension access (1–5). Similar demographic and labour market changes have been observed in countries such as Australia and the United Kingdom (6,7). The nature of the work environment also has changed in recent decades, with a large number of older individuals working in non-standard arrangements or re-entering employment following retirement (8).

In many countries, economic policies have focused on keeping older workers engaged in the labour market, along with younger workers, in order to retain critical skills, transfer knowledge to new and younger employees, and ensure a balanced labour supply for the coming decades (3). However, as the population ages in high-income countries, individuals who may have retired in past decades are now working longer and under potentially precarious conditions. This is within the context of a shifting disability burden of compensated claims for work-related injuries and diseases among older workers in Canada and elsewhere (9). This not only represents a future challenge to health and safety, but also underscores the importance of identifying where interventions might be targeted to achieve the greatest reductions in health inequalities (10). An aging workforce also will have important implications for the promotion of healthy and meaningful participation in work among older workers, which has been emphasized as a key priority at the provincial and national level in Canada (3,4,11).

2.2 Importance of retirement planning and return-to-work

In the changing arena of aging and work, age-related differences in work outcomes, such as early retirement expectations, return-to-work following work injury (RTW) and wage-replacement duration, are of renewed interest because they can impact organizational planning and potentially can impact worker health and well-being (1–5,12). Retirement planning focuses on the long-term planning or expectation process for eventual labour market transitions (such as changes in work hours, careers, employment or work status) (13–18), and RTW focuses on the extent of inability to work due to impaired health, functional limitations and participation restrictions (19,20).

The two outcomes are tied indirectly in the sense that older workers who are on long-term sickness absence or have functional limitations may anticipate earlier retirement (21–27); while workers who are fully or partially retired may experience a desire to return to work in the labour market due to a range of health, economic and life-course factors outside of age (27). For example, a Canadian study based on workers' compensation claims data linked with tax records found that workers with a permanent impairment due to a work-related injury were more likely to exit the labour market (25).

Achieving successful work participation is important for many stakeholders, in terms of general health, quality of life, financial stability, life satisfaction (for the injured worker); workforce productivity (for the employer); and reduced impact on health systems (for society) (28–30). Moreover, RTW and wage-replacement duration represent two of the most commonly-used outcome measures in work-disability research (19), with both measures serving as key indicator variables for occupational health and safety stakeholders (28). As such, understanding age-related differences in retirement planning, RTW, and wage-replacement duration will be the key outcomes in this dissertation.

2.3 Epidemiology of work outcomes by age

Older workers may have lower overall risk of work injury, better well-being outcomes following injury, and less injury-related financial stress (31–34). However, studies find that, after injury, older age is associated with earlier plans for retirement, longer time to RTW, multiple recurrences of work absence following an initial RTW attempt, and greater overall duration of wage-replacement duration following work-related injury (14,33,35–39). A recent systematic review of reviews focusing on prognostic factors for RTW among injured workers (37) found that older chronological age was one of the most commonly cited determinants of negative RTW outcomes. For example, a study by Berecki-Gisolf and colleagues (40) found that greater chronological age was associated with a 30-40% decrease in the likelihood of RTW and a 20-50% increase in the risk of disability recurrences. Smith and colleagues (35) found that males aged 45+ years had a greater median duration of sickness absence and a 50-70% relative increase in mean days of sickness absence compared to males aged 15-24 years. Chronological age is also strongly linked with retirement expectations given that social norms, pension policies and mandatory retirement legislations are strongly tied in to age thresholds (41–43). For example, greater years of age may serve as an index of changes in income, organizational resources or seniority (44), as well as changing attitudes towards retirement (45). Retirement eligibility also is defined by chronological age in some jurisdictions (46), typically using thresholds of 65 years of age (41). Thus, the structuring of society around chronological age may lead to important differences in retirement outcomes at the individual level that persist even after accounting for underlying age-related changes (47).

2.4 Pathways and mechanisms to work outcomes

As noted in the previous section, a large body of research has examined age-related similarities and differences in retirement planning (14) and RTW outcomes following a workplace injury (31,35–39). A natural question, then, is what are the underlying factors that might explain these age differences in work outcomes? By examining the underlying pathways through which chronological age may lead to inequalities in work outcomes, we can shift the focus away from non-modifiable aspects (such as chronological age) (48–51) and develop a more holistic approach to counter the proliferation of pessimistic and fatalistic perceptions about older-aged workers (52–54). Despite this gap, only a small subset of studies have examined the underlying factors that are responsible for the differences across age groups (31,35,38,39), and findings are mixed in terms of the role chronological age plays in work outcomes once other factors like chronic disease, job tenure, and injury severity are included (35,38,39,55).

A study by Smith et al. (35) examined the role of pre-existing chronic health conditions using administrative workers' compensation claims data on injured workers in Canada. The authors found that a greater prevalence of chronic conditions among older workers only partly explained why older chronological age was associated with longer duration of sickness absence. A study by Besen et al. (39) examined the role of job tenure using administrative data from a private disability insurance company in the United States. The authors found job tenure did not explain longer duration of sickness absence in older workers who were disabled due to non-work-related conditions. Fan et al. (38) examined the role of injury characteristics using workers' compensation claims data from Australia, observing that age differences in wage-replacement duration were not attenuated to a great extent after accounting for injuries of different types and severity. In contrast, Pransky et al. (31) observed that age differences in RTW following work-related injury were no longer significant after adjustment for injury severity, injury-related surgery and physical functioning scores. Moreover, Pransky found that older workers fared better than younger workers in terms of broader recovery outcomes (e.g., having less injury-related financial problems). The authors suggested that factors such as higher job satisfaction and workplace attachment may have provided a relative advantage to older workers during the RTW process.

In relation to labour market outcomes, previous studies have found that age differences in retirement expectations, planned age of retirement and overall motivation to continue working can be explained by both work and non-work factors. A longitudinal cohort study on early retirement intentions among Finnish employees (56) found that retirement intentions were driven by negative self-perceptions of health rather than chronological age. A study by Kooij (48) examined the role of subjective health and self-perceptions of remaining future time on work engagement using survey data on Dutch employers. The authors found that age differences in work motivations were partly explained by underlying differences in these factors. A study by Akkermans (57) examined the role of perceptions of remaining opportunities and future time in explaining chronological age differences in motivation to continue working for one's organization. The authors found that age differences in motivation were no longer significant after controlling for these factors.

Taken together, the above studies suggests that only a moderate proportion of the overall association between older age and work outcomes can be explained by the presence of physical, clinical and injury-related characteristics; and that other factors or mechanisms may account for the remaining effect of age as described in Section 2.3. In existing models that adjust for potential covariates, these other factors are currently captured in the remaining or residual inequalities observed across chronological age groups (58) and could be the subject of future research. These factors are discussed in detail below.

2.5 Research gaps and opportunities

2.5.1 Gap 1: Are age differences observed across multiple contexts?

Whether age plays a significant role in retirement planning and RTW is important to understand because research and policy discourse on work outcomes often focuses on the negative aspects of age rather than the positive aspects (52,59). The finding that age differences may be contextually dependent would suggest that a fatalistic view of older workers may not be warranted (52,59); that there may be social and contextual determinants of age effects that are important to understand in relation to RTW (20,60); and that concerns about older workers having greater sickness absence duration or claim costs (61) may require further study that is contextually-sensitive. One contextual factor that has been largely overlooked in research studies on age and work outcomes is the potential impact of the phase of recovery of a work injury (20,60). The process of recovery following a work-related injury or illness is complex. Within the workers' compensation system, the process is embedded not only within health needs and treatment, but also within organizational and social contexts that may change over time (20,62,63). Thus, different explanatory factors may play a phase-specific role depending upon the timing of recovery.

To the extent that time serves as a marker or proxy for these contextual factors (20,60), we might expect a differential impact on the relationship between age and disability duration depending upon the phase of recovery (i.e., time-varying age effects). However, previous studies have either ignored the phase-specificity of the RTW process across age groups (20,60) or have used less flexible methods to model the complexity of time-varying estimates across phases of recovery (60). Within the workers' compensation system, the RTW process is embedded not only within health needs and treatment, but also within organizational and social contexts that change over time (20,62,63). Physical, psychosocial, claim or economic-related factors may play a phase-specific role depending on the timing of recovery (20,62–72), such as greater control over job and work scheduling, recovery expectations or adequacy of benefits. If the phase of recovery acts as a modifier of the age–RTW relationship (67,73), then reliance on a single summary measure (e.g., hazard ratio from a Cox proportional hazards model) may not provide a meaningful interpretation because hazards are not proportional (60,74). By testing for unique variations across the entire range of follow-up time, we gain important contextual information on situations in which older workers fare better or worse compared to younger workers (10,75), which is useful for determining the optimal timing of interventions (10,60,73) and identifying individuals that may require early interventions or workplace support (10,75–78).

2.5.2 Gap 2: Understanding age differences via underlying dimensions

As noted in Section 2.4, existing studies focusing on clinical or functional factors (35,38,55,79) have not completely accounted for chronological age differences in work outcomes, although they point to some age-related factors like differences in chronic disease prevalence or self-perceptions of health (8). Moreover, there is a large body of research examining health and economic determinants of retirement planning, yet less research examining life-course and social factors within one analytic model (13,80). Previous literature suggests that aging is a heterogeneous process that is not completely understood by the number of calendar years attained (46,81). Individuals vary in their experiences of age-related changes in biological, cognitive or social functioning even within similar chronological age groups (48,49). This suggests that the development of better conceptual measures of aging may be warranted. By illuminating these underlying dimensions of the aging process, we gain a better understanding of the mechanisms that produce inequalities across age groups (48,82). A focus on age dimensions also may be advantageous in shifting the conversation away from non-modifiable aspects such as chronological age (51), as well as addressing negative stereotypes about chronologically-older workers that are often tied in to the age structuring of society (45,52,53). Moreover, chronological measures of age (i.e., calendar years) have been described as an ‘insufficient operationalization’ of the construct of age within the work setting (46,82), hence the recent research interest in moving towards a more holistic approach to conceptualizing age (45)

A paper by Sterns and Doverspike (81) addressed the need for multidimensional conceptualizations of age that may be of relevance to labour market outcomes. They conceptualized age as representing functional, psychosocial, organizational, and life-stage age. By distinguishing the non-modifiable concept of chronological age from other potentially modifiable underlying dimensions of age, we can gain a better understanding of factors that contribute to chronological age differences in work outcomes such as retirement expectations (10,51,83). However, previous research has often lacked validated measures of age beyond the number of calendar years attained, as well as data that can be used to operationalize these dimensions within population-level surveys.

Functional age in the context of employment relates to worker limitations and performance. As individuals age chronologically, they may experience declines in physical (e.g., strength, motor skills) or cognitive (e.g., memory) functioning, as well as the development of chronic conditions that can result in activity limitations (46,84–86). There may be large between-person variations in function within similar chronological age groups. A large number of studies have focused on the role of health status and functioning in explaining age differences in retirement outcomes (14). Yet, studies have found mixed evidence on the role of health factors in predicting earlier versus later retirement expectations. For example, some studies suggest that older workers' retirement plans are not fully explained by self-perceived health status and chronic conditions (12,87), including recent meta-analyses that found only small effect sizes for physical and health-related factors (13,80). One possible explanation for the mixed association between health factors and retirement expectations may be the importance of fit between a person and their job, as well as contextual workplace factors (e.g., job stress) and disability insurance policies, rather than health factors alone (12,13,88,89).

Psychosocial age relates to self and social perceptions of aging. Self-perceptions relate to how old an individual believes that they feel/act/appear to others, in comparison to their perceptions of what they think it means to be a particular chronological age. Social-perceptions relate to how old others appraise an individual to be in terms of their looks, emotions, actions or expressed desires (82). However, some authors have argued that these existing measures of subjective age lack consistency and interpretability (54,90–92) by ignoring the multidimensionality of sub-dimensions within subjective age, as well as the potential impact of confounding variables such as core self-evaluations (e.g., self-esteem, self-efficacy) and perceived work ability. Accordingly, the research on the link between psychosocial age and retirement outcomes is mixed with some studies finding a link between subjective age measures (e.g., felt age, self-perceptions of longer life horizons) and work outcomes such as retirement expectations and work motivation (46,48,57,93,94); and other studies finding that psychosocial factors (91) do not explain age differences in work outcomes once other age-related factors are accounted for (80).

Organizational age relates to the employment trajectory of individuals within jobs or organizations over time (46). Previous studies have measured this construct using indicators for career stage, job tenure or skill obsolescence (46). Given that organizational age is nested within a job or organization at any given time, there may be large variations in what may be deemed "older" or "younger" organizational age depending on the work context (95). Recent studies and systematic reviews (14) have found that organizational age is linked with retirement outcomes. Longitudinal studies by Clarke (96) and Damman (97), for example, found that workers with lower job tenure, as well as those who changed jobs before age 50 years or entered the labour market at an older age, were more likely to expect to retire at a later age.

Finally, *life-stage age* relates to normative and non-normative role changes throughout the life course that may have an impact on behaviour and are often thought to relate to a particular time of life. This age dimension is typically measured by life events such as finishing school, finding a partner, having children, starting a career, labour market experiences of a spouse/partner, caregiving responsibilities for older relatives or a spouse/partner and retirement (46,98). Although life-stage events may correlate with chronological age, there is often variability among the youngest and oldest workers (98). For example, although child rearing tends to occur during middle adulthood, both older and younger workers may have young children (98). Providing health-related care to a spouse/partner often occurs at later ages, although both younger and middle chronologically aged workers may have these responsibilities in addition to older workers

(98). Previous studies have found that life-stage aging plays a strong role in influencing retirement decisions, including factors such as spousal retirement (80,99,100), household dependents (101,102), and caregiving responsibilities (103–107). For example, a study based on data from the Survey of Health, Aging and Retirement in Europe (108) found that having a retired spouse/partner was linked with earlier retirement. A 2001 longitudinal study by Szinovacz (102), based on data from the U.S. National Survey of Families and Households, found that individuals with no financial responsibilities for children were more likely to plan to retire.

2.5.3 Gap 3: Incorporating age dimensions into analytic and measurement models

Operationalizing the model

The dimensions outlined by Sterns and Doverspike (81) provide guidance in understanding the different dimensions of age. However, they do not explicitly address how the dimensions could be operationalized or measured within an analytic model. One approach is to conceptualize different age dimensions as occurring along a mediating pathway between chronological age and retirement expectations or other work-health outcomes (50,51,109). In this approach, age dimensions are treated as intermediate variables, whereby chronological age is presumed to have an impact on age dimensions that are, in turn, presumed to have an impact on subsequent outcomes. This allows for a partitioning of effects into the proportion that would be eliminated after equalizing mediators across chronological age groups (i.e., indirect effects) and the proportion that would remain even if mediators were equalized (i.e., remaining age-related inequalities in work outcomes) (51,109). If these factors lie on the causal pathway, then it would be inappropriate to simply “adjust away” the effect of these factors. Rather, it would be important to quantify the magnitude of each individual pathway as a component of the total effect. See **Figure 2.1** for a path diagram depicting the proposed analytic model.

A strength of this approach is that it shifts the focus away from non-modifiable aspects such as chronological age (51), and instead focuses on disentangling the various changes in biological, cognitive or social functioning within similar chronological age groups (48–50). Moreover, this approach is useful for identifying areas for future intervention research by identifying the underlying pathways through which interventions can be targeted (10,83). In addition, a more holistic approach towards the multiple dimensions of aging can counter the proliferation of pessimistic and fatalistic perceptions about chronologically-older workers (52–54). This method has been used to examine the role of individual sets of clinical or psychosocial factors in explaining chronological age differences in other work and health outcomes such as sickness absence duration, motivation to continue working, and return-to-work (35,46,48,57,91,110,111). However, no studies have examined the role of the age dimensions in explaining retirement and RTW outcomes within one conceptual model to account for both positive and negative relationships with subsequent outcomes (46,112). This has yet to be examined, in part because theoretical and data limitations make assessing and simultaneously incorporating age dimensions challenging (46,97).

Operationalizing the dimensions

The most direct way to measure the above age dimensions would be to incorporate measures using valid and reliable scales developed in previous studies (91,92,113–115). However, these measures are not often available in population-based health surveys (115,116). Moreover, some age dimensions (e.g., psychosocial age) may be challenging to measure, in part due to theoretical limitations (54) and a lack of direct survey questions (92). However, if aspects of age dimensions could be captured by existing indicators, then this would allow for the measurement of age using a broader range of data sources with relevant work outcomes (such as RTW or wage-replacement duration collected within longitudinal cohort studies) in a feasible and efficient way. To date, proxy measures have not been developed or validated in relation to retirement planning or RTW outcomes among injured workers. If there are aspects of age dimensions that could be captured by existing indicators, then this would allow for the measurement of age using data that was not originally collected to directly measure age dimensions (117,118). It is important to note that if age dimensions are not well captured using existing indicators, then the proportion of the effect attributed to the age dimension (i.e., indirect effects in the aforementioned mediation models) would be biased towards the null and underestimated (119). To address these measurement questions and obtain valid estimates of the role of underlying age dimensions, there is a need to assess whether these age dimension indicators are strongly linked with chronological age in expected ways, as proposed in existing theoretical models (46,81).

2.6 Overarching research objectives

The overarching aims of this dissertation were to investigate similarities and differences in work outcomes among older versus younger workers; demonstrate a methodological approach that could be used to create indices of age dimensions using existing data sources that were not originally collected for this purpose; and to better understand whether differences in work outcomes across chronological age groups can be explained via age dimensions. Three original analyses were conducted to address the research gaps and opportunities outlined in Section 2.5:

1) Understand age differences in wage-replacement duration by focusing on variations in the relationship across different periods of follow-up time using administrative claims data from six workers' compensation systems across Canada;

2) Develop and validate a methodological approach that can be used to better understand chronological age differences in retirement expectations using underlying age dimensions (e.g., functional, psychosocial, organizational, life-stage age) using population-based data from the Canadian Longitudinal Study on Aging; and,

3) Examine the role of age dimensions in explaining the overall association between chronological age and RTW/wage-replacement duration outcomes using longitudinal survey data on injured workers in Victoria, Australia, linked with administrative claims data.

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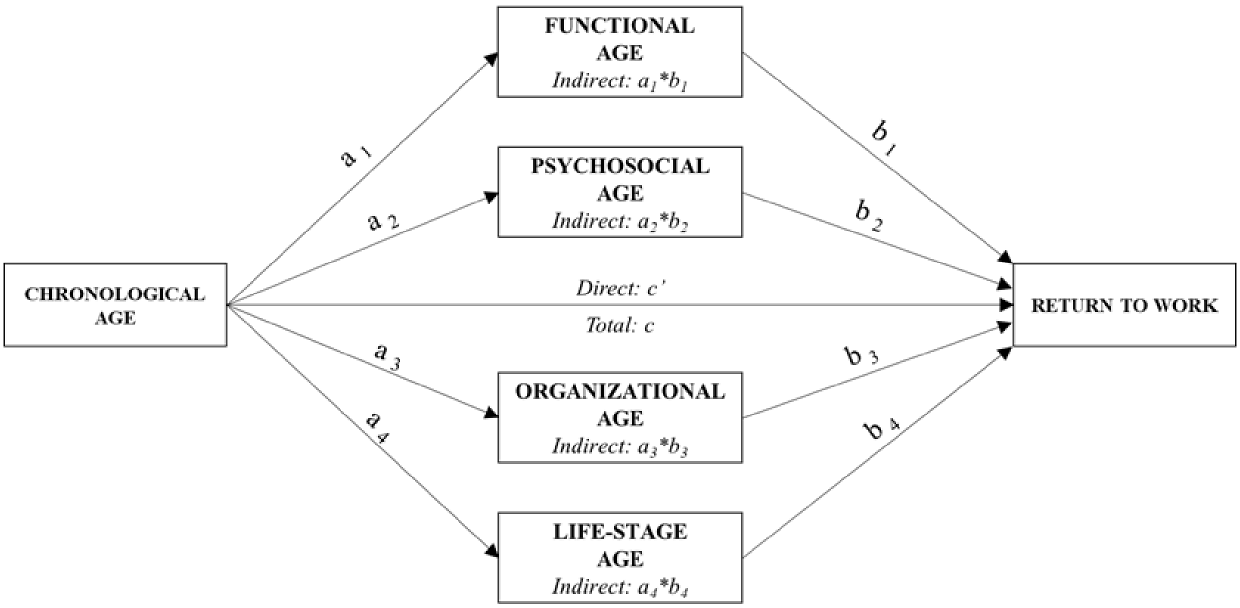
2.8 Tables and figures

Figure 2.1. Path diagram of mediation model examining the relationship between chronological age, *m* mediators (age dimensions) operating in parallel, and return-to-work outcomes.



[1] *Positive estimates for a-paths denote higher (vs. lower) levels of age dimensions with older chronological age (and vice versa).*

[2] *Positive estimates for b-paths denote non-RTW (vs. sustained RTW) with higher levels of age dimensions (and vice versa).*

[3] *Indirect effects are calculated using path tracing rules (product of coefficients a*b).*

[4] *Residual covariances between pairs of mediators are not displayed but are included in model.*

Chapter 3
Data and Methods

3.1 Reader's note

This chapter presents a summary of data sources, research variables, and methodological considerations that are common to each study. The chapter also provides additional information on data analytic considerations that was not included in the standalone manuscripts outlined in Chapter 4. The analytic methods used to address each of the dissertation objectives are listed under each separate research study. See **Table 1.1** (Chapter 1), which presents a summary of research variables used across the three studies.

3.2 Data sources and study design

This research used a combination of survey and administrative data collected from various samples of working-age individuals across Canada and Australia, including: 1) workers' compensation claims data from six provinces in Canada; 2) population-based survey data from the Canadian Longitudinal Study on Aging; and 3) longitudinal survey data on injured workers in Victoria, Australia, linked with workers' compensation claim data. All three analyses were based on observational study designs.

Study #1 was a retrospective cohort study using administrative workers' compensation claims data obtained from six provincial workers' compensation systems: British Columbia (BC), Alberta (AB), Saskatchewan (SK), Manitoba (MB), Ontario (ON) and New Brunswick (NB). Data were available on accepted time-loss claims for work-related injury/illness from 2011 to 2015 with at least one day of time-loss (n = 763,647). Study #2 was a cross-sectional study using data from the Canadian Longitudinal Study on Aging (CLSA), which is a large, national, longitudinal study that focuses on the health and well-being of older Canadians (1). Baseline data (collected over the 2011-2015 period) were available on approximately 51,000 participants aged 45-85 years and living in private dwellings. Study #3 used data from a prospective cohort study that was established to investigate the RTW process for older versus younger workers (2). The sampling frame was based on a population of workers' compensation claimants in Victoria, Australia, aged 18 years and older, who had an accepted claim for psychological or musculoskeletal injury resulting in 10 or more days of work absence. A total of 869 claimants participated in the baseline survey over the 2014-2015 period.

3.3 Measurement

3.3.1 Chronological age

For all three studies, the key explanatory variable was chronological age, defined as the age of the worker in years at time of injury or survey. This variable was operationalized as both a continuous and categorical variable given the potential for non-linear relationships by age (3). Note that chronological age refers strictly to the number of years of age attained and does not capture the developmental process of aging or developmental trajectories that may occur across time within a given respondent. Studies #1, #2 and #3 examined the overall relationship between chronological age and work outcomes.

3.3.2 Age dimensions

In addition to chronological age, other dimensions of age (functional, psychosocial, organizational and life-stage age) were included as mediating variables to better understand the pathways between chronological age and work outcomes (Studies #2 and #3). Survey data were used to operationalize the dimensions of age (functional, psychosocial, organizational and life-stage age). As the two surveys did not specifically set out to measure the dimensions within the Sterns and Doverspike (4) framework, available items were chosen for broad conceptual unity (5) following discussion with study team members, a review of existing studies (6–13), and existing age-related models (e.g., functional items from healthy aging and frailty models) (7,14–17). A total of 8 indicators of functional age, 3 indicators of psychosocial age, a single item for organizational age, and 6 items for life-stage age were selected across the two studies. For each age dimension, a composite measure of age was created by normalizing the response ranges for the individual indicators and then combing them into a summary index variable. Higher scores indicated “more” versus “less” of the age construct (13,18). For example, higher scores for functional age denote having more chronic conditions, greater activity limitations, greater participation restrictions, and lower physical activity levels.

3.3.3 Work outcomes

Three distinct work outcomes were examined across the studies, including wage-replacement duration (Study #1), retirement expectations (Study #2), and RTW (Study #3). As described in Section 2.2, a broad approach was used for the definition of work outcomes by incorporating aspects of both labour market status and work participation (19–22). These concepts relate to a broader conceptualization of working status (19–22), with retirement planning focusing on the long-term planning or expectation process for eventual labour market transitions (such as changes in work hours, careers, employment or work status) (19,23–25); and RTW focusing on the extent of inability to work due to impaired health, functional limitations and participation restrictions (20,26). Each of these measures represents an important dimension of the work-health process with relevance to an aging workforce (20,22).

Return-to-work (RTW) and wage-replacement duration were the primary outcomes of interest for Studies #1 and #3. Given that RTW represents a complex process with recurrences of disability and no defined consensus measure (26,27), a variety of conceptualizations were used in this research: 1) categorical measures of the state of RTW at any given static follow-up period (e.g., working versus not working at 12-months post-injury); 2) time-to-event outcomes (e.g., time to termination of wage-replacement benefits); and 3) cumulative duration of disability (e.g., days of wage-replacement benefits paid to the worker for time off work). RTW outcomes were measured among worker populations who were off work and/or receiving wage-loss or rehabilitation benefits due to a work-related condition.

Retirement expectations were the primary outcome for Study #2. As described in Section 2.2, retirement is a dynamic process that relates to retirement intentions, retirement decision planning and ultimate decision making and realization of retirement (19,23–25,28). Analyses focused on the self-perceived process of retirement planning, which has been referred to by the synonyms of expectations, anticipations, intentions, preferences or plans in previous studies (29). Planned age of retirement was measured in the CLSA with the question “At what age do you plan to retire?”, recorded in years. This operationalization of retirement planning has been used in previous studies (23,29–33). Using a combination of the respondent’s current chronological age and planned age of retirement, participants were classified into one of the following ordinal levels of subjective proximity to retirement: 1 ‘No plans to retire or doesn’t know when they will retire’; 2 ‘Expects to retire in more than 5 years’; 3 ‘Expects to retire within the next 5 years’. Higher scores on the outcome variable denote having plans or expectations to retire in the near future, versus no immediate plans or expectations. Retirement expectations were assessed among individuals who were currently working and not yet fully retired.

3.3.4 Covariates

Study #2 (CLSA) and Study #3 (RTW longitudinal cohort) each contained a wide range of sociodemographic and work characteristics that were used to adjust for statistical confounding. A total of 17 variables were selected for inclusion in the final analytic models across the sum of studies. See **Table 3.1** for a listing of variables. Common variables included in two or more studies were sex, geographic region, and injury type. Work variables such occupation and industry were only available for Study #1. Sociodemographic and health variables such as education, household income, immigrant status, smoking status, and self-rated health were used for Study #2. Job and workplace factors such as union status, work hours and psychosocial work conditions were only available for Study #3. Overall, the data provided for Study #1 (WCB claims) contained a focused set of covariates due to data limitations and the need for harmonization of content across multiple jurisdictions (34).

3.4 Software

For Study #1, survival analyses were completed using Stata/SE 15.0 (College Station, TX), using the suite of survival analysis commands. For Studies #2 and #3, path models were completed using Mplus (Los Angeles, CA), which is a robust latent variable modelling program that can handle a mix of categorical and continuous mediator and outcome variables within one model. Data management was completed using a combination of Stata/SE 15.0 and SAS 9.4 (Cary, NC).

3.5 Ethical approval and data access

Ethical approval for the dissertation was obtained from the University of Toronto Research Ethics Board, in addition to the existing ethical approval obtained for each overarching data collection project. As all three dissertation studies utilize existing data sources with no ongoing enrollment of study subjects by the research team, the main harm to participants relates to potential disclosures of personal information or breaches in practices relating to privacy and confidentiality. As such, data were not handled or reported in any way that could lead to secondary disclosure of participant identity. Access to survey and claim identifiers was limited to technical staff, with the research extract containing only anonymous identifiers. The full data repository was stored on secure servers, accessible only to approved study team members.

For Study #1, the overarching research initiative was supported by a Canadian Institutes for Health Research Operating Grant 'Return to work after work injury and illness: An international comparative effectiveness study of Canada, Australia and New Zealand' (Application Number 326940) and by the Research and Workplace Innovation Program of the Workers Compensation Board of Manitoba. Data storage and access services were provided by Population Data BC (Vancouver, Canada).

For Study #2, the research was made possible using data collected by the Canadian Longitudinal Study on Aging (CLSA). Funding for the Canadian Longitudinal Study on Aging (CLSA) is provided by the Government of Canada through the Canadian Institutes of Health Research (CIHR) under grant reference: LSA 9447 and the Canada Foundation for Innovation. This research has been conducted using the CLSA datasets Baseline Tracking version 3.3 and

Baseline Comprehensive version 3.2, under Application Number 171006. The CLSA is led by Drs. Parminder Raina, Christina Wolfson and Susan Kirkland.

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3.7 Tables and figures

Table 3.1. Summary of variables used for final analytic models across studies/data sources.

Type	Name	Measurement	WCB	CLSA	RTW
Chronological age	Age of worker	Continuous; grouped	X	X	X
Functional age	Chronic conditions	Ordinal		X	X
	Activity limitations	Ordinal		X	
	Participation restrictions	Ordinal		X	
	Pain limitations	Ordinal		X	
	ADL limitations	Binary		X	
	Physical activity	Continuous		X	
	Change in driving abilities	Binary		X	
	Work activity limitations	Ordinal			X
Psychosocial age	Self-rated own healthy aging	Binary		X	
	Feeling hopeful about the future	Binary		X	
	Influence of age on recovery	Ordinal			X
Organizational age	Years of job tenure	Ordinal		X	X
Life-stage age	Children living in household	Binary		X	X
	Dwelling ownership status	Ordinal		X	
	Spousal caregiving	Binary		X	
	Spousal retirement status	Binary		X	
	Years lived in community	Ordinal		X	
	Spousal work status	Binary			X
Confounders	Sex	Male, female	X	X	X
	Geographic region	Broad regions	X	X	
	Year of injury	2011 to 2015	X		
	Occupation	NOC	X		
	Industry	NAICS	X		
	Injury type	Broad groupings	X		X

	Education level	Categorical		X	
	Household income	Categorical		X	
	Immigrant status	Yes/No		X	
	Smoking status	Categorical		X	
	Self-rated general health	Categorical		X	
	Self-rated mental health	Categorical		X	
	Interview sample	Categorical		X	
	Unionization status	Yes/No			X
	Work hours	Ordinal		X	X
	Psychosocial conditions	Continuous			X
	Injury severity	Yes/No			X
Outcomes	Wage-replacement	Continuous; survival	X		X
	Retirement planning	Imminent plans (vs. not)		X	
	Return-to-work	Sustained RTW (vs. not)			X

1 WCB = Workers' compensation claims data from 6 Canadian provinces.

2 CLSA = Canadian Longitudinal Study on Aging baseline data.

3 RTW = Return-to-work longitudinal cohort in Victoria, Australia.

Chapter 4
Research Studies

4.1 Study 1: Age differences in work-disability duration across Canada: Examining variations by follow-up time and context

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Original Article Accepted in *Journal of Occupational Rehabilitation*

4.1.1 Reader's note

This paper aimed to understand age differences in wage-replacement duration by focusing on variations in the relationship across different periods of follow-up time. The paper uses administrative claims data provided by six workers' compensation systems in Canada, focusing on time-loss claims for workers aged 15-80 years with a work-related injury/illness during the 2011 to 2015 period. The paper was accepted in the *Journal of Occupational Rehabilitation* (#JOOR-D-19-00228).

4.1.2 Acknowledgements

Data access and storage services were provided by Population Data BC (University of British Columbia, Vancouver, Canada). The full data repository was located on a secure server, accessible only via encrypted remote access. Research extracts were provided to the research team in de-identified format. Access to the data for research purposes was made possible through project-specific research agreements with the respective data stewards. Ethical approval for the current study was obtained from the University of Toronto Health Sciences Research Ethics Board (Certificate 36039). The overarching research initiative was approved by the University of British Columbia Behavioural Research Ethics Board (#H13-00896), and was supported by a Canadian Institutes for Health Research Operating Grant 'Return to work after work injury and illness: An international comparative effectiveness study of Canada, Australia and New Zealand' (Application Number 326940) and by the Research and Workplace Innovation Program of the Workers Compensation Board of Manitoba. Data were provided by WorkSafeBC, Workers' Compensation Board of Alberta, Saskatchewan Workers' Compensation Board, Workers' Compensation Board of Manitoba, Workplace Safety and Insurance Board (Ontario), and WorkSafeNB. All inferences, opinions, and conclusions drawn in this paper are those of the authors, and do not reflect the opinions or policies of the Data Steward(s).

4.1.3 Abstract

Purpose: This study aimed to understand age differences in wage-replacement duration by focusing on variations in the relationship across different periods of follow-up time.

Methods: We used administrative claims data provided by six workers' compensation systems in Canada. Included were time-loss claims for workers aged 15-80 years with a work-related injury/illness during the 2011 to 2015 period (n = 751,679 claims). Data were coded for comparability across cohorts. Survival analysis examined age-related differences in the hazard of transitioning off (versus remaining on) disability benefits, allowing for relaxed proportionality constraints on the hazard rates over time. Differences were examined on the absolute (hazard difference) and relative (hazard ratios [HR]) scales.

Results: Older age groups had a lower likelihood of transitioning off wage-replacement benefits compared to younger age groups in the overall models (e.g., 55-64 vs. 15-24 years: HR 0.62). However, absolute and relative differences in age-specific hazard rates varied as a function of follow-up time. The greatest age-related differences were observed at earlier event times and were attenuated towards a null difference across later follow-up event times.

Conclusions: Our study provides new insight into the workplace injury/illness claim and recovery processes and suggests that older age is not always strongly associated with worse disability duration outcomes. The use of data from multiple jurisdictions lends external validity to our findings and demonstrates the utility of using cross-jurisdictional data extracts. Future work should examine the social and contextual determinants that operate during various recovery phases, and how these factors interact with age.

4.1.4 Background

A large body of research has examined age-related similarities and differences in return to work (RTW) following a workplace injury (1–6). Although older age has been linked with positive health and well-being outcomes (1), studies find that older age tends to be associated with negative RTW outcomes such as delayed time to RTW, greater duration of sickness absence, and more frequent disability recurrences following work-related injury (2–6). Accordingly, a small subset of studies have examined the underlying factors that are responsible for the differences across age groups, including factors like chronic disease, job tenure, and injury severity are accounted for (1,2,5,6). A study from the Canadian province of British Columbia using workers' compensation data (2) found that age differences in the prevalence of pre-existing chronic health conditions partly explained why older age was associated with a greater duration of sickness absence. A study of time-loss injury claimants in the United States state of New Hampshire (1) found that age differences in RTW were not significant after adjustment for injury severity, injury-related surgery and physical functioning scores. In contrast, studies of workers' compensation claimants in Australia (5) and the United States (6) found that age differences in wage-replacement duration were not attenuated to a great extent after accounting for factors such as injury severity or job tenure, and that older age remained strongly associated with greater duration of sickness absence.

Taken together, these studies suggest that various clinical, functional or physiological factors may not fully account for age differences in wage-replacement duration, and that there are remaining research gaps in our understanding of age differences in work outcomes. One contextual factor that has been largely overlooked in research studies on age and work-disability duration is the potential impact of the phase of recovery (7,8). The process of recovery following a work-related injury or illness is complex. Within the workers' compensation system, the process is embedded not only within health needs and treatment, but also within organizational and social contexts that may change over time (8–10). Thus, to the extent that time serves as a marker or proxy for these contextual factors (7,8), we might expect a differential impact on the relationship between age and disability duration depending upon the phase of recovery (i.e., time-varying age effects). For example, a study by Krause (11) found that physical and psychological job demands were associated with greater work disability duration across all phases of disability; whereas factors such as low job control, high job strain, and low work scheduling flexibility were relevant during the later phases of recovery. The authors hypothesized that greater control over job and work scheduling facilitated an earlier RTW. A systematic review by Steenstra (12), examining prognostic factors for the duration of sick leave among workers off-work due to low back pain, found that recovery expectations were most important during the later phases of recovery. Other studies (11–17) suggest that psychosocial or claim-related factors are more strongly associated with work disability duration during the later phases of recovery, but less so during earlier phases. Finally, system-level factors, such as limitations in access to or adequacy of benefits at the tail ends of follow-up, might incentivise workers to RTW during later phases of recovery (18–20).

Recent economic policies have aimed to promote the retention of older workers in the labour market in order to retain critical skills, transfer knowledge to newer employees, and balance the labour supply for the coming decades (21–23). This is within the context of a shifting disability burden of compensated claims for work-related injuries and diseases among older workers in Canada and elsewhere (24). From a policy perspective, it is important to understand the time-varying nature of RTW rates to determine the optimal timing for interventions (7,25,26) and to identify individuals that may require early interventions or workplace supports (27–31). Moreover, if the phase of recovery is a modifier of age–duration relationships, reliance on a single summary measure (e.g., hazard ratio from a Cox proportional hazards model) may not provide a meaningful interpretation because hazards are not proportional (7,32). Despite this, most studies have ignored the potential for time-varying estimates and report instead on a single, pooled summary measure that assumes a constant association across follow-up time points (7,26). By testing for unique variations across the entire range of disability follow-up time, we gain potentially important nuances and contextual information on situations in which older workers fare better or worse compared to younger workers (27,28). Moreover, recent initiatives in the development of multi-jurisdictional workers' compensation claims databases for research purposes (16,24,33,34) provide an opportunity to assess the generalizability of findings across settings.

Using a large dataset of claims records from six workers' compensation systems across Canada, this study aimed to better understand age-related similarities and differences in wage replacement duration following a work-related injury by investigating whether age differences varied across earlier versus later periods of follow-up time (as an indicator of the phase of recovery). We hypothesized there would be an age-related gradient in disability duration, with older age groups having greater disability duration compared to younger age groups. However, based on earlier studies examining time-varying effects of age on disability duration (13,14,26,35), we anticipated that the relationship between age and disability duration would differ depending on follow-up time with age differences being attenuated during later periods of follow-up.

4.1.5 Methods

Data sources and study population

This study used claim-level data provided by six provincial workers' compensation systems in Canada: WorkSafeBC (Workers' Compensation Board of British Columbia; BC), WCB Alberta (Workers Compensation Board – Alberta; AB), WCB Saskatchewan (Saskatchewan Workers' Compensation Board; SK), WCB Manitoba (Workers Compensation Board of Manitoba; MB), WSIB Ontario (Workplace Safety and Insurance Board; ON), and WorkSafeNB (Workplace Health, Safety and Compensation Commission of New Brunswick; NB). In Canada, workers' compensation systems operate at the provincial-level based on a principle of no-fault, cause-based insurance (36). Core operating funds for these systems are provided through employer premiums paid to the compensation authority. The employed workforce covered under these systems ranges from approximately 70% to 99% across jurisdictions (37). Using these data, we created comparable analytic cohorts with harmonized research variables as part of an overarching research initiative, described in more detail elsewhere (16).

Inclusion criteria were accepted time-loss claims for work-related injury/illness from 2011 to 2015 with at least one day of time-loss (N=763,647); and aged 15 to 80 years at time of injury (N=762,750). We excluded observations with missing data on study covariates, including sex, occupation and industry (N=11,071, 1.5%), which resulted in a final analytic cohort of N=751,679 claims.

Measures

The primary outcome was wage-replacement duration, defined as the cumulative number of days paid to the injured worker for temporary disability benefits as a result of time off work. Wage-replacement days were ascertained over a 1-year calendar period. Days were standardized to a 5-day work week and then right-censored at 260 days, per methodology developed for a previous research initiative (16). We note that most individuals would have returned to work within this study period of interest. Consistent with previous studies, we conceptualized wage-replacement days as a proxy measure for time to cessation of benefits (14,34,38), with the caveat that days may be accumulated non-consecutively. This variable has been described as an appropriate indicator of the overall burden of work disability duration among studies based solely on administrative claims data (38).

Our primary explanatory variable was age at time of injury, measured in calendar years and grouped for analysis (15-24, 25-34, 35-44, 45-54, 55-64, 65+). Covariates used for analyses included: province of claim submission (BC, AB, SK, MB, ON, NB); sex (male, female); occupation; industry; nature of injury; and year of injury (ranging from 2011 to 2015). Occupation and industry were harmonized to the 2006 National Occupation Classification and 2012 North American Industry Classification System, respectively. Nature of injury was coded to Canadian Standards Association Z795 codes and aggregated into the broad groupings of musculoskeletal disorders (MSD) versus non-MSD. MSDs were further classified into soft-tissue versus fracture injuries (16).

Analyses

Descriptive statistics compared the distribution of injured worker characteristics across age groups. We used survival regression models to examine age-related differences in the hazard of transitioning off wage-replacement benefits comparing a given age group to the youngest age group (15-24 years) as the reference category. Hazard, in the context of our study, refers to the instantaneous rate of exit from wage-replacement benefits at a specific time point, given that the individual has remained on benefits until that time. Hazard ratios (HR) greater than ‘1’ denote a more rapid transition off benefits (e.g., shorter disability duration) for a given age group compared to the reference age group; whereas HRs less than ‘1’ denote a slower transition off benefits (e.g., longer disability duration).

To examine whether age differences in wage-replacement duration varied across earlier versus later phases of follow-up time, we used flexible parametric survival models (32), which incorporate non-linear time transformations that allow for the continuous estimation of the baseline hazard function. These non-linear time transformations (via restricted cubic splines) were then interacted with age to estimate hazard ratios at specific follow-up event times, thus allowing for non-proportional hazard specifications. We examined both absolute and relative differences in hazard rates to provide additional nuance into the time-varying relationships between age and disability duration (7,32,39,40).

All analyses were completed with Stata/IC 15 (College Station, TX). Flexible parametric survival models were run using the ‘stpm2’ package. Model estimates for flexible parametric survival models are robust to different specifications for the functional form of time-varying hazards (32). To define the functional shape of the splines, we placed two interior knots at the 33^{rd} and 67^{th} percentiles of the distribution of uncensored log survival times (for the baseline hazard function) and four interior knots at the 25^{th}, 50^{th}, 75^{th} and 90^{th} centiles of the distribution of uncensored log survival times (for the age-by-time interactions). All models were adjusted for the full set of covariates, described above.

4.1.6 Results

Table 4.1.1 presents the distribution of selected study variables, calculated overall and by age group. The majority of the cohort had soft-tissue MSDs (63%); were employed in trades & transport (35%) or sales & service (26%) occupations; and/or were male (62%). The frequency of compensation claims was stable over the study period. The majority of the cohort was comprised of claims from BC (32%) and ON (32%), with the smallest proportions from SK (6%) and NB (3%). By age group, there were notable differences in the distribution of claims by sex, injury type, industry and injury year.

[Table 4.1.1 about here]

Table 4.1.2 presents the unadjusted median days of wage-replacement across age groups. There was an age-related gradient with older age groups having a greater median number of days compared to younger age groups (ranging from 5 days among the youngest age group to 17 days among the oldest age group). The relative variation in median days ranged from 3 to 4 times greater, comparing the oldest versus youngest age groups. The absolute difference was 12 days, comparing the oldest versus youngest age groups.

[Table 4.1.2 about here]

Figure 4.1.1 presents descriptive information on the proportion of individuals who were still receiving wage-replacement benefits at specific follow-up event times, by age group. After 5 work days of follow-up (approximately 1 calendar work week), the proportion of individuals still receiving wage-replacement ranged from 49% among the 15-24 age group to 71% among the 65+ age group. By 130 work days of follow-up (6 calendar months), the proportion ranged from

2% among the 15-24 age group to 11% among the 65+ age group. By the end of 1-year of follow-up, less than 3% of individuals within each age group were still on benefits.

[Figure 4.1.1 about here]

Figure 4.1.2 present the adjusted hazard rates of transitioning off benefits per 100 workers (Panel A), the differences in hazard rates (Panel B), and the ratios of hazard rates across age groups (Panel C), derived from the flexible parametric models that allowed for non-proportional hazards for the estimates of age. Estimates are based on data pooled across provinces and adjusted for the full set of covariates. **Appendix 4.1.1** presents the accompanying model coefficients (with 99% confidence intervals) for various follow-up event times.

Overall, the rate of exit from wage-replacement (**Figure 4.1.2, Panel A**) was greatest in the initial few weeks of follow-up, followed by a decrease in the first calendar month and then a gradual decline to approximately 2 to 5 wage-replacement exits per 100 workers. The relative ordering of hazard functions for each age group was consistent during the initial follow-up periods, with the youngest age groups (compared to the oldest age groups) having the highest rate of exit.

The greatest absolute and relative differences (**Figure 4.1.2, Panels B and C**) were observed for claims that received up to 20 work days of wage-replacement benefits. For example, among individuals who remained on benefits for 5 work days (approximately 1 calendar week), those aged 55-64 years had an absolute difference of 11.4 fewer exits (per 100 workers) and a relative difference of HR 0.52 (99% CI: 0.51, 0.53), compared to those aged 15-24 years. However, by 20 work days of follow-up (approximately 1 calendar month), the absolute difference attenuated to less than 3.0 exits per 100 workers while the relative difference attenuated to HR 0.64 (99%

CI: 0.62, 0.65). By approximately 145 and 220 work days of follow-up (7 to 10 calendar months), the age-specific hazard functions converged due to an ‘accelerating’ decline in the exit rate among younger workers and a ‘decelerating’ decline in the exit rate among older workers. As a result, the age difference in hazard rates on the absolute and relative scales further attenuated towards a null difference of '0' (for absolute differences in rates) and '1.00' (for relative differences in rates) at later follow-up times. For comparison, the time-constant hazard ratio, assuming proportional hazards across the entire length of follow-up, was HR 0.62 (99% CI: 0.61, 0.62) for ages 55-64 vs. 15-24 years.

[Figure 4.1.2 about here]

4.1.7 Discussion

This study aimed to better understand age-related similarities and differences in wage-replacement duration by examining this relationship across earlier versus later periods of follow-up time as an indicator of the phase of recovery. The research is novel in its focus and in using a large and comprehensive source of data while addressing existing methodological limitations in the analysis of wage-replacement duration outcomes. Our study has two main findings. First, we observed that older age groups exited wage-replacement benefits at a slower rate (i.e., greater disability duration) compared to younger age groups in our initial models. Second, we found unique patterns in these age-related associations depending upon follow-up time. As follow-up progressed, hazard rates for older and younger workers converged, suggesting an interaction between age and time since injury. The overall pattern of time-varying age differences was present using our cross-jurisdictional dataset, lending external validity to our findings. Together, these findings suggest that age differences in wage-replacement duration may not be ubiquitous across all contexts and that there may be social and contextual determinants that operate during various recovery phases that are important to understand.

Time-varying hazards

Previous studies examining the time-varying effects of age (13,26) have found that the relationship between age and length of disability differs across acute versus chronic phases of the recovery process, with the greatest differences observed during the earlier phases followed by a diminishing effect of age over time. These studies focused on restricted samples with selected injury conditions, while using less flexible analytic methods to model the complexity of time-varying estimates across phases of recovery (7). Our findings are consistent with these previous studies but extend the existing literature by improving upon the estimation of time-varying effects of age (32) and using a broader sample of compensation claimants.

As noted earlier, one possible explanation for the time-varying hazards is that time serves as a marker for unique contextual or workplace factors that play a differential role depending on the phase of recovery (4,12). If these mechanisms operate primarily during earlier versus later phases of the claim process (7,8), then this might explain the large differences in hazard rates between age groups during the initial phases of follow-up. For example, previous systematic reviews of workplace interventions suggest that offers of modified duties and early contact with care providers may be important factors that facilitate the RTW process following work-related injury and disability (29–31). The importance of early intervention has been noted in previous studies, and fits with a phase-specific conceptualization of RTW (8–10). Yet, previous research examining workers' compensation claimants (41) found that older workers may be less likely to receive offers of modified work duties compared to younger workers. Thus, to the extent that the older workers have reduced control over job or work scheduling during the initial phases of follow-up (11), we might expect to see differences in the impact of these factors among older versus younger workers. On the other hand, system-level factors, such as limitations in access to, or adequacy of, benefits at the tail ends of follow-up, might incentivise workers to RTW at an increasingly faster rate over time (18). For example, a recent study (18) found that the amount of lost income due to work-related injury increased as time off work progressed, and that the decline in income over time was greater among the oldest age groups. If these economic consequences lead to incentives to RTW (19), then this might explain the ‘decelerating decline’ in wage-replacement exit rates over time among older versus younger workers. Alternatively, factors such as higher job satisfaction and workplace attachment (1) may have provided a relative advantage to older workers during the later phases of the RTW process. Nevertheless, the reduced differences at later phases among both older and younger workers suggests that once workers remain off work for longer periods, they are likely to remain off work, regardless of age.

Important to note is that we conceptualized the cessation of wage-replacement payments as a terminal event that demarcated the end of a disability episode following a work-related injury, which is in keeping with previous studies [42]. However, this may be a poor indicator for an actual recovery or RTW event given the existence of competing risks, such as commencement of other benefit programs or services (e.g., vocational rehabilitation, long-term disability), labour market exit, or claim termination (e.g., being deemed capable of returning to work with no actual return) (38). Alternatively, workers may be receiving temporary disability benefits but have actually returned to work in some capacity. Although early and safe RTW may be beneficial for health outcomes such as functional recovery following back injury (42), the early termination of benefits may not necessarily imply better outcomes from a broader RTW perspective (43).

Future work could examine other conceptualizations of disability duration (38) and confirm whether age differences persist (or attenuate) beyond the point of censoring in our study.

Taken together, our findings suggest that older age may not always be strongly associated with duration of wage-replacement and that the time-varying nature of risk estimates should be considered when examining the potential burden and impact of increased duration of wage-replacement. From a policy perspective, the time-varying nature of RTW provides information on optimal timing points for interventions (7,25,26) given that the relationship may vary in magnitude across the duration of recovery. Specifically, the largest absolute differences in hazard rates between age groups was observed within the first few weeks of receiving wage-replacement, followed by smaller absolute differences at later follow-up times that amounted to only two to three exits per 100 workers. Thus, applied work interventions, workplace supports or multi-component interventions for older workers (20,27–31) might be targeted towards this period of greatest absolute risk to maximize the potential public-health impact among specific age groups (40). These interventions may include vocational rehabilitation and claims management activities, such as return-to-work planning, worker education/training or modified work duties (30,41). From a methodological perspective, if the phase of recovery serves as a modifier of the relationship between age and disability duration, then the reliance on a single summary measure of risk (e.g., hazard ratio from a Cox proportional hazards model) may not provide a meaningful interpretation due to non-proportional hazards. Future studies should continue to examine the potential for time-varying effects across follow-up, given the availability and accessibility of methods (7,32). Finally, the finding that age differences may be contextually dependent would suggest that a fatalistic view of older workers may not be warranted (44,45); that we need greater understanding of social and contextual determinants of age in relation to

RTW (7,8); and that concerns about older workers having greater sickness absence duration or claim costs (43) may require further study that is contextually-sensitive.

Strengths and limitations

A key strength of this study was the opportunity to combine claim-level data on injured workers from six provincial-level compensation systems in Canada. Our methods accounted for time-varying relationships by considering both absolute and relative age effects. Comparisons of additive differences in hazard rates remain underutilized in previous studies (7,32). Moreover, we estimated the time-varying nature of these estimates across the entire range of follow-up to provide a balanced understanding of overall age differences (7,32). The attenuated age gradients that we observed might not have been recognized had we relied only on a single summary measure of effect. Finally, the presence of time-varying age differences using data across multiple jurisdictions lends external validity to our findings.

Our study also had limitations. The findings for time-varying hazards may be impacted by spurious duration dependence (46), whereby the population of claimants still on benefits may contain an increasingly smaller proportion of those who exit benefits at a faster rate and a growing proportion of those who exit benefits at a slower rate, resulting in a selected population with lower overall hazard rates and potential unobserved heterogeneity. At the population-level, distinguishing between true time-varying processes and unobserved heterogeneity is limited due to model identification issues (46). The measure of wage-replacement duration was based on the cumulative number of days paid to the injured worker for temporary disability benefits as a result of time off work. Given that individuals may experience multiple recovery attempts throughout the course of recovery (3), this might have underestimated the total duration of disability following work injury if there were large gaps between payments or if days were accumulated towards the end of follow-up. Nevertheless, our outcome of cumulative days paid has been described as an appropriate option to convey the overall burden of work disability based on administrative claims data (38). Future work should consider the role of these alternative explanations when examining time-varying age gradients in disability duration. Finally, given the use of multi-jurisdictional administrative claims data with different data collection systems, we could only examine a selected range of harmonized variables across provinces. However, there may be other unmeasured variables that could bias the results, including physical or psychosocial work conditions, injury severity or job tenure (4–6,11,13).

Conclusions

In this multi-jurisdictional study of workers' compensation claimants, we observed that absolute and relative differences in age-specific hazard rates of cessation of wage replacement varied as a function of follow-up time. This may have relevance for the development of targeted interventions, such as case management activities, return-to-work planning, worker education/training or modified work duties. For example, workplace supports or multi-component interventions for older workers could be targeted towards the earlier phases of the process where the hazard differences may be greatest. Future research on the different contextual factors that operate during early versus later phases of recovery, and how these factors interact with age, may help to understand why older age is strongly associated with greater duration of wage-replacement when examined overall, but perhaps less so once the differences are considered within the entirety of the recovery process.

4.1.8 References

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4.1.9 Tables and figures

Table 4.1.1. Distribution of study covariates by age group. WCB claims, 2011-2015.

		Age group (years)		
	Total	**15-34**	**35-54**	**55+**
	N (col. %)	***N (col. %)***	***N (col. %)***	***N (col. %)***
Province				
British Columbia	243,222 (32.4%)	83,323 (32.5%)	116,469 (32.1%)	43,430 (32.8%)
Alberta	129,808 (17.3%)	48,955 (19.1%)	58,753 (16.2%)	22,100 (16.7%)
Saskatchewan	44,629 (5.9%)	16,277 (6.4%)	20,781 (5.7%)	7,571 (5.7%)
Manitoba	70,565 (9.4%)	25,605 (10.0%)	33,779 (9.3%)	11,181 (8.4%)
Ontario	239,084 (31.8%)	75,342 (29.4%)	120,402 (33.2%)	43,340 (32.7%)
New Brunswick	24,371 (3.2%)	6,486 (2.5%)	12,979 (3.6%)	4,906 (3.7%)
Sex				
Male	465,327 (61.9%)	172,298 (67.3%)	215,697 (59.4%)	77,332 (58.4%)
Female	286,352 (38.1%)	83,690 (32.7%)	147,466 (40.6%)	55,196 (41.6%)
Occupation (NOC) [a]				
Management	17,720 (2.4%)	4,397 (1.7%)	9,652 (2.7%)	3,671 (2.8%)
Business, finance, admin.	47,874 (6.4%)	12,080 (4.7%)	26,051 (7.2%)	9,743 (7.4%)
Natural/applied sciences	13,181 (1.8%)	4,380 (1.7%)	6,575 (1.8%)	2,226 (1.7%)
Health	82,292 (10.9%)	21,188 (8.3%)	45,868 (12.6%)	15,236 (11.5%)
Social sciences	33,044 (4.4%)	9,970 (3.9%)	17,128 (4.7%)	5,946 (4.5%)
Art, culture, rec., sport	4,748 (0.6%)	2,000 (0.8%)	1,980 (0.5%)	768 (0.6%)
Sales, service	195,188 (26.0%)	70,307 (27.5%)	88,791 (24.4%)	36,090 (27.2%)
Trades, transport	264,874 (35.2%)	96,273 (37.6%)	123,979 (34.1%)	44,622 (33.7%)
Primary industry	23,109 (3.1%)	10,561 (4.1%)	9,402 (2.6%)	3,146 (2.4%)
Processing, manufacturing	69,649 (9.3%)	24,832 (9.7%)	33,737 (9.3%)	11,080 (8.4%)

Industry (NAICS) [b]				
Natural resources and mine.	24,310 (3.2%)	10,058 (3.9%)	10,549 (2.9%)	3,703 (2.8%)
Construction	89,640 (11.9%)	42,852 (16.7%)	36,442 (10.0%)	10,346 (7.8%)
Manufacturing	100,771 (13.4%)	33,315 (13.0%)	50,143 (13.8%)	17,313 (13.1%)
Trade, trans., and utils.	191,981 (25.5%)	65,673 (25.7%)	90,568 (24.9%)	35,740 (27.0%)
Information	6,652 (0.9%)	1,701 (0.7%)	3,721 (1.0%)	1,230 (0.9%)
Financial activities	8,132 (1.1%)	2,093 (0.8%)	3,983 (1.1%)	2,056 (1.6%)
Professional and bus. serv.	31,488 (4.2%)	12,206 (4.8%)	13,959 (3.8%)	5,323 (4.0%)
Education and health serv.	151,599 (20.2%)	33,781 (13.2%)	84,335 (23.2%)	33,483 (25.3%)
Leisure and hospitality	59,338 (7.9%)	30,940 (12.1%)	20,747 (5.7%)	7,651 (5.8%)
Other (including public)	87,768 (11.7%)	23,369 (9.1%)	48,716 (13.4%)	15,683 (11.8%)
Injury type [c]				
Non-MSD	211,694 (28.2%)	90,196 (35.2%)	88,936 (24.5%)	32,562 (24.6%)
MSD soft tissue	475,753 (63.3%)	146,911 (57.4%)	245,374 (67.6%)	83,468 (63.0%)
MSD fractures	64,232 (8.5%)	18,881 (7.4%)	28,853 (7.9%)	16,498 (12.4%)
Injury year				
2011	153,468 (20.4%)	51,526 (20.1%)	77,067 (21.2%)	24,875 (18.8%)
2012	152,277 (20.3%)	51,980 (20.3%)	74,680 (20.6%)	25,617 (19.3%)
2013	150,770 (20.1%)	51,213 (20.0%)	72,815 (20.1%)	26,742 (20.2%)
2014	150,503 (20.0%)	51,359 (20.1%)	71,339 (19.6%)	27,805 (21.0%)
2015	144,661 (19.2%)	49,910 (19.5%)	67,262 (18.5%)	27,489 (20.7%)
	751,679	*255,988*	*363,163*	*132,528*

[a] *NOC = National Occupation Classification, by major groups.*

[b] *NAICS = North American Industrial Classification System, by supersector.*

[c] *MSD = musculoskeletal disorder.*

Table 4.1.2. Unadjusted median days of cumulative wage-replacement (with interquartile ranges), by age group. WCB claims, 2011-2015.

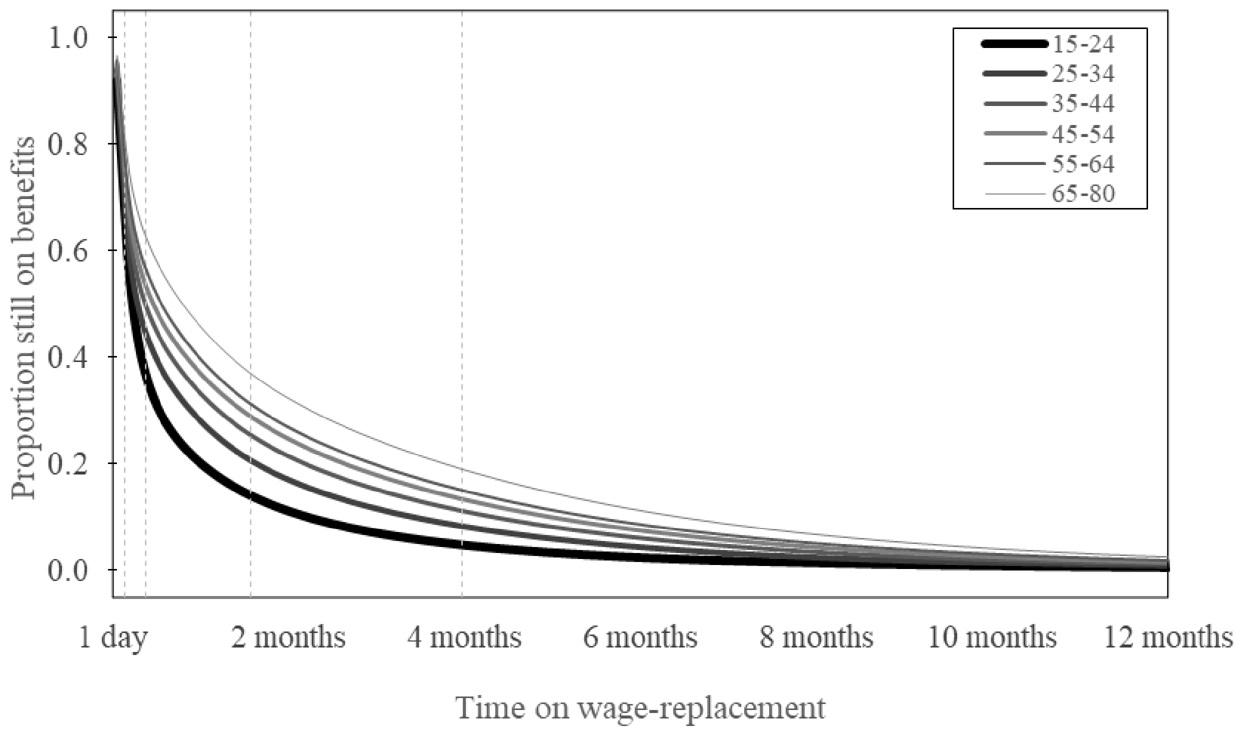
	Med. (IQR) [a]	***Diff.*** [a]	***Ratio*** [b]
Age group			
15-24	5 (2 to 16)	0 (ref.)	1 (ref.)
25-34	6 (2 to 27)	1	1.2
35-44	8 (3 to 36)	3	1.6
45-54	10 (3 to 43)	5	2.0
55-64	12 (3 to 48)	7	2.4
65+	17 (4 to 62)	12	3.4
Overall median (IQR)	8 (3 to 35)		
Overall mean	31 days		

[a] *Days are standardized work days and are not raw calendar counts.*

[b] *Differences >0 correspond to greater days for given age group compared to reference group.*

[c] *Ratios >1.00 correspond to greater days for given age group compared to reference group.*

Figure 4.1.1. Unadjusted survivor function showing the proportion of individuals still receiving wage-replacement benefits at specific follow-up event times, by age group. WCB claims, 2011-2015.

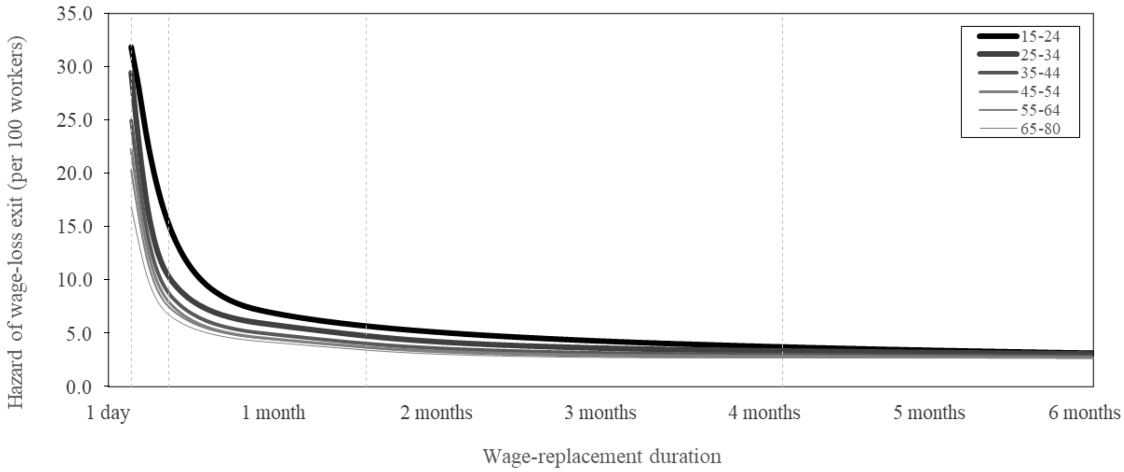


[a] *Estimated using flexible parametric models to allow for time-varying hazards across the distribution of event times. Interior knots for flexible parametric models are placed at the 25th, 50th, 75th and 90th centiles of the distribution of uncensored log survival times (5 degrees of freedom), denoted on the graph by dashed vertical lines.*

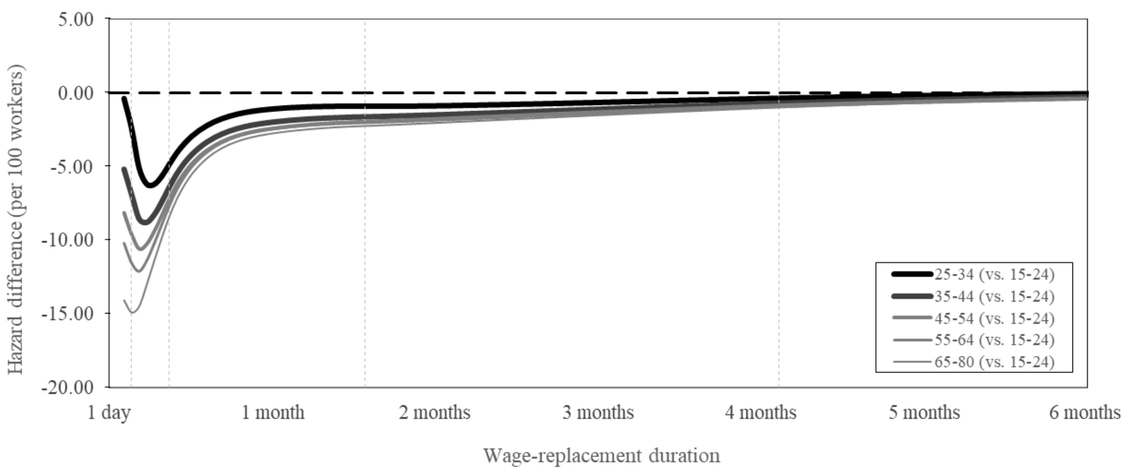
[b] *Days are standardized across provinces.*

Figure 4.1.2. Adjusted hazard rates (Panel A), rate differences (Panel B) and rate ratios (Panel C) for the event of transitioning off benefits, by age group. WCB claims, 2011-2015.

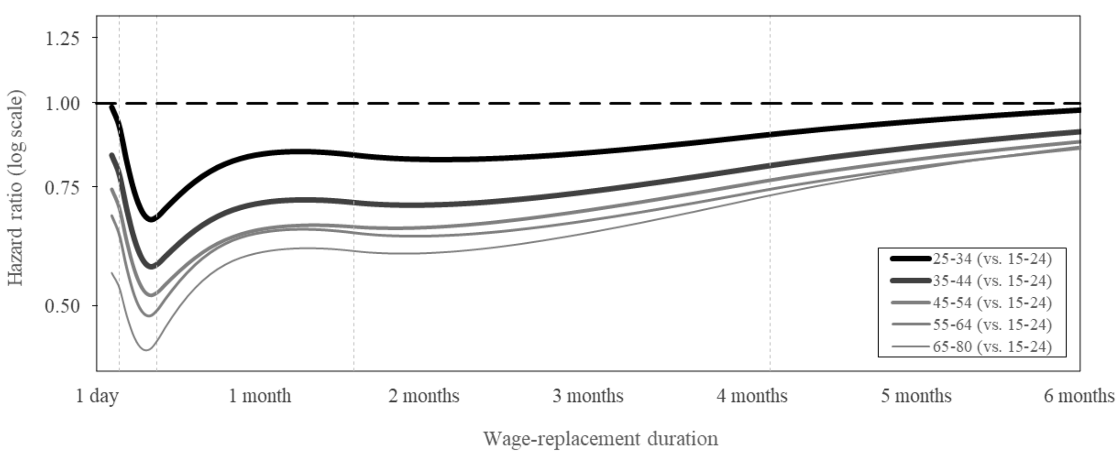
A) HAZARD RATES:



B) HAZARD DIFFERENCES:



C) HAZARD RATIOS:



[a] *Models are adjusted for: age, sex, province, occupation, industry, injury type, and injury year.*

[b] *Estimated using flexible parametric models to allow for time-varying hazards across the distribution of event times. Interior knots for flexible parametric models were placed at the 25th, 50th, 75th and 90th centiles of the distribution of uncensored log survival times (5 degrees of freedom), denoted on the graph by dashed lines.*

[c] *Differences <0 correspond to longer duration for given age group compared to reference.*

[d] *Ratios <1.00 correspond to longer duration for given age group compared to reference.*

[e] *Days are standardized across provinces.*

[f] *Graphs display up to 6 calendar months of follow-up.*

Appendix 4.1.1. Adjusted hazard rates, rate differences and rate ratios for the event of transitioning off benefits, by age group and follow-up event time. WCB claims, 2011-2015.

A) HAZARD RATES PER 100 WORKERS (99% CI):

Age group	1 week	1 month	2 months	3 months	6 months	9 months	12 months
15-24	23.7 (23.2, 24.1)	7.2 (7.0, 7.3)	5.3 (5.2, 5.4)	4.4 (4.3, 4.6)	3.1 (3.1, 3.3)	2.6 (2.5, 2.7)	2.3 (2.2, 2.4)
25-34	17.5 (17.1, 17.8)	6.0 (5.9, 6.1)	4.4 (4.3, 4.5)	3.7 (3.6, 3.8)	3.1 (3.0, 3.2)	2.7 (2.7, 2.8)	2.5 (2.4, 2.6)
35-44	14.9 (14.6, 15.2)	5.1 (5.0, 5.2)	3.7 (3.7, 3.8)	3.2 (3.2, 3.3)	2.9 (2.8, 2.9)	2.6 (2.5, 2.7)	2.4 (2.3, 2.5)
45-54	13.4 (13.1, 13.6)	4.6 (4.5, 4.7)	3.5 (3.4, 3.5)	3.0 (3.0, 3.1)	2.8 (2.7, 2.8)	2.6 (2.5, 2.6)	2.4 (2.3, 2.5)
55-64	12.2 (12.0, 12.5)	4.6 (4.5, 4.7)	3.4 (3.3, 3.4)	2.9 (2.9, 3.0)	2.7 (2.6, 2.8)	2.5 (2.5, 2.6)	2.4 (2.3, 2.5)
65+ yrs	10.6 (10.1, 11.2)	4.3 (4.1, 4.5)	3.2 (3.0, 3.3)	2.8 (2.7, 2.9)	2.7 (2.6, 2.8)	2.6 (2.5, 2.8)	2.5 (2.3, 2.7)

B) HAZARD DIFFERENCES PER 100 WORKERS (99% CI):

Age group	1 week	1 month	2 months	3 months	6 months	9 months	12 months
15-24	0.00 (ref.)	0.00 (ref.)	0.00 (ref.)	0.00 (ref.)	0.00 (ref.)	0.00 (ref.)	0.00 (ref.)
25-34	-6.2 (-6.6, -5.8)	-1.2 (-1.3, -1.0)	-0.9 (-1.0, -0.8)	-0.7 (-0.8, -0.6)	-0.1 (-0.2, 0.0)	0.1 (0.0, 0.2)	0.2 (0.1, 0.3)
35-44	-8.8 (-9.2, -8.4)	-2.1 (-2.3, -2.0)	-1.6 (-1.7, -1.5)	-1.1 (-1.2, -1.0)	-0.3 (-0.4, -0.2)	0.0 (-0.1, 0.1)	0.1 (0.0, 0.2)
45-54	-10.3 (-10.6, -9.9)	-2.6 (-2.7, -2.4)	-1.8 (-1.9, -1.8)	-1.3 (-1.4, -1.2)	-0.4 (-0.5, -0.3)	0.0 (-0.1, 0.1)	0.1 (0.0, 0.2)
55-64	-11.4 (-11.8, -11.0)	-2.6 (-2.8, -2.5)	-1.9 (-2.0, -1.8)	-1.4 (-1.5, -1.3)	-0.4 (-0.6, -0.3)	-0.1 (-0.2, 0.0)	0.1 (0.0, 0.2)
65+ yrs	-13.0 (-13.7, -12.4)	-2.9 (-3.2, -2.7)	-2.1 (-2.3, -2.0)	-1.5 (-1.7, -1.4)	-0.4 (-0.6, -0.3)	0.0 (-0.2, 0.2)	0.2 (0.0, 0.4)

C) HAZARD RATIOS (99% CI):

Age group	1 week	1 month	2 months	3 months	6 months	9 months	12 months	Time-constant
15-24	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
25-34	0.74 (0.72, 0.75)	0.83 (0.81, 0.85)	0.83 (0.81, 0.85)	0.84 (0.82, 0.87)	0.98 (0.94, 1.01)	1.05 (1.00, 1.10)	1.09 (1.03, 1.14)	0.83 (0.82, 0.84)
35-44	0.63 (0.62, 0.64)	0.71 (0.69, 0.72)	0.71 (0.69, 0.72)	0.74 (0.72, 0.76)	0.91 (0.88, 0.94)	1.00 (0.96, 1.05)	1.06 (1.01, 1.11)	0.71 (0.70, 0.72)
45-54	0.57 (0.56, 0.58)	0.64 (0.63, 0.66)	0.65 (0.64, 0.67)	0.69 (0.68, 0.71)	0.88 (0.85, 0.91)	0.98 (0.95, 1.02)	1.05 (1.00, 1.10)	0.65 (0.64, 0.66)
55-64	0.52 (0.51, 0.53)	0.64 (0.62, 0.65)	0.64 (0.62, 0.65)	0.67 (0.65, 0.69)	0.86 (0.83, 0.89)	0.97 (0.93, 1.01)	1.04 (0.99, 1.09)	0.62 (0.61, 0.62)
65+ yrs	0.45 (0.43, 0.47)	0.59 (0.56, 0.63)	0.60 (0.57, 0.63)	0.64 (0.61, 0.68)	0.86 (0.82, 0.91)	1.00 (0.93, 1.08)	1.09 (1.00, 1.19)	0.56 (0.55, 0.57)

[a] *Models are adjusted for: age, sex, province, occupation, industry, injury type, and injury year.*

4.2 Study 2: Going beyond chronological age in understanding retirement expectations: Utilizing multi-dimensional indicators of aging in the Canadian Longitudinal Study on Aging (CLSA)

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Original Research Paper Submitted for Peer-reviewed Publication

4.2.1 Reader's note

This paper aimed to: 1) develop multi-dimensional measures of aging using existing population-based survey data; and 2) validate a methodological approach that can be used to better understand chronological age differences in retirement expectations using these dimensions. The paper was submitted to a peer-reviewed journal for publication.

4.2.2 Acknowledgements

This research was made possible using the data collected by the Canadian Longitudinal Study on Aging (CLSA). Funding for the Canadian Longitudinal Study on Aging (CLSA) is provided by the Government of Canada through the Canadian Institutes of Health Research (CIHR) under grant reference: LSA 9447 and the Canada Foundation for Innovation. This research has been conducted using the CLSA datasets Baseline Tracking version 3.3 and Baseline Comprehensive version 3.2, under Application Number 171006. The CLSA is led by Drs. Parminder Raina, Christina Wolfson and Susan Kirkland. The opinions expressed in this manuscript are the author's own and do not reflect the views of the Canadian Longitudinal Study on Aging. Ethical approval for the secondary analysis of the CLSA data were obtained from the University of Toronto Health Sciences Research Ethics Board, under Certificate Number 36039.

4.2.3 Abstract

Background: Although it is recognized that aging is more than chronological age, few measures exist that can be used to operationalize other age-related dimensions (e.g., functional, psychosocial, organizational, life-stage age). This study aimed to: 1) develop multi-dimensional measures of aging using existing population-based survey data; and 2) validate a methodological approach that can be used to better understand chronological age differences in retirement expectations using these dimensions.

Methods: We used cross-sectional data from the Canadian Longitudinal Study on Aging, focusing on working, non-retired adults aged 45-64 years (n = 17,938). Age dimensions were operationalized using existing variables to create composite age dimension scores. Path models examined the relationship between chronological age and retirement expectations (near future versus no immediate plans), and the proportion of the relationship explained via each age dimension.

Results: Chronological age was associated with all age dimension scores in expected directions. Older chronological age also was associated with earlier retirement expectations. Path model results suggested 25-30% of the total relationship between chronological age and retirement intentions was mediated through life-stage and organizational age.

Conclusions: Our study demonstrates the feasibility of measuring functional, psychosocial, organizational and life-stage age via existing data. The inclusion of theoretically stronger age conceptualizations may help to better understand factors that contribute to chronological age-related inequalities in work outcomes. Future research should focus on measuring additional

items for psychosocial and organizational age, followed by validation of the extent to which each dimension explains age differences in other work outcomes.

4.2.4 Background

The proportion of the labour market comprised of older-aged workers has increased in many high-income countries. For example, from 2008 to 2017, the proportion of Canadians aged 55 years and older in the labour force increased from 15% to 21% (1) due to an aging population coupled with improved health, an increased desire among many older adults to work longer, and policy changes to retirement and pension access (1–4). Similar demographic and labour market changes have been observed in countries such as Australia and the United Kingdom (5,6).

In this changing arena of aging and work, retirement expectations are of renewed interest because they can impact organizational planning and potential worker health and well-being (7). However, large variations in retirement outcomes have been noted across chronological age groups (8,9). A recent systematic review, focusing on antecedents of retirement timing among older workers, found that older chronological age was one of the strongest predictors of decisions about when to retire (9). However, despite the focus on chronological age, previous literature suggests that aging is a heterogeneous process that is not completely understood by the number of calendar years attained (10,11). Individuals vary in their experiences of age-related changes in biological, cognitive or social functioning even within similar chronological age groups (12,13). Thus, chronological age has been described as an ‘insufficient operationalization’ of age within the work setting (11).

A paper by Sterns and Doverspike (10) addressed the need for multi-dimensional conceptualizations of age that may be of relevance to labour market outcomes. They conceptualized age as representing functional, psychosocial, organizational, and life-stage age. By distinguishing the non-modifiable concept of chronological age from other potentially modifiable underlying dimensions of age, we can gain a better understanding of factors that contribute to chronological age differences in work outcomes such as retirement expectations (14–16). However, previous research has often lacked validated measures of age beyond the number of calendar years attained, as well as data that can be used to operationalize these dimensions within population-level surveys.

Functional age in the context of employment relates to worker limitations and performance. As individuals age chronologically, they may experience declines in physical (e.g., strength, motor skills) or cognitive (e.g., memory) functioning, as well as the development of chronic conditions that can result in activity limitations (11,17,18). There may be large between-person variations in function within similar chronological age groups.

Psychosocial age relates to self and social perceptions of aging. Self-perceptions, for example, relate to how old an individual believes that they feel/act/appear to others, in comparison to their perceptions of what they think it means to be a particular chronological age (19). Previous studies have found a link between subjective age measures (e.g., felt age, self-perceptions of longer life horizons) and work outcomes such as retirement expectations and work motivation (11,12,20,21).

Organizational age describes the employment trajectory (e.g., career stage, job tenure or skill obsolescence) of individuals within jobs or organizations over time (11). Given that organizational age is nested within a job or organization, there may be large variations in what may be deemed “older” or “younger” organizational age depending on the work context (22). Recent studies and systematic reviews (9,23) have found that workers with lower job tenure, as well as those who changed jobs early or entered the labour market at an older age, are more likely to expect to retire at a later age.

Finally, *life-stage age* relates to normative and non-normative role changes throughout the life course (e.g., having children, starting a career, or providing care for older relative) that may have an impact on behaviour and are often thought to relate to a particular time of life (11,24). Although life-stage events may correlate with chronological age, there is often variability among the youngest and oldest workers (24). Previous studies have found that life-stage aging plays a strong role in influencing retirement decisions, including factors such as spousal retirement, household dependents, and caregiving responsibilities (8).

Operationalizing age dimensions

The most direct way to capture the above age dimensions would be to incorporate survey measures using valid and reliable scales developed in previous studies (25–29). However, these measures are not often available in population-based health surveys. This is in part due to theoretical limitations (30) and also due to a lack of direct survey questions (29). While existing data sources often do not contain items specifically intended to measure other age dimensions (e.g., functional, psychosocial, organizational, life-stage), they can contain items that could be used to assess these dimensions. If age dimensions could be assessed using existing data sources, which also contain relevant work outcomes, this can provide a feasible and efficient approach to examine the relationships between chronological age, age dimensions and outcomes of interest in existing large samples. To date, proxy measures have not been developed or validated in relation to retirement planning outcomes among injured workers.

Finally, the dimensions outlined by Sterns and Doverspike (10) provide guidance in understanding the different dimensions of age. However, they do not explicitly address how the dimensions could be operationalized within an analytic model. One approach is to conceptualize different age dimensions as occurring along a mediating pathway between chronological age and retirement expectations or other work-health outcomes (16,31,32). This allows for a decomposition of effects into the proportion that would be eliminated after equalizing mediators across chronological age groups (i.e., indirect effects) and the proportion that would remain even if mediators were equalized (i.e., remaining age-related inequalities in work outcomes) (16,31). (16,31). A strength of this approach is the shift away from non-modifiable aspects such as chronological age (16) toward a focus on disentangling the various changes in biological, cognitive or social functioning within similar chronological age groups (12,13,32). Moreover, various authors recommend that all five dimensions be operationalized and validated within one conceptual model (11,33) based on evidence that the dimensions exhibit both positive and negative relationships with subsequent outcomes (11,33).

Objectives

To address these research gaps, our study aimed to understand how item-level indicators of functional, psychosocial, organizational and life-stage age varied across chronological age groups using a large population health survey. We hypothesized that each dimension would be determined by a composite of the underlying age-related indicators, and that the distribution of dimensions would differ significantly across chronological age, allowing us to distinguish between individuals with the same chronological age, but with different scores on the age dimensions. The second objective was to outline a methodological approach for using these measures to better understand chronological age differences in retirement expectations. We hypothesized that older chronological age would be associated with having plans to retire in the near future (versus no immediate plans). We also hypothesized that age dimensions would mediate a proportion of this relationship, given the strong link between age-related dimensions and retirement (8,9,11,34–36).

4.2.5 Methods

Data sources and study population

We used baseline (cross-sectional) data from the Canadian Longitudinal Study on Aging (CLSA), which is an ongoing study focusing on the health and well-being of older Canadians, published in detail elsewhere (37). Data were collected from 51,338 participants via telephone and in-person interview over the 2011-2015 period, focusing on Canadians aged 45-85 years who were living in private dwellings. Inclusion criteria for the current study focused on individuals aged 45-64 years (n=27,854), who were not yet retired (n=19,103) and who had worked for pay in the 12-months prior to the survey (n=17,938). Final models excluded individuals with missing data on covariates (n=833, 4.6%). See **Appendix 4.2.1** for a sample flow chart.

Dimensions of age

The CLSA variables were used to operationalize the dimensions of age (functional, psychosocial, organizational and life-stage age). Although the CLSA had a focus on aging, it did not specifically set out to measure the dimensions within the Sterns and Doverspike framework. As such, available CLSA items for each dimension were chosen for broad conceptual unity following discussion with study team members, a review of existing studies (11), and existing age-related models (e.g., functional items from healthy aging and frailty models) (11,38–40). For age dimensions with multiple items, we combined the indicators into a summary index variable, with higher scores indicating “more” versus “less” of the age construct (33,41). For example, higher versus lower scores for functional age denote having greater chronic conditions, greater activity limitations, greater participation restrictions, and lower physical activity levels. Response options were normalized to a common range (0 to 1) before summing. Final summary scores were rescaled to a range of 0 to 10 for analysis. See **Appendix 4.2.2** for a summary of survey items.

[*Reader’s note: See* ***Section 5.4.1*** *for additional information on the development of age dimensions and the results from the use of alternative reflective approaches (i.e. factor analysis).]*

Functional age indicators

Chronic conditions (FA1) were defined as self-reported long-term conditions that were expected to last, or have already lasted, 6 months or more as diagnosed by a health professional. We included seven major physical conditions, each coded as 1’Present’ versus 0 ‘Absent’: arthritis, lung conditions (e.g., COPD), osteoporosis, stroke, cancer, diabetes, and heart disease. For analyses, we created a composite measure (18,42) based on the number of conditions: 0 ‘None’, 1 ‘One condition’, and 2 ‘Two or more’.

Social activity limitations due to health condition (FA2) refer to social, recreational, or group activities that were prevented due to a health condition during the past 12-months. Participants were asked a single question on whether they felt like they wanted to participate in more of these activities, and if so, what reason prevented them from doing so. Respondents were coded as 1

‘Limitations’ versus 0 ‘No limitations’ if they chose “health condition/limitation” as the reason for their limitations.

Physical activity participation restrictions due to health (FA3) refer to whether health or injury conditions prevented participation in more physical activities during past 12-months. Participants were asked a single question on whether they felt like they wanted to participate in more activities, and if so, what reasons prevented them from doing so (allowing for multiple responses). Respondents were coded as 1 'Prevented' versus 0 'Not prevented' if they chose “health conditions” or “injury/illness” as the reason for their restrictions.

Activities prevented due to pain or discomfort (FA4) were based on a single question that ascertained the self-reported frequency of the number of activities that were prevented due to pain or discomfort during day-to-day life. The question wording placed no restrictions on the types of allowed activities. Ordinal responses were recoded as 1 ‘No limitations’, 2 ‘A few activities’, and 3 ‘Some/most activities.’

Difficulties performing activities of daily living (ADL) (FA5) refer to limitations in performing basic or instrumental daily tasks such as walking without help or getting to places out of walking distance without help. The module included in the CLSA was based on a modified version of the Older Americans Resources and Services (OARS) Multidimensional Assessment Questionnaire, which contained a total of 14 activities. Ordinal responses for the derived score were recoded as 1 ‘Mild/moderate/severe/total’ versus 0 ‘No functional impairment’.

Physical activities (FA6) were measured using a modified version of the Physical Activity Scale for the Elderly (PASE). Respondents rated their frequency and duration of participation in various leisure, household, work and volunteer activities (11 items total) over the past 7 days.

The PASE scale is typically scored as a continuous variable based on a weighted multiplication of frequency and duration items, with higher scores denoting greater physical activity. For analyses, we created a simplified summary score based on the frequency items, with higher scores denoting less frequent participation.

Self-perceived change in driving abilities (FA7) measures whether a respondent's driving skills are perceived as being better or worse in comparison to 10 years prior to the survey. A total of 9 situations are rated by the respondent (e.g., performing high speed lane changes, driving safely) (43). For analyses, we derived a composite measure based on the frequency of positive or negative responses, coded as better, worse, mixed, and no change. We then created a binary measure denoting 0 'Better' versus 1 'Not better' abilities. Those with no current license were grouped with the 'Not better' category. Previous authors have used driving perceptions as a marker for underlying age-related changes (44–46), given that they may result from internal perceptions of diminished capacity and/or exposure to external age-related stereotypes.

Psychosocial age indicators

Self-rated healthy aging (PA1) was measured with a single item that asked respondents to rate their own healthy aging on a scale ranging from poor to excellent. Respondents were prompted to focus on health as a state of physical, mental, and social well-being, rather than just the absence of disease or injury. Ordinal responses were recoded as 1 'Excellent/very good' versus 0 'Good/fair/poor'. We conceptualized this measure as an indicator for psychosocial age, given the emphasis on self-perceptions of the aging process (19). However, we note the lack of validated usage of this item in previous studies.

Feeling hopeful about the future (PA2) was measured with a single item from the Center for Epidemiological Studies Depression Scale that asked how often the respondent felt hopeful about the future, in reference to the past week. Ordinal responses were recoded as 1 ‘All of the time’ versus 0 ‘Occasionally, some, rarely or never’. Similar to item PA1, we conceptualized this measure as a proxy indicator for psychosocial age, given the conceptual similaries of ‘hopefulness’ with future time perspective (FTP) (47–50). FTP refers to goal-oriented thinking or affect towards the future and has been used as an indicator of psychosocial age in previous studies (11,21).

Organizational age indicators

Organizational age (OA1) was measured using a single-item indicator of the number of years worked with the present employer or business (if currently working), or with the longest held job over lifetime (if currently unemployed). Both response frames were combined (i.e., present employer versus longest held job) due to question wording differences for those who were working versus not working at time of interview. Responses were coded as 1 ‘5+ years’ versus 0 ‘Less than 5 years’. These broad categories, and the ceiling of five or more years are a function of the survey question.

Life-stage age indicators

Children living in household (LA1) was ascertained by self-reported number of children, aged 18 years and younger, who currently reside in the household. Responses were coded as 1 ‘No children living in the household’ versus 0 ‘One or more children’. The focus on children under 18 years of age is consistent with previous studies examining life-stage factors in relation to retirement outcomes (51).

Dwelling ownership status (LA2) was based on two self-reported questions: whether the respondent (or their spouse/partner) owned, rented or leased their dwelling; and if owned, whether the mortgage was remaining versus paid off completely. Responses were combined to create a measure of housing ownership/tenure, with ‘renting’ conceptualized as the reference category: 1 ‘Rent’, 2 ‘Own with mortgage remaining’, and 3 ‘Own with no mortgage or no housing costs’.

Retirement status of the respondent’s spouse/partner (LA3) was based on self-reported marital status of the respondent, and if married, whether the respondent’s spouse/partner was retired. Responses were coded for analyses as 1 ‘Spouse/partner currently retired’ versus 0 ‘Spouse/partner not retired’. Those with no spouse/partner were grouped with spouse/partner currently retired.

Spousal caregiving responsibilities (LA4) captured whether the respondent provided any type of assistance to their spouse/partner because of a health condition or limitation during the past twelve months. Respondents were prompted to consider various types of assistance, such as personal care, medical care, managing appointments, activities of daily living or transportation, although any type of assistance was permitted. Questions were framed in reference to the one person to whom they have dedicated the most time and resources to assisting. We created a binary indicator denoting whether the care recipient was 1 ‘Spouse or partner’ versus 0 ‘All other recipients’, including parents, children, siblings, friends or neighbors. Consistent with previous studies, we focused on the role of spouse/partner care as a key determinant of retirement intentions (51).

Years lived in the community (LA5) denotes the self-reported length of time that the respondent lived in their current community, defined as a town, village or city. Responses were coded as 1= '0-4 years', 2 = '5-9 years', 3 = '10-19 years', 4 = '20-39 years', and 5 = '40+ years'.

Chronological age

Chronological age was defined as age (in years) of the respondent at time of survey. For descriptive analyses, we grouped participants into 5-year age ranges (45-49, 50-54, 55-59, 60-64). For path models, we analyzed age as a continuous variable (years, ranging from 45 to 64).

Retirement expectation outcomes

Respondents were asked the age at which they plan to retire. Using the respondent's current chronological age and planned age of retirement, we then classified participants into one of the following ordinal levels: 1 'No plans to retire or doesn't know when they will retire'; 2 'Expects to retire in more than 5 years'; 3 'Expects to retire within the next 5 years'. Higher scores on the outcome variable denote having plans or expectations to retire in the near future, versus no immediate plans or expectations.

Covariates

The CLSA contains data on sociodemographic and economic characteristics that were used to adjust for statistical confounding, including sex, geographic region (5 groups), education level (4 groups; from less than secondary to post-secondary/diploma), household income (5 groups; from <$20,000 CAD to $150,000+), immigrant (vs. non-immigrant), smoking status (never; former; current), self-rated general and mental health (excellent/very good vs. good/fair/poor), work hours (30+ hours/week vs. <30), and interview sample (comprehensive, tracking).

Analyses

For objective #1, descriptive statistics (counts, proportions) compared the distribution of item-level indicators for each age dimension, across chronological age groups. Descriptive analyses were completed using SAS 9.4 (Cary, NC).

To validate the newly created age dimensions (objective #2), we used path models to examine the simultaneous relationships between chronological age, age dimensions and retirement outcomes. The following relationships were examined: 1) chronological age and each age dimension (a-paths); 2) age dimensions and retirement (b-paths); 3) direct association between chronological age and retirement (c'-path); and 4) indirect association as mediated via each of the age dimensions (a*b paths). The total relationship between chronological age and retirement (c-path) was calculated as the sum of the indirect and direct paths. Path analyses were completed with Mplus 8 (Los Angeles, CA). Standardized path coefficients with bootstrapped 95% confidence intervals are reported. Goodness-of-fit for the final model was deemed adequate based on various indices (i.e., Chi-Sq p-value=0.40; RMSEA=0.002).

4.2.6 Results

Study sample

Table 4.2.1 presents the distribution of sociodemographic and health variables for the study sample, by chronological age group. The majority of the sample had high levels of education, were non-immigrants, and/or reported excellent to very good self-rated health. The overall sample contained a similar proportion of males and females. With the exception of urban/rural status and self-rated health, the distribution of study covariates differed significantly across age groups.

[Table 4.2.1 about here]

Objective 1: Chronological age and age dimensions

Table 4.2.2 presents the distribution of *functional age* items across chronological age groups. The strongest variation was observed for chronic conditions, which increased in prevalence with older age. We also found differences in social participation restrictions, activities prevented due to pain, difficulties performing ADLs, and negative changes in self-perceived driving abilities. For *psychosocial age*, older adults were more likely to report feeling hopeful about the future, although there were no chronological age differences in self-ratings of one's own healthy aging. For *organizational age*, older chronological age was associated with longer job tenure. For *life-stage age*, items such as having less children in the household, residing in a dwelling with no mortgage or ownership costs, having a spouse/partner retired and living for a greater number of years in their community tended to increase with older chronological age.

[Table 4.2.2 about here]

Figure 4.2.1 presents the distribution of summary index scores for functional age and life-stage age, which were comprised of multiple indicators. The distribution of index scores differed across chronological ages, with older chronological age groups scoring higher on each age dimension index compared to younger chronological age groups. Visual inspection of the graphs shows evidence of shared overlap in summary scores across chronological age groups, yet tail ranges with no overlap in score distributions (i.e., there were individuals with the same chronological age but with different scores on the age dimension index, and vice versa). For functional age, there was some truncation of responses at the lower range of index scores, limiting the usefulness of distinguishing between individuals who scored low versus very low on functional age items. In contrast, life-stage age was more normally distributed across the range of index scores.

Objective 2: Retirement outcomes

Figure 4.2.2 presents the total, direct and indirect effects for the relationship between chronological age and retirement expectations, as mediated through each age dimension. There was a statistically significant total effect (c-path) of chronological age on retirement outcomes (standardized beta 0.244), with older chronological age being associated with near retirement expectations.

Chronological age also was associated with each of the four age dimensions (a-paths), with standardized betas ranging from 0.083 (psychosocial age) to 0.438 (life-stage age). For example, older chronological age was associated with greater scores on the life-stage age index (e.g., no children living in the household, having a spouse/partner retired), and the relative strength of this association was greater in comparison to functional, psychosocial and organizational age.

However, only organizational and life-stage age were associated with near retirement expectations (b-paths), with standardized betas of 0.126 and 0.114, respectively. As a result, these dimensions accounted for a statistically significant indirect effect (standardized beta 0.066), with 27% of the total relationship between chronological age and retirement expectations being mediated by these dimensions.

The remaining direct effect (c’-path) of older chronological age on retirement expectations (i.e., not operating via age dimensions) was standardized beta 0.178, representing 73% of the total effect of older chronological age on near retirement expectations.

[Figure 4.2.2 about here]

4.2.7 Discussion

The aim of this study was to demonstrate a method to incorporate multiple dimensions of aging in a single model to better understand the relationship between aging as a multidimensional concept and work outcomes. Our study has two main findings. First, using cross-sectional survey data from the CLSA, we were able to create composite measures of diverse age dimensions that captured unique heterogeneity in the concept of age. Second, we found that older workers were more likely to plan to retire in the next five years, but that a moderate proportion of this overall relationship was explained by greater levels of the age dimensions (life-stage and organizational age). These findings indicate that different dimensions of aging can be used to better understand the overall link between chronological age and retirement expectations by disentangling the different age-related pathways (i.e., indirect effects) from the residual differences that are not due to age dimensions (i.e., remaining direct effects) within one conceptual model.

Objective 1: Creating indicators of different age dimensions

Overall, we were successful in identifying at least one indicator of each age dimension. The greatest number of indicators was available for functional and life-stage age, with only one to two indicators available for organizational and psychosocial age, respectively. Notably, the strong association between older chronological age and life-stage indicators was consistent with previous studies examining the normative and non-normative role changes that occur throughout the life course (11,24,33). However, not all life-stage indicators demonstrated variations by chronological age as hypothesized, including spousal/partner caregiving responsibilities (24,52,53). The available measure of caregiving responsibilities in the CLSA was framed in reference to the one person to whom the most time and resources were provided, and thus may not fully capture care responsibilities among those who provided care to multiple individuals.

In contrast, the smaller variations in functional, psychosocial and organizational item scores likely reflects the lack of adequate measures that capture the breadth and variation in each dimension. For functional age, there was evidence of floor effects for some items, suggesting that the included measurement scales may have less conceptual validity among working-age versus general populations. For psychosocial age, we did not have access to direct measures (i.e., looking, feeling or acting older than their chronological age). Direct measures have been developed in previous studies (25,27–29), and have been included in other surveys such as the US Health and Retirement Study (27). However, these measures were not available in this study.

Taken together, our findings demonstrate that age is a multidimensional construct and that chronological age is associated with underlying age-related changes (11,33). Various survey items may be useful as parsimonious markers for underlying age-related changes, including the number of chronic conditions, having children in the household, or years of organizational tenure. However, in terms of existing population-based data, psychosocial age may be challenging to measure unless explicit survey questions are included in the design phase. Theoretical discussion on how to operationalize psychosocial age (28–30,54) may be warranted and is beyond the scope of the current paper.

Objective 2: Understanding chronological age differences in retirement outcomes

The moderate proportion of the total relationship that was explained by life-stage age suggests that role changes throughout the life course may be important factors that influence a respondent’s retirement planning. For example, retirement of one’s spouse or partner may change the relative values placed on earnings and leisure time (7,8,11), with a greater emphasis on spending leisure time with a retired spouse (8). For *organizational age*, greater financial resources or maximized pensions among those with greater work tenure may facilitate earlier retirement (9). Future work could examine these additional intervening pathways as a research and policy objective of interest.

Although our study found age-related changes in *functional age* items, these variables were not linked with retirement planning in our full models. This is consistent with previous studies demonstrating a weaker link between health and functioning-related factors and retirement outcomes, as well as the importance of person-job fit (7,8,18,34,55). Our findings extend the existing literature by incorporating both health and non-health related factors within one conceptual model. We also found limited evidence of a relationship between *psychosocial age* and retirement expectations in our study. These findings are consistent with some (28), but not all (20), previous studies examining the role of psychosocial factors such as perceptions of longer life horizons and greater time remaining. However, we note that the lack of mediation via psychosocial age items is likely also due to incomplete measurement of the underlying age dimension (as noted in the previous section) (28–30).

As the various age dimensions exhibited differential indirect effects on work outcomes, future studies should continue to measure each dimension separately. It is also important to note that only a moderate proportion of the total effect of chronological age on retirement expectations was mediated via age dimensions, suggesting that there are remaining inequalities and/or measurement differences that are currently captured in the residual direct effect in our models (56). As such, other important mediators (such as age stereotypes or workplace-level factors) (9) and/or alternatively measured age dimensions might contribute to our understanding of age differences in retirement outcomes.

Strengths and limitations

A strength of the current study is its novel approach in operationalizing the age dimensions using routinely collected data on the physical, psychological, social and organizational aging process. Some of the variables used to measure each dimension (e.g., children in the household, dwelling ownership status, spousal retirement, chronic conditions and job tenure) are available in various population-based health surveys and could be readily incorporated into future studies. Additionally, the analytic approach outlined in our study can be extended to other work and health outcomes of interest (16,31).

Our study has limitations. The interpretation of relationships between exposure–mediator, mediator–exposure, and exposure–outcome variables may depend upon the control of confounders for each of these respective pathways. Causal-ordering assumptions between the mediators and retirement outcomes may not be satisfied, given that research variables were measured contemporaneously in the baseline survey. Finally, the observed relationships between chronological age, age dimensions, and retirement expectations may not generalize to other age groups (e.g., less than 45 years) (32), historical time periods (35), or subsequent retirement behaviours (8,9,34).

Conclusions

Our findings suggest that the inclusion of theoretically stronger conceptualizations of age may help to better understand the pathways that lead to chronological age-related inequalities in work and health outcomes. Given that chronological age is not a “modifiable” risk factor, a holistic understanding of the multidimensional nature of age helps to address unintended workplace discrimination and negative stereotypes that may result from simply identifying at-risk groups without taking the further step to understand why these groups may be at increased risk. However, there may be additional factors and measurement considerations that need to be addressed within future research studies, as well as limitations in using secondary data to measure age dimensions. Future research and survey initiatives might find value in capturing additional items relating to psychosocial and organizational age, followed by validation of the extent to which each item explains chronological age differences in other work and health outcomes.

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4.2.9 Tables and figures

Table 4.2.1. Distribution of study covariates (weighted) by chronological age group. CLSA baseline, ages 45-64 years, worked in the past year and not yet retired. n = 17,938 respondents.

	CHRONOLOGICAL AGE				
COVARIATES	**45-49** *Col. %*	**50-54** *Col. %*	**55-59** *Col. %*	**60-64** *Col. %*	***P-value for trend***
	n = 4,188	*n = 6,613*	*n = 4,423*	*n = 2,714*	
Geographic region [a]					
British Columbia	13.2%	14.6%	13.5%	17.2%	<0.001
Prairies (AB, MB, SK)	14.9%	17.3%	17.2%	19.4%	
Ontario	37.7%	37.9%	39.1%	37.2%	
Québec	27.1%	23.4%	23.1%	19.3%	
Atlantic (NB, NS, PE, NL)	7.0%	6.8%	7.2%	6.9%	
Urban/rural status					
Rural	23.9%	26.1%	23.8%	22.6%	0.090
Urban	76.1%	73.9%	76.2%	77.4%	
Sex					
Male	50.5%	52.7%	49.9%	58.4%	<0.001
Female	49.5%	47.3%	50.1%	41.6%	
Education level					
Less than secondary	2.0%	3.3%	4.6%	5.9%	<0.001
Secondary graduation	8.5%	9.6%	13.8%	12.5%	
Some post-secondary	4.9%	7.1%	7.2%	8.8%	
Post-secondary	84.6%	80.0%	74.4%	72.8%	
Total household income					
<$20,000 CAD	1.3%	1.4%	2.2%	2.1%	<0.001
$20,000 to $49,999	8.7%	10.3%	14.1%	17.1%	
$50,000 to $99,999	31.7%	31.1%	36.7%	43.5%	
$100,000 to $149,999	30.4%	28.2%	24.1%	20.4%	
$150,000+	27.8%	29.0%	22.9%	16.9%	
Immigration status					
Non-immigrant	83.1%	87.5%	86.1%	79.9%	<0.001
Immigrant	16.9%	12.5%	13.9%	20.1%	
Interview sample					
Comprehensive	28.3%	29.9%	25.8%	28.8%	0.001

Tracking	71.7%	70.1%	74.2%	71.2%	
Smoking status					
Never	37.4%	35.0%	30.5%	28.8%	<0.001
Former occasional/daily	51.1%	53.9%	58.2%	61.2%	
Current occasional/daily	11.5%	11.2%	11.2%	10.0%	
Self-rated general health					
Excellent/very good	64.1%	63.9%	62.6%	61.3%	0.422
Good/fair/poor	35.9%	36.1%	37.4%	38.7%	
Self-rated mental health					
Excellent/very good	69.2%	71.5%	68.8%	72.4%	0.081
Good/fair/poor	30.8%	28.5%	31.2%	27.6%	
Work hours					
<30 hours/week	12.6%	15.2%	15.4%	20.1%	<0.001
30+ hours/week	87.4%	84.8%	84.6%	79.9%	

[a] *AB Alberta; MB Manitoba; SK Saskatchewan; NB New Brunswick; NS Nova Scotia; PE Prince Edward Island; NL Newfoundland.*
[b] *Percentages are weighted to account for complex sampling design.*

Table 4.2.2. Distribution (weighted) of functional, psychosocial, organizational and life-stage age indicators by chronological age group. CLSA baseline, ages 45-64 years, worked in the past year and not yet retired.

	CHRONOLOGICAL AGE				
FUNCTIONAL AGE	**45-49** ***n = 4,188*** ***Col. %***	**50-54** ***n = 6,613*** ***Col. %***	**55-59** ***n = 4,423*** ***Col. %***	**60-64** ***n = 2,714*** ***Col. %***	***P-value for trend***
FA1 Chronic conditions (% yes)					
Arthritis	17.4%	23.0%	30.6%	35.5%	<0.001
Lung conditions	1.9%	2.7%	4.0%	5.1%	<0.001
Osteoporosis	1.8%	2.5%	6.1%	6.9%	<0.001
Stroke	0.3%	1.0%	1.9%	4.0%	<0.001
Cancer	5.7%	7.1%	8.9%	13.0%	<0.001
Diabetes	8.0%	9.8%	13.0%	15.7%	<0.001
Heart conditions	5.3%	6.8%	9.2%	13.5%	<0.001
FA2 Social participation restrictions					
0 'No restrictions'	97.2%	96.2%	94.7%	96.1%	0.001
1 'Restrictions'	2.8%	3.8%	5.3%	3.9%	
FA3 Physical activity participation restrictions					
0 'No restrictions'	88.4%	87.5%	86.4%	87.2%	0.369
1 'Restrictions'	11.6%	12.5%	13.6%	12.8%	
FA4 Activity limitations due to pain					
1 'No limitations'	82.0%	81.5%	78.7%	81.4%	0.045
2 'A few activities limited	10.5%	10.3%	12.3%	8.7%	
3 'Some/most activities limited	7.6%	8.2%	8.9%	9.9%	
FA5 ADL and IADL limitations					
0 'No functional impairment'	97.0%	96.9%	96.5%	94.1%	0.001
1 'Mild/moderate/severe/total'	3.0%	3.1%	3.5%	5.9%	
FA6 Physical Activity Scale for the Elderly					
Q1: 5-17 (more participation)	35.6%	32.0%	30.9%	27.6%	<0.001
Q2: 18-19	26.5%	27.4%	26.2%	28.8%	
Q3: 20-21	24.2%	25.2%	24.4%	23.8%	
Q4: 22-26 (less participation)	13.6%	15.5%	18.5%	19.7%	
FA7 Self-perceived change in driving abilities					
0 'Better'	23.3%	18.6%	13.9%	14.0%	<0.001
1 'Worse, neutral, mixed'	76.7%	81.4%	86.1%	86.0%	

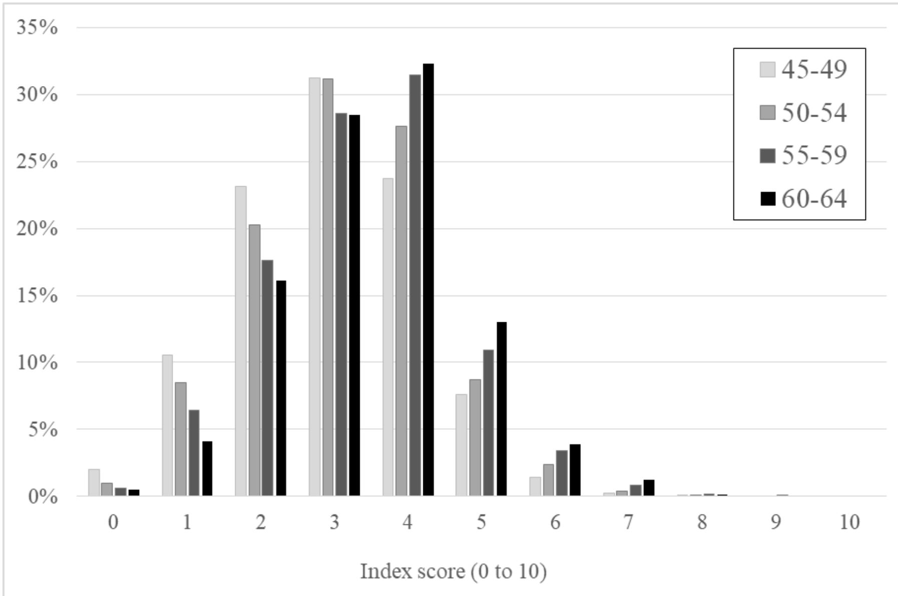
PSYCHOSOCIAL AGE	*Col. %*	*Col. %*	*Col. %*	*Col. %*	*P-value*
PA1 Self-rated own healthy aging					
0 'Good/fair/poor'	39.5%	40.1%	40.5%	38.8%	0.833
1 'Excellent/very good'	60.5%	59.9%	59.5%	61.2%	
PA2 Feeling hopeful about the future					
0 'Occasionally, some, rarely, never'	39.7%	37.7%	37.6%	34.1%	0.047
1 'All of the time'	60.3%	62.3%	62.4%	65.9%	

ORGANIZATIONAL AGE	*Col. %*	*Col. %*	*Col. %*	*Col. %*	*P-value*
OA1 Organizational/industry tenure					
0 'Less than 5 years'	22.9%	17.5%	15.8%	13.3%	<0.001
1 '5+ years'	77.1%	82.5%	84.2%	86.7%	

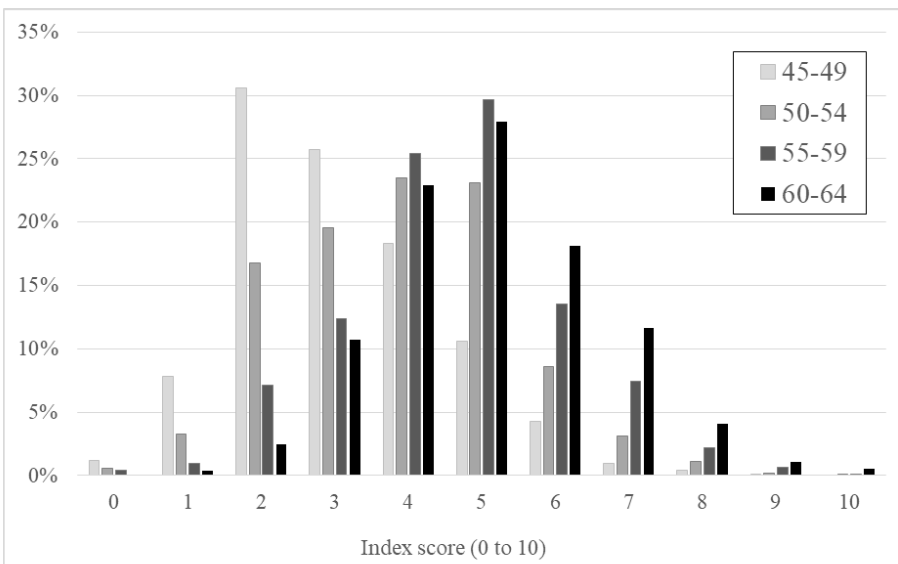
LIFE-STAGE AGE	*Col. %*	*Col. %*	*Col. %*	*Col. %*	*P-value*
LA1 Children living in household					
0 Children living in household (1+)	62.5%	33.1%	12.0%	3.6%	<0.001
1 No children living in household	37.5%	66.9%	88.0%	96.4%	
LA2 Dwelling ownership status					
1 Rent	8.8%	8.6%	8.5%	10.5%	<0.001
2 Own with mortgage remaining	63.9%	53.3%	44.6%	40.0%	
3 Own with no mortgage	27.3%	38.1%	46.8%	49.5%	
LA3 Retirement status of spouse/partner					
0 Spouse/partner not retired or none	97.2%	93.8%	85.9%	77.8%	<0.001
1 Spouse/partner retired	2.8%	6.2%	14.1%	22.2%	
LA4 Caregiving responsibilities due to health					
0 All other recipients	95.2%	95.1%	95.6%	93.1%	0.055
1 Spouse/partner main care recipient	4.8%	4.9%	4.4%	6.9%	
LA5 Years lived in community					
1 '0-4 years'	6.0%	5.4%	5.1%	3.8%	<0.001
2 '5-9 years'	11.9%	9.0%	7.6%	7.6%	
3 '10-19 years'	30.4%	23.8%	18.3%	17.1%	
4 '20-39 years'	33.7%	41.9%	47.0%	43.8%	
5 '40+ years'	18.1%	19.8%	22.1%	27.7%	

Figure 4.2.1. Weighted distribution of functional age and life-stage age index scores, across chronological age groups. CLSA baseline, ages 45-64 years, worked in the past year and not yet retired.

<u>A) Functional age index score, by chronological age group:</u> [a]

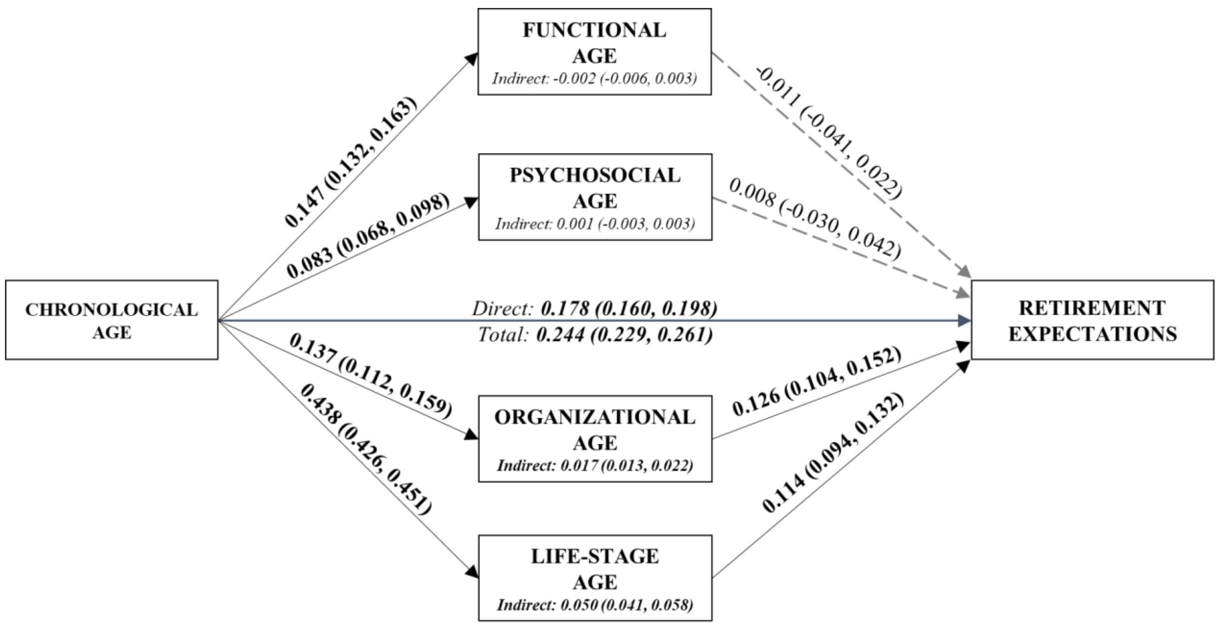


<u>B) Life-stage age index score, by chronological age group:</u> [b]



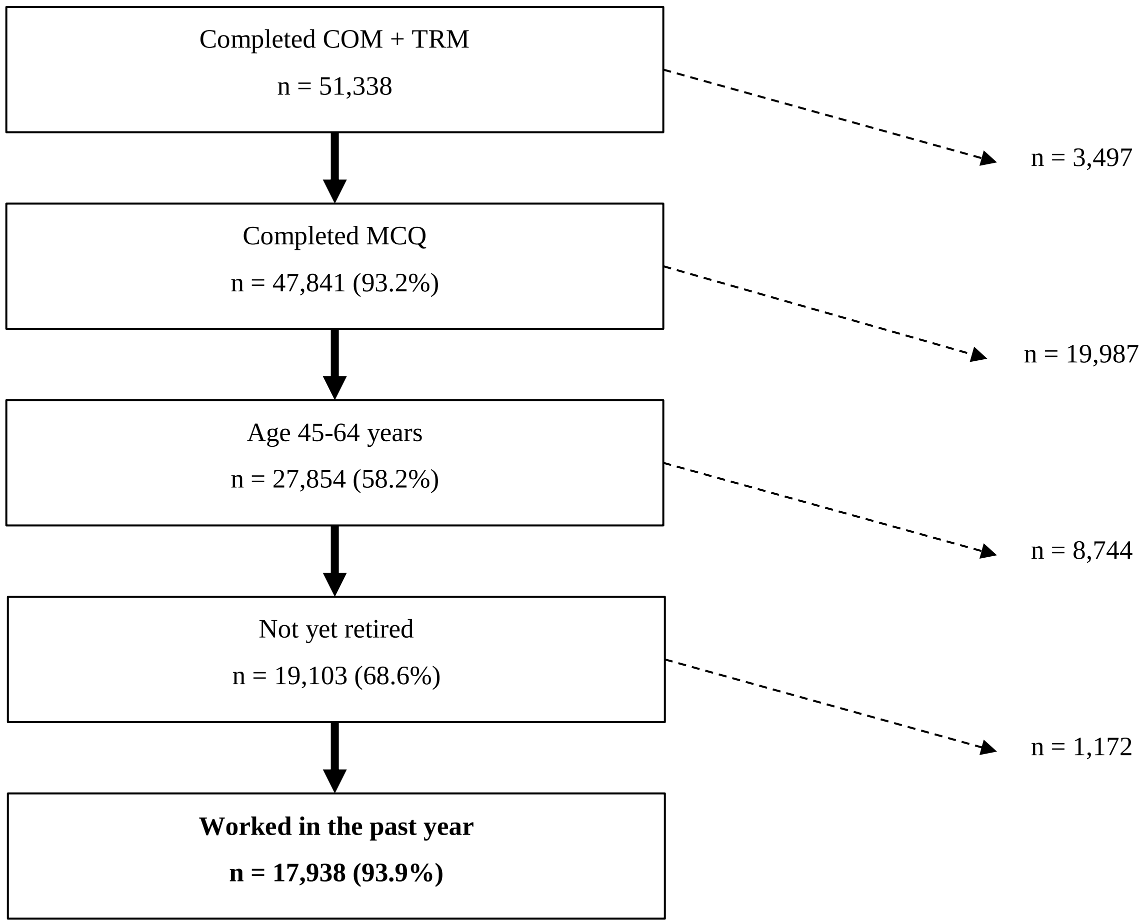
[a] *Highest index scores = greater chronic conditions + social activity limitations due to health condition + physical activity participation restrictions + activities prevented due to pain + difficulties performing ADLs + lower physical activity levels + worse driving abilities.*
[b] *Highest index scores = no children in household + residing in dwelling with no mortgage or costs + spouse retired + no spouse caregiving responsibilities + greater years in community.*
[c] *Estimates are weighted to account for complex sampling design.*

Figure 4.2.2. Total, direct and indirect effects (standardized coefficients, t-value) between chronological age and retirement expectations, mediated through age dimensions.



[a] *Positive estimates for a-paths denote higher (vs. lower) levels of age dimensions with older chronological age (and vice versa).*
[b] *Positive estimates for b-paths denote near (vs. later) retirement plans with higher levels of age dimensions (and vice versa).*
[c] *Dashed path lines denote estimates that are not statistically significant.*
[d] *Indirect effects are calculated using path tracing rules (product of coefficients).*
[e] *All paths are adjusted for full set of covariates.*
[f] *Estimates are weighted to account for complex sampling design.*

Appendix 4.2.1. Flow diagram for selection of CLSA analytic sample.



COM = Comprehensive sample

TRM = Tracking sample

MCQ = Maintaining Contact Questionnaire sample.

Appendix 4.2.2. Description of CLSA baseline survey items used to measure the five dimensions of age.

Dimension	Item	Variable	Description	Values
FUNCTIONAL AGE	FA1	Chronic conditions (arthritis, lung conditions, osteoporosis, stroke, cancer, diabetes, and heart disease)	Self-reported long-term conditions, lasting 6 months or more, diagnosed by a health professional	2 'Two or more' 1 'One condition' 0 'None'
	FA2	Social participation restrictions due to health	Social, recreational, or group activities prevented due to health condition during past 12-months	1 'Restrictions' 0 'No restrictions'
	FA3	Physical activity participation restrictions due to health	Whether health or injury conditions prevented participation in more physical activities during past 12-months	1 'Prevented' 0 'Not prevented'
	FA4	Activity limitations due to pain	Number of activities prevented due to pain or discomfort during day-to-day life	3 'Some/most activities prevented' 2 'A few activities prevented' 1 'No limitations'
	FA5	ADL and IADL limitations	Limitations in performing basic or instrumental daily tasks	1 'Mild/moderate/severe/total' 0 'No functional impairment'
	FA6	Physical Activity Scale for the Elderly (PASE)	Frequency and duration of participation in various leisure, household, work and volunteer activities over past 7 days	5 to 26 (higher=less participation)
	FA7	Self-perceived change in driving abilities compared to 10 years ago	Whether respondent’s driving skills (9 situations) were better or worse compared to 10 years ago	1 'Worse, neutral, mixed' 0 'Better'
PSYCHOSOCIAL AGE	PA1	Self-rated own healthy aging	Self-ratings of the respondent's level of own healthy aging, focus on health as a state of physical, mental, and social well-being	1 'Excellent/very good' 0 'Good/fair/poor'
	PA2	Feeling hopeful about the future	How often the respondent felt hopeful about the future (CES-D scale) during past week, as a	1 'All of the time' 0 'Occasionally, some, rarely or never'

			proxy for future time perspective	
ORGANIZATIONAL AGE	OA1	Organizational/industry tenure	Number of years worked with the present employer or business (if currently working), or with the longest held job over lifetime (if currently unemployed)	1 '5+ years' 0 'Less than 5 years'
LIFE-STAGE AGE	LA1	Children living in household	Whether respondent has children (age <19 years) living at home	1 No children living in household 0 Children living in household (1+)
	LA2	Dwelling ownership status	Whether respondent owned, rented or leased their dwelling; and if owned, whether mortgage was paid off	3 Own with no mortgage 2 Own with mortgage remaining 1 Rent
	LA3	Retirement status of spouse/partner	Whether respondent's spouse/partner is retired	1 Spouse/partner retired 0 Spouse/partner not retired or no spouse/partner
	LA4	Caregiving responsibilities due to health	Care provided to another person due to health conditions during past 12-months	1 Spouse/partner was main care recipient 0 All other recipients
	LA5	Years lived in the community	Self-reported length of time lived in current town, village or city	5 '40+ years' 4 '20-39 years' 3 '10-19 years' 2 '5-9 years' 1 '0-4 years'

4.3 Study 3: Age differences in return-to-work and wage-replacement duration following injury: Understanding the role of age dimensions across longitudinal follow-up

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Original Article Accepted in *Journal of Occupational and Environmental Medicine*

4.3.1 Reader's note

This third and final paper examines the overall association between chronological age and return-to-work (RTW) and wage-replacement duration outcomes across longitudinal follow-up, and the role of age-related dimensions (e.g., functional, psychosocial, organizational, life-stage age) in explaining these associations. The paper was accepted in the *Journal of Occupational and Environmental Medicine* (#JOEM-S-20-00337).

4.3.2 Acknowledgements

This research was funded by a Linkage Grant from the Australian Research Council (LP130100091). The funding sources had no role in the writing of the manuscript or in the decision to submit the manuscript for publication. The authors declare no conflicts of interest. Ethical approval was obtained from the Monash University Human Research Ethics Committee (#CF13/3312-2013001735) and the University of Toronto Health Sciences Research Ethics Board (#36039). Participants gave informed consent before taking part in the study.

4.3.3 Abstract

Objectives: To examine the overall association between chronological age and return-to-work (RTW), and understand if secondary data can be used to better understand the role of age-related dimensions (functional, psychosocial, organizational, life-stage) in explaining these associations.

Methods: We used survey data from a prospective cohort of injured workers in Victoria, Australia. Path models examined the relationship between chronological age and RTW, and the proportion mediated via age dimensions.

Results: Older chronological age was associated with non-RTW, although the pattern was not observed consistently across follow-up surveys. A proportion of the overall relationship between chronological age and non-RTW was explained by functional and life-stage age and RTW status at previous time points.

Conclusions: Findings underscore the importance of moving beyond age measured only in chronological years, towards more complete conceptual and analytical models that recognize age as a multidimensional construct.

4.3.4 Background

Older age tends to be associated with negative return-to-work (RTW) outcomes following a workplace injury, such as longer time to RTW, multiple recurrences of work absence following an initial RTW attempt, and greater overall duration of wage-replacement (1–5). However, only a small subset of studies have examined the underlying factors that are responsible for the differences across age groups (1,4–6). A study using workers' compensation data have found that age-related differences in the prevalence of pre-existing chronic conditions might explain a proportion of the variance in sickness absence duration, rather than the chronological age of the worker (1). A study using survey data collected from injured workers (6) also found that injury severity, injury-related surgery and physical functioning scores accounted for age-related differences in RTW. Across these studies, only a moderate proportion of the overall association between older age and non-RTW was explained by the presence of physical, clinical and injury-related characteristics, suggesting that other factors or mechanisms may account for the remaining effect of age on RTW outcomes.

Given the impact of negative RTW outcomes on well-being, quality of life (7,8), and claim costs (9,10), it is important to conceptually understand age effects and whether age is a proxy for other age-related factors as they may signal the potential for targeted interventions (11). However, there are several important limitations that need to be addressed from previous research. First, previous studies tend to focus only on chronological age (i.e., the age of the worker in calendar years), despite the acknowledgement that age can be measured using a variety of dimensions (12–15). By distinguishing chronological age from other age dimensions, we can gain a better understanding of underlying pathways that contribute to age-related differences in work outcomes (16–20). A paper by Sterns and Doverspike (12) outlined four additional age dimensions that may be of relevance to work outcomes. *Functional age* relates to worker performance and work functioning within the context of employment. As individuals age chronologically, they may experience declines in physical or cognitive functioning, as well as the development of chronic conditions that can result in activity limitations (1,13,21). *Psychosocial age* relates to self-perceptions of how old an individual believes they look, feel, act or desires to be, and social-perceptions of how old others appraise an individual to be (22). *Organizational age* relates to the job or employment trajectory of individuals over time, and is often measured using indicators of career stage, job tenure or skill obsolescence. Finally, *life-stage age* relates to the various role changes and life events that occur throughout the life course, such as finishing school, finding a partner, having children, starting a career, labour market experiences of a spouse/partner, caregiving responsibilities for older relatives or a spouse/partner and retirement (13).

Age dimensions have been linked with work outcomes such as motivation to continue working and labour market participation in previous studies (12,13). However, in relation to RTW outcomes, there are few studies and, those that exist, have focused only on individual subsets of each dimension (e.g., functional age) (1,5,6), in part due to lack of comprehensive data and measurement challenges (13). Moreover, previous studies have ignored the potential for competing pathways by not examining all age dimensions within one conceptual model, despite evidence that the dimensions exhibit both positive and negative relationships with subsequent outcomes (13,14). In contrast, a simultaneous approach to examining the multidimensionality of age could help counter age-related stereotypes and negative perceptions about older workers by identifying causal pathways that both promote and hinder successful RTW outcomes (14,15,19,20).

The most direct way to measure the above age dimensions would be to incorporate measures using validated scales developed in previous studies. However, these measures are not always available in existing data sources that were not originally collected to directly examine age dimensions (13). If there are aspects of age dimensions that could be captured by existing indicators, then this would allow for the measurement of age using a broader range of data sources with relevant work outcomes where direct measures had not been collected.

This paper aimed to better understand differences in RTW outcomes across age groups by exploring whether dimensions of age could be generated using existing datasets and by assessing the role of different conceptualizations of age. Objectives were to: 1) Demonstrate an approach that could be used to create indices of functional, psychosocial, organizational and life-stage age based on available survey measures; 2) Examine the overall association between chronological age and RTW outcomes across longitudinal follow-up; and 3) Examine the extent to which each age dimension explains the overall relationship between chronological age and RTW, and whether there is a remaining direct proportion not mediated by the age dimensions.

4.3.5 Methods

We used survey data collected from a prospective cohort of workers' compensation claimants in Victoria, Australia. In Victoria, approximately 85% of the state's labour force is covered by the workers' compensation system, which provides insurance for wage-replacement and health care expenditures in the event of a work-related injury or illness. The sampling frame, recruitment procedures, and response rates are published in more detail elsewhere (23). In brief, the sampling frame was based on a population of claimants with an accepted claim for work-related psychological or musculoskeletal injury resulting in 10 or more days of work absence, which is the administrative threshold for receipt of compensation from the system. Participants aged 18 years and older were recruited over the 2014-2015 period from monthly random samples of claimants identified by the compensation system, with a total of n = 2495 claimants included in the sampling frame.

Of the n = 869 claimants who participated at T1 baseline interview (approximately 3.5 months post-injury), n = 632 (73%) completed the 6-month follow-up interview (T2), and n = 572 (66%) completed the 12-month follow-up interview (T3). We included all available data for individuals who completed the baseline survey and who had complete data on study covariates (n = 776, 89%), excluding individuals with missing data (n = 93).

Return-to-work status (RTW) was defined as whether the worker self-reported being back at work, at the time of survey, for a sustained period of at least one month. Responses were coded as 1 "Working >1 month", 2 "Working but <1 month)", 3 "Off work but made attempts to RTW", and 4 "Off work", with higher values denoting non-RTW. Outcomes were measured at T1, T2 and T3 for respondents who completed the respective surveys.

Chronological age: Our primary explanatory variable was worker age at time of injury. For descriptive and regression models, we examined age as a categorical variable (18-34, 35-44, 45-54, and 55+ years). The 18-34 group was selected as the reference category. For path models, we examined age as a continuous variable (years).

Functional age was defined as a summary index based on the presence of four chronic conditions (arthritis, high blood pressure, diabetes, and heart disease); and work activity limitations as a result of health conditions, in reference to pre-injury activities, ascertained from four scale items (restrictions in the amount of activity that could be done at work, the type of activity, the pace of work, and the way in which work was done) (24). Chronic conditions were self-reported and defined as long-term conditions that have lasted or are expected to last 6 months or more and that have been diagnosed by a health professional. Each of the eight items were coded as binary variables (yes/no to the presence of each chronic condition or work restriction) and summed to create a composite index.

Psychosocial age was defined as self-rated perceptions of whether the worker's age would influence or has influenced the speed of recovery, and if so, whether this resulted in the recovery being slower or faster. Responses were coded as 1 "Faster speed of recovery due to age", 2 "No influence of age on recovery" and 3 "Slower speed of recovery due to age", with higher scores denoting a negative influence. We conceptualized this measure as an indicator for psychosocial age, given its emphasis on self-perceptions of the aging process (13,22), although we note the lack of validated usage of this item in previous studies.

Organizational age was defined as the number of years of tenure with the current employer at time of injury, coded as 1 "<1 year", 2 "1-2 years", and 3 "3+ years", with higher scores denoting greater tenure.

Life-stage age was defined by spousal working status and children aged <=16 years living in the household. Spouse/partner living arrangement/working status was coded as 0 "Not living with a spouse or partner", 1 "Spouse/partner working full-time", 2 "Spouse/partner working part-time", and 3 "Spouse/partner not working", with the highest score denoting living with a spouse/partner with less labour market attachment. Children in the household was coded as 0 "One or more children" and 1 "No children living in the household". These two variables are commonly used markers of age across the life span (12,13).

Covariates: All models were adjusted for the following covariates based on hypothesized relationships with chronological age, age dimensions and RTW outcomes (3): sex (male, female); injury type (musculoskeletal, psychological); unionization status of workplace (yes, no); usual work hours (<30 hours, 30-39, 40+); injury severity (very severe vs. severe / moderate / slight / very slight); and pre-injury psychosocial work conditions (physical demands, mental demands and job autonomy, with higher scores denoting better conditions).

Analysis

For objective #1, descriptive statistics (counts, proportions) compared the distribution of age dimension items by chronological age group.

For objective #2, we ran ordinal logistic regression models to examine the overall relationship between chronological age and the odds of having higher levels of the outcome (i.e., being off-work) compared to lower levels (i.e., having sustained RTW). Models were estimated separately for each follow-up time point (T1, T2 and T3), adjusting for covariates and lagged levels (T-1) of the respective outcome variable where applicable. Models were fully-adjusted for covariates, but unadjusted for the age dimension mediators to quantify the total effect of chronological age (25).

For objective #3, path analyses examined the mediating role of age dimensions in explaining the total relationships between chronological age and non-RTW (at T1/T2/T3). The following relationships were examined: 1) the association between chronological age and each age dimension (*a*-paths); 2) the association between age dimensions and non-RTW (*b*-paths); 3) the indirect association between chronological age and non-RTW, as mediated via each age dimension (*a**b* paths); and 4) the remaining direct association between chronological age and non-RTW (*c'*-path). The total relationships between chronological age and non-RTW (*c-path*) were calculated as the sum of the indirect and direct paths. We accounted for the longitudinal structure of the data by examining both cross-sectional (X1 → M1 → Y1) and longitudinal (X1 → M1 → Y2/Y3) mediated effects (26).

Regression and path models were run using Mplus 8 (Los Angeles, CA). Path models used a robust, weighted least-squares estimator (WLSMV), which models any categorical endogenous variables as continuous latent response variables underlying the probability of membership in different levels of each observed category. Standardized path coefficients are reported along with bias-corrected and bootstrapped 95% confidence intervals. Selected covariates with non-significant pathways were removed to improve model fit.

[*Reader's note: See **Section 5.4.1** for additional information on the development of age dimensions and the results from the use of alternative reflective approaches (i.e. factor analysis). This information is discussed in relation to Study 2 using data from the CLSA, although a similar approach was used for the current study.]*

4.3.6 Results

Table 4.3.1 presents the distribution of study covariates, by chronological age group. Overall, 44% of the sample were female and 77% had a musculoskeletal injury. Fifty-nine percent of the sample worked for unionized employers (with a greater proportion among older workers) and worked 30-39 hours per week (with older age groups working less hours). A large proportion of the sample rated their injury as being very severe (37%), but this did not vary significantly by age group. Mean scores for physical demands, psychological demands and job autonomy were rated more positively among older age groups.

[Table 4.3.1 about here]

Objective #1: Distribution of age dimensions

Table 4.3.2 presents the distribution of age dimension items across chronological age groups. The distribution of each item varied significantly across chronological age groups ($p<0.05$). For *functional age*, older chronological age groups had a greater prevalence of chronic conditions and greater restrictions in pre-injury work ability. For *psychosocial age*, older chronological age groups were more likely to perceive their age as having a negative impact on the speed of their recovery (compared to none or positive impact). For *organizational age*, older chronological age was associated with greater years of job tenure. For *life-stage age*, older chronological age groups were more likely to have a spouse/partner that was not working, whereas both the youngest and oldest age groups were less likely to have children <=16 years in the household.

[Table 4.3.2 about here]

Objective #2: Total relationship between age and RTW

Table 4.3.3 presents the overall relationship between chronological age non-RTW at follow-up. Older chronological age was associated with a greater odds of being off work at T1 in a graded fashion (e.g., at T1: 55+ age group vs. 18-34 years: OR 2.97). At T2 and T3 (adjusted for lagged T-1 outcomes), there was no consistent gradient in point estimates across age groups, although the 55+ age group had a greater odds of non-RTW at T2 (OR 2.08) and the 45-54 age group had a decreased odds of non-RTW at T3 (OR 0.41).

[Table 4.3.3 about here]

Objective #3: Role of age dimensions

Figure 4.3.1 presents the path models examining the mediating role of age dimensions in explaining non-RTW outcomes. See **Table 4.3.4** for the accompanying estimates. Goodness-of-fit of the final path model was adequate based on various indices (i.e., Chi-Sq p-value = 0.40; Root Mean Square Error of Approximation = 0.008; Comparative Fit Index = 1.00; Tucker Lewis Index = 0.99) (27).

We found a total association (c-path) between older chronological age and non-RTW at T1 (standardized beta 0.182) and T2 (standardized beta 0.137), but not statistically significantly at T3 (standardized beta 0.069). We also found that older chronological age was associated with each of the four age dimensions at T1 (a-paths), with standardized betas ranging from 0.224 to 0.486 across age dimensions. Two of the age dimensions also were significantly associated with non-RTW at T1 (life-stage age) and T2 (functional age). Residual covariances between each pair of age dimensions ranged from standardized beta 0.021 to 0.096, suggesting minimal overlap between the dimensions.

For T1 outcomes, the indirect association (*a*b* paths) of chronological age on non-RTW was significant only for life-stage age (standardized beta -0.020), accounting for 8% of the absolute total association (0.020 divided by 0.265). This pathway was in the “protective” direction, whereby older chronological age was associated with a greater life-stage age index, yet greater life-stage age was associated with better RTW outcomes. The remaining direct association (*c’*-path) of older chronological age on non-RTW at T1, not via age dimensions, was standardized beta 0.203 (77% of the absolute total association). Note that in the presence of suppression effects (i.e., both positive and negative indirect pathways) (28), the total sum of mediating pathways could be less (rather than greater) than the direct association, hence the calculation of proportion mediated using the absolute values.

For T2 outcomes, the total association between chronological age and non-RTW was mediated via functional age (standardized beta 0.044, 19% of the absolute total association); and via non-RTW status at T1 (standardized beta 0.087, 54% of the absolute total association). The remaining direct association of older chronological age on non-RTW at T2 (i.e., not via age dimensions or RTW at T1) was not statistically significant (standardized beta 0.022).

[Figure 4.3.1 about here]

[Table 4.3.4 about here]

4.3.7 Discussion

This study aimed to better understand age-related differences in RTW using existing survey data from a prospective cohort of injured workers in Victoria, Australia. Our study developed distinct measures of underlying age dimensions that were strongly associated with chronological age. We also found that older chronological age was associated with non-RTW in a graded fashion, but that this pattern was not observed consistently across study follow-up waves. Finally, we found that a proportion of the overall relationship between age and non-RTW was explained by functional age and RTW status at previous time points; and that life-stage age had a protective effect on RTW.

Objective #1: Creating measures of age dimensions

We achieved our objective of identifying at least one indicator of each age dimension using survey data that was not explicitly collected to measure age. As some indicators (e.g., chronic conditions, years or job tenure, children in the household) are commonly available in existing labour market and health surveys, these measures could be readily incorporated into future studies to provide a stronger conceptualization of age. The strong links (i.e., concurrent validity) between chronological age and each dimension, yet low correlations between the dimensions, suggest that our derived measures are a good fit with multidimensional age constructs as proposed in existing measurement models (12,13). These models were previously developed in relation to general working-age populations but, to date, have not been validated among samples of injured workers.

At the same time, psychosocial age and organizational age were only measured with one variable each, highlighting the limitations in defining age dimensions using existing data without direct survey questions (15,29). We also were unable to measure other facets of organizational age as outlined in existing models (12,13), such as career stage or skill obsolescence. Together, these observations suggest that inclusion of simple and parsimonious measures of age dimensions from existing survey data may contribute to a well-developed measure of a given age dimension, although future research and survey initiatives will likely require the inclusion of direct survey measures for a fuller assessment of age.

Objective #2: Chronological age and RTW

Although our findings of an overall age gradient in RTW outcomes are consistent with previous studies (3), the lack of robust association once we examined the entire trajectory of follow-up suggests that a more nuanced understanding is required. First, the time-varying nature of RTW outcomes suggests that age effects may not be adequately represented by a single summary measure of effect. This points to the need for the collection of longitudinal survey data to characterize the role of age across the length of study follow-up (7). Second, the non-consistency of age differences across the entire follow-up trajectory may have relevance for the development of interventions, which could be targeted towards the earlier phases of the process where the age-inequalities in RTW may be greatest. Systematic reviews suggest that multi-component interventions may be effective in promoting work participation and RTW among older workers (11). These interventions may include vocational rehabilitation and claims management activities, such as return-to-work planning, worker education/training or modified work duties (11,30) and could be targeted towards the period of greatest absolute risk to maximize the public-health impact. Yet, studies have shown that older workers may be less likely to receive offers of modified work duties compared to younger workers (30). Future work should identify specific differences in job or workplace-level contexts across phases of recovery and examine potential targets via intervention and evaluation studies. Finally, the lack of significant differences between older versus younger workers during T2 and T3, as well as the finding that RTW status at follow-up may be driven indirectly by RTW status at T1, suggests that older workers may encounter challenges to recovery if they do not achieve early, safe and sustained RTW (31).

Objective #3: Mediating role of age dimensions

The moderate proportion of the total relationship between chronological age and non-RTW that was mediated via functional and life-stage age suggests that our model was successful in identifying some pathways that may be driving overall age differences in work outcomes. These findings have several important implications. First, functional age and life-stage age may be factors that explain some of the variation in work outcomes across age groups (32,33). Given the increasing burden of chronic conditions among older individuals in many high-income countries (1,34), interventions and workplace policies could continue to support injured workers who may require workplace accommodations due to pre-existing chronic conditions or work activity limitations (35–38). However, the relevance of these factors as important target points for intervention may need to be examined with further studies given the moderate proportion of indirect effects and the finding that functional age only played a role in RTW at later follow-up periods.

Second, it is likely that some of the remaining age differences are due to measurement considerations. In our study, we used the best available measures from survey data that were not explicitly collected to examine age dimensions. If there are effects due to age dimensions that are not well captured using the available indicators, then these effects also would be captured in the residual direct effect in our models (39). For example, other life stage factors such as spousal retirement, household dependents and caregiving responsibilities may play a role in influencing labour market and work outcomes (7,40). As noted above, the collection of better data on age dimensions using validated scales (12,13,15,29) may help to address some of these measurement limitations.

Third, the large proportion of the total relationship that was unexplained by our path model suggests that non-age-related factors (rather than age per se) could be driving the relationship between older age and non-RTW. These remaining differences in non-age factors are currently captured in the residual direct effect in our models (39) and could be the subject of future research. For example, offers of modified duties or workplace interactions might play a key role in understanding why younger workers may have a greater likelihood of returning to work compared to older workers (11,30). Differences in claim processing times during the initial period of recovery also might exacerbate age differences in work outcomes, given that processing times (and thus the total disability duration window) may be shorter among younger versus older workers (41). On the other hand, positive claim experiences might buffer the negative effect of other mediators (42), given that claim experiences are rated more positively among older versus younger workers.

Finally, the remaining direct effects suggest that chronological age continues to serve as an important index variable that encodes both direct effects of chronological age, as well as any residual indirect effects captured along with the direct effect (43). For example, retirement eligibility is defined by chronological age thresholds even though there may be differences in underlying health status or organizational tenure (13). Definitions of older versus younger workers also are based on chronological age, typically using cut-points of 55 or 65 years of age (44). This structuring of society around age may lead to important differences in work and health outcomes at the individual level that persist even after accounting for underlying age related changes (43).

Strengths and limitations

Our study findings should be interpreted in relation to the following strengths and limitations. Although data on RTW outcomes were collected prospectively across three follow-up waves, we did not have access to follow-up data on age dimension items beyond their baseline measurement. This would have enabled the testing of a fully longitudinal path model (26). As our study data were collected from a sample of workers' compensation claimants who met a certain threshold for duration of work-disability, our findings may not generalize to other jurisdictions or less severe injury types (4).

Our study also has a number of strengths, including the prospective collection of self-reported survey data and measurement of RTW outcomes across multiple waves of follow-up. Although confounding remains an issue with observational studies, our regression and path models controlled for several characteristics that are not typically included in administrative data studies or general population surveys, such as self-reported injury severity and psychosocial work conditions (3,4,45,46). Our analyses also examine multiple age dimensions simultaneously in a single model to address concerns about competing pathways across each dimension (13,14).

Conclusions

Our study demonstrated an approach that can be used to create indices of functional, psychosocial, organizational and life-stage age based on available survey measures. Given the moderate proportion of the age–RTW relationship that was accounted for by RTW status at previous time points and age-related dimensions, our findings underscore the importance of moving beyond simple definitions of age based on chronological years, to more complex conceptual and analytical models that recognize that aging is a multidimensional construct. However, the remaining direct effects suggests that there are additional non-age-related factors and/or measurement considerations that need to be addressed within future research studies, as well as limitations in using secondary data to measure age dimensions. Future research should continue to incorporate better measures of the multidimensionality of age, followed by the use of appropriate analytic techniques that allow for a balanced understanding of age differences across time and underlying mechanisms.

4.3.8 References

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4.3.9 Tables and figures

Table 4.3.1. Distribution of study covariates at baseline survey. Stratified by chronological age group. Victoria, Australia. n = 776.

	CHRONOLOGICAL AGE (YEARS)					
	18-34	**35-44**	**45-54**	**55+**	**Total**	
	n = 173	***n = 188***	***n = 249***	***n = 166***	***n = 776***	
	Col. %	***Col. %***	***Col. %***	***Col. %***	***Col. %***	***P-value***
Sex						
Male	55%	64%	51%	57%	56%	0.064
Female	45%	36%	49%	43%	44%	
Injury type						
Musculoskeletal	81%	74%	79%	72%	77%	0.122
Psychological	19%	26%	21%	28%	23%	
Union status						
No	52%	46%	36%	33%	41%	0.001
Yes	48%	54%	64%	67%	59%	
Work hours per week						
<30	8%	6%	17%	18%	12%	0.008
30-39	51%	52%	46%	48%	49%	
40+	41%	42%	37%	34%	38%	
Injury severity						
Very slight to severe	69%	60%	63%	59%	63%	0.321
Very severe	31%	40%	37%	41%	37%	
Psychosocial work conditions	***Mean***	***Mean***	***Mean***	***Mean***	***Mean***	***P-value***
Low physical demands (5-25)	8.5	10.5	11.2	12.1	10.6	<0.001
Low psych demands (6-30)	15.2	16.8	16.6	16.9	16.4	0.042
Job autonomy (5-25)	15.3	16.7	17.1	17.5	16.7	0.001

Table 4.3.2. Distribution of age dimension items at baseline survey. Stratified by chronological age group. Victoria, Australia.

	CHRONOLOGICAL AGE (YEARS)				
	18-34	**35-44**	**45-54**	**55+**	
	n=173	***n=188***	***n=249***	***n=166***	
FUNCTIONAL AGE	***Col. %***	***Col. %***	***Col. %***	***Col. %***	***P-value***
Chronic conditions (% yes)					
Arthritis (% yes)	4%	7%	17%	31%	<0.001
High blood pressure (% yes)	<3%	11%	21%	34%	<0.001
Diabetes (% yes)	<3%	4%	8%	11%	<0.001
Heart disease (% yes)	<3%	<3%	<3%	6%	0.004
Work activity limitations (% some, most, all of the time)					
Restricted amount of activity?	13%	12%	15%	29%	<0.001
Restricted type of activity?	10%	11%	15%	25%	0.001
Having to slow down?	11%	14%	18%	26%	0.002
Having to change the way done?	13%	17%	20%	34%	<0.001
PSYCHOSOCIAL AGE	***Col. %***	***Col. %***	***Col. %***	***Col. %***	***P-value***
Perceived influence of age on speed of recovery					
1 Positive influence (faster)	45%	15%	5%	4%	<0.001
2 No influence	46%	60%	58%	54%	
3 Negative influence (slower)	9%	25%	37%	41%	
ORGANIZATIONAL AGE	***Col. %***	***Col. %***	***Col. %***	***Col. %***	***P-value***
Employment tenure					
<1 year	27%	16%	8%	6%	<0.001
1-2 years	35%	17%	14%	10%	
3+ years	39%	66%	79%	84%	

LIFE-STAGE AGE	*Col. %*	*Col. %*	*Col. %*	*Col. %*	*P-value*
Spouse/partner living/working status					
1 Not living with a spouse/partner	48%	35%	30%	36%	0.003
2 Spouse/partner working full-time	30%	32%	42%	29%	
3 Spouse/partner working part-time	9%	19%	15%	15%	
4 Spouse/partner not working	14%	14%	13%	21%	
Children <=16 years in household					
0 'One or more children'	24%	59%	38%	13%	<0.001
1 'No children'	76%	41%	62%	87%	

Table 4.3.3. Relationship between chronological age and non-RTW (proportional odds of being off work versus working for a sustained period) at given follow-up surveys.

	NON-RTW STATUS		
	T1	T2 [2]	T3 [3]
	n = 776	*n = 566*	*n = 456*
	OR (95% CI)	*OR (95% CI)*	*OR (95% CI)*
Age group			
18-34 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
35-44	**1.75 (1.16, 2.66)**	1.48 (0.83, 2.63)	0.83 (0.42, 1.62)
45-54	**2.27 (1.53, 3.38)**	1.28 (0.74, 2.23)	**0.41 (0.21, 0.81)**
55+ years	**2.97 (1.91, 4.64)**	**2.08 (1.16, 3.72)**	0.87 (0.44, 1.73)

[1] Adjusted for sex, injury type, injury severity, union status, work hours, psychosocial conditions.

[2] Additionally adjusted for lagged RTW status (T1).

[3] Additionally adjusted for lagged RTW status (T2).

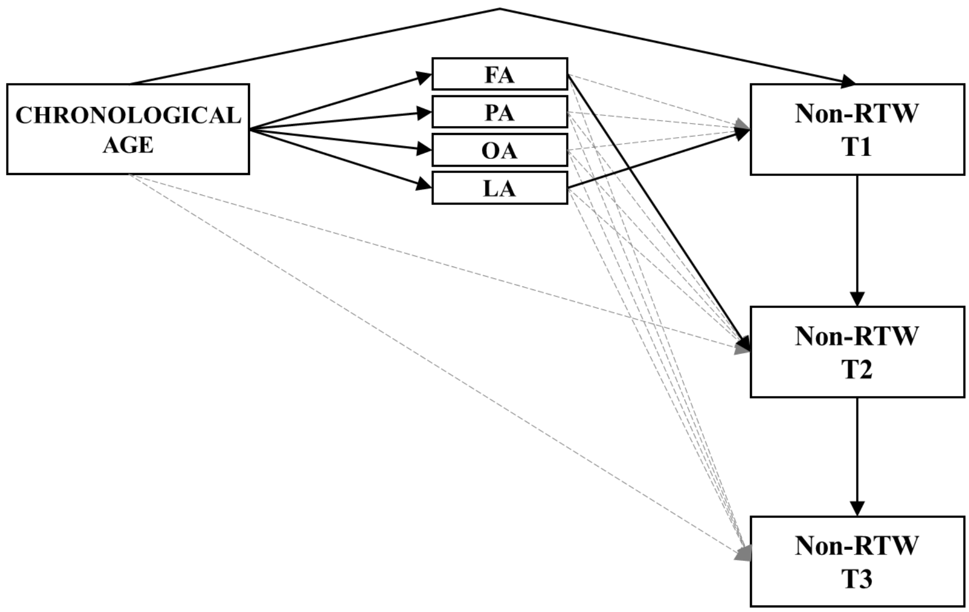
[4] All models adjusted for covariates[1], but exclude the age dimension mediators.

Table 4.3.4. Standardized coefficients (95% confidence intervals) for path models examining chronological age, age dimensions and non-RTW outcomes.

T1 SURVEY	**Age1 → Mediator1**	**Mediator1 → Outcome1**	**Age1 → M1 → O1**
Indirect			
via FA	**0.301 (0.235, 0.367)**	0.032 (-0.049, 0.112)	0.010 (-0.014, 0.034)
via PA	**0.486 (0.412, 0.552)**	0.020 (-0.087, 0.125)	0.010 (-0.041, 0.062)
via OA	**0.344 (0.272, 0.417)**	-0.063 (-0.172, 0.051)	-0.022 (-0.062, 0.017)
via LA	**0.224 (0.151, 0.291)**	**-0.088 (-0.165, -0.006)**	**-0.020 (-0.040, -0.002)**
Direct	-	-	**0.203 (0.102, 0.309)**
Total	-	-	**0.182 (0.106, 0.268)**
T2 SURVEY	**Age1 → Mediator1**	**Mediator1 → Outcome2**	**Age1 → M1 → O2**
Indirect			
via FA	**0.301 (0.235, 0.367)**	**0.145 (0.047, 0.233)**	**0.044 (0.015, 0.079)**
via PA	**0.486 (0.412, 0.552)**	0.028 (-0.104, 0.165)	0.014 (-0.049, 0.081)
via OA	**0.344 (0.272, 0.417)**	-0.050 (-0.183, 0.120)	-0.017 (-0.065, 0.039)
via LA	**0.224 (0.151, 0.291)**	-0.057 (-0.158, 0.055)	-0.013 (-0.039, 0.010)
via RTW T1	**0.182 (0.106, 0.268)**	**0.480 (0.360, 0.575)**	**0.087 (0.048, 0.135)**
Direct	-	-	0.022 (-0.103, 0.144)
Total	-	-	**0.137 (0.036, 0.245)**
T3 SURVEY	**Age1 → Mediator1**	**Mediator1 → Outcome3**	**Age1 → M1 → O3**
Indirect			
via FA	**0.301 (0.235, 0.367)**	-0.036 (-0.131, 0.055)	-0.011 (-0.041, 0.015)
via PA	**0.486 (0.412, 0.552)**	-0.132 (-0.276, 0.000)	-0.064 (-0.137, 0.000)
via OA	**0.344 (0.272, 0.417)**	0.037 (-0.101, 0.198)	0.013 (-0.034, 0.071)
via LA	**0.224 (0.151, 0.291)**	0.083 (-0.027, 0.188)	0.019 (-0.006, 0.045)
via RTW T2	**0.137 (0.036, 0.245)**	**0.781 (0.684, 0.866)**	**0.107 (0.032, 0.202)**
Direct	-	-	0.006 (-0.125, 0.142)
Total	-	-	0.069 (-0.042, 0.188)

[1] Chronological age at time of injury is measured in years.
[2] Non-RTW = return-to-work status based on self-reported survey data (higher = off work).
[3] FA = functional age; PA = psychosocial age; OA = organizational age; LA = life-stage age.
[4] Adjusted for sex, injury type, injury severity, union status, work hours, psychosocial conditions.
[5] Model fit: Chi-Sq 9.402, df 9, p =0.40; RMSEA 0.008, 90% CI: >0 to 0.042; CFI 1; TLI 0.99.

Figure 4.3.1. Path models examining relationships between chronological age, age dimensions and non-RTW status.



[1] *Chronological age at time of injury is measured in years.*

[2] *Non-RTW = return-to-work status based on self-reported survey data (higher = off work).*

[3] *FA = functional age (higher scores = chronic conditions, pre-injury work activity limitations).*

[4] *PA = psychosocial age (higher scores = negative influence of age on the speed of recovery).*

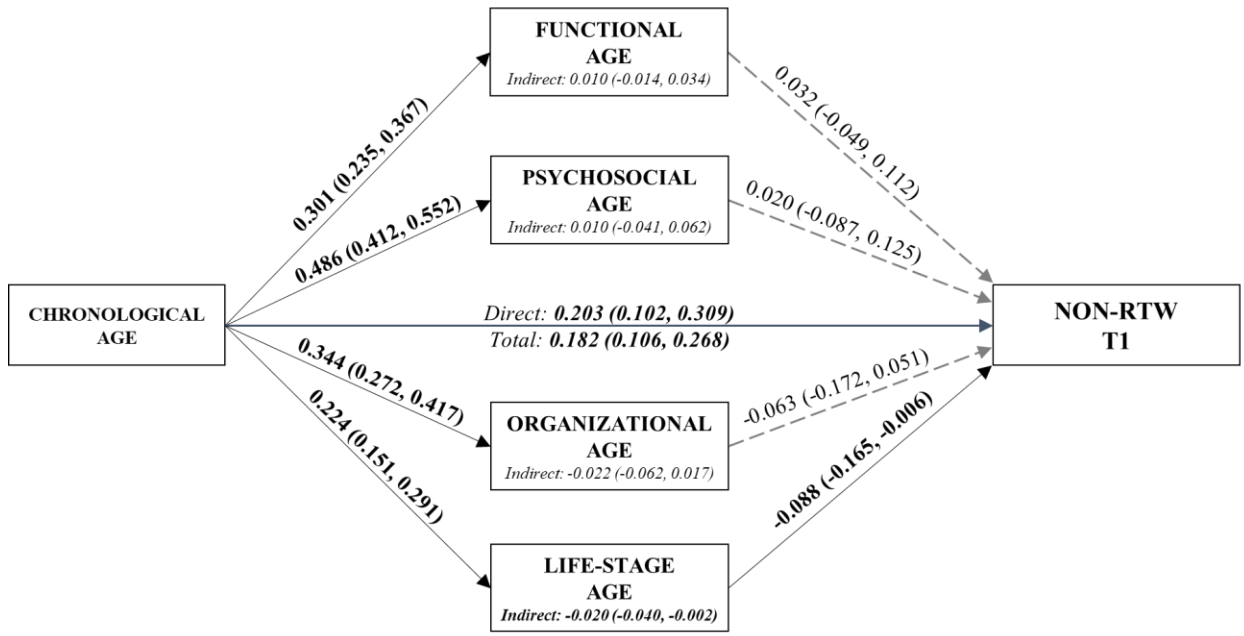
[5] *OA = organizational age (higher scores = greater years of job tenure).*

[6] *LA = life-stage age (higher scores = spouse/partner not working, no children in household).*

[7] *Adjusted for sex, injury type, injury severity, union status, work hours, work conditions.*

[8] *Statistically significant estimates = solid arrows; non-significant estimates = dashed arrows.*

Appendix 4.3.1. Path model examining relationship between chronological age, age dimensions and non-RTW outcomes at T1.



[1] *Standardized coefficients with bootstrapped 95% confidence intervals.*

[2] *Chronological age at time of injury is measured in years.*

[3] *Non-RTW = return-to-work status based on self-reported survey data (higher = off work).*

[4] *FA = functional age (higher scores = greater chronic conditions, greater restrictions in pre-injury work activity limitations).*

[5] *PA = psychosocial age (higher scores = negative influence of age on the speed of recovery).*

[6] *OA = organizational age (higher scores = greater years of job tenure).*

[7] *LA = life-stage age (higher scores = spouse/partner not working, no children in household).*

[8] *Adjusted for sex, injury type, injury severity, union status, work hours, work conditions.*

[9] *Statistically significant estimates = solid arrows; non-significant estimates = dashed arrows.*

[10] *Model fit: Chi-Sq 9.4, df 9, p-value 0.40; RMSEA 0.008, 90% uCL<0.042; CFI 1; TLI 0.99.*

Chapter 5
Supplementary Analyses

5.1 Introduction

5.1.1 Reader's note

This chapter provides a compendium of supplementary analyses that were completed to provide robustness checks to the main analyses (presented in the previous chapter) and alternative approaches considered for the development of age dimensions. See **Table 5.2** for an overview of objectives, rationale and methods used for each analysis. Analyses are grouped according to each study. An overarching synthesis of findings is provided in **Section 5.7**.

5.1.2 Assumptions and rationale

In carrying out the analyses presented in Chapter 4, a variety of analytic and methodologic assumptions were made to facilitate the identification of model estimates and interpretation of study findings. These assumptions relate to measurement issues, analytic issues and missing data. Each of these assumptions are reviewed in detail below, followed by discussion of sensitivity analyses that were used to test the validity of each assumption.

Measurement

As described in Section 3.3.2, 4.5.2, and 4.3.5, the age dimensions were measured using a formative conceptualization (1–6) whereby each age dimension is determined by a composite of experiences that occur throughout the lifespan. However, age dimensions also can be measured using a reflective specification. In this reflexive approach, the direction of causality flows *from* the construct of interest *to* each of the indicators. For analyses, we assumed that a formative conceptualization was the most appropriate based the potential for each item to form a defining characteristic of the construct (rather than manifestation of the construct); the lack of need for indicators to be interchangeable or capture the same content; and the potential for each indicator to have differential indirect pathways even within a given age dimension (1,6–8). However, to facilitate comparability with reflective models, we conducted an initial confirmatory factor analysis treating the age dimensions as latent factors. See **Section 5.4.1** for the results of this analysis, which found that the reflective model was not strongly supported by the data.

Survival analysis

For Study 1, survival regression was used to estimate the hazard of exit from wage-replacement benefits across chronological age groups. Initial analyses were based on the Cox proportional hazards model, under the assumption that the underlying age-specific hazard rates are proportionally related across the length of follow-up event time. However, subsequent tests of the proportional hazards assumption, using plots of exponentiated Schoenfeld residuals against follow-up time (9), found evidence of non-proportional hazards for each age group compared to the reference 15-24 age group ($p<0.05$). Accordingly, a flexible parametric specification with restricted cubic splines (10) was used to directly estimate the baseline hazard function and allow for the calculation of both absolute and relative hazard differences across follow-up event times. These models are presented in Section 4.1 and **5.5.3**.

An additional assumption is the potential that censoring across longitudinal follow-up was non-informative and that there were no competing risks, such as commencement of other benefit programs or services (e.g., vocational rehabilitation, long-term disability), labour market exit, or claim termination (e.g., being deemed capable of returning to work with no actual return).

Although this assumption was not tested in the dissertation as it was beyond the scope of analyses and available data, these issues are discussed in Section 4.1.6.

Mediation assumptions

Given the observational design of Studies 2 and 3, the isolation and interpretation of the path coefficients depends upon these variables controlled for in the analyses (11). Specifically, conditional on the set of measured confounders *C*, the sequential ignorability assumption implies that there should be no unmeasured confounding of the *exposure–outcome*, *mediator–outcome*, and *exposure–mediator* relationships (11,12). These assumptions were satisfied by the inclusion of all potential variables that may confound these relationships (see Section 3.3.5), as identified by a scoping review of the literature. Under these assumptions, we were able to estimate the total, direct and indirect effects of chronological age on work outcomes as presented in Chapters 4.2 and 4.3. However, some confounders were unmeasured in some studies (e.g., psychosocial work conditions and occupation in the CLSA). These issues are discussed in **Section 5.5.4**, with sensitivity analyses suggesting that a moderate to strong level of confounding would be required to explain away the observed total association between older age and non-RTW (as an example).

Another consideration is the case of *exposure-mediator interaction*, whereby chronological age and the age dimension mediators would interact with each other to produce differential mediating effects across levels of chronological age (or conversely, differential direct effect of chronological age across levels of each age dimension). The traditional linear path models presented in Chapters 4.2 and 4.3 assume that these exposure-mediator interactions are minimal. However, these assumptions were tested using the potential outcomes framework, which allows for the decomposition of a total effect into direct and indirect effects even in the presence of exposure-mediator interactions. See **Section 5.4.3** for the results of this analysis, which found minimal differences in the overall mediated proportion using these methods.

There also may be theoretical situations where a *mediator-outcome confounder is affected by exposure*. Injury severity, for example, has been conceptualized as an important driver of age-related differences in RTW and wage-replacement outcomes in previous studies (13,14), with some studies finding that age differences in RTW are no longer significant after adjustment for injury severity and other factors (14). For the analyses presented in Chapters 4.2 and 4.3, injury severity was conceptualized as a confounding variable, although the mediating role of severity was tested as a sensitivity analysis in **Section 5.5.1**, which found minimal evidence of mediation of the age to return to work relationship via injury severity.

One final note is that the causal inference assumptions of no interference, consistency, exchangeability and positivity are typically not discussed in the language of path models (15) even though these assumptions are implicitly invoked for causal interpretations (16–18). However, path models (and other types of analyses) can only reject causal assumptions and inconsistent models, and cannot derive any causal theory from the data model. As noted in Section 2.5.3, this dissertation adopts a relaxed theoretical approach that allows for decomposition of effects into the proportion that would be eliminated after equalizing mediators across chronological age groups (i.e., indirect effects) and the proportion that would remain even if mediators were equalized (i.e., remaining age-related inequalities in work outcomes) (19,20).

Missing data

Finally, as Studies 2 and 3 were based on survey data with longitudinal components (for Study 3), there were some observations where participants had missing data on exogenous covariates, endogenous age dimension mediators, and study outcomes. Approximately 5-10% of the study sample were missing data on baseline covariates. These individuals were excluded from analyses using listwise deletion due to modelling constraints. However, to handle participants with missing data on age dimensions and/or study outcomes, all path models were estimated using full-information maximum likelihood under the assumption that missing data are missing at random. Moreover, the availability of linked survey and administrative data (from Study 3) provided a complementary measure of wage-replacement duration, ascertained passively over time for a broader sample of respondents. These issues are discussed in **Sections 5.5.2** and **5.6**.

5.2 Tables and figures

Table 5.2. Overview of objectives, rationale and methods used for the supplementary analyses.

Study	#	Objectives	Rationale	Methods	Findings
WCB	5.3.1	Understand age differences in wage-replacement duration across jurisdictions	The workers' compensation system plays a role in moderating the association between age and work outcomes. If age differences are consistent, then broader system-level factors may not be the primary drivers.	Descriptive and survival analysis by geographic region	Overall age gradients in disability duration may not be modified to a great extent by workers' compensation system features, suggesting that proximal factors may be relevant.
CLSA	5.4.1	Creation of age dimensions	Additional information on the creation of age dimensions and use of factor analysis	Factor analysis	Reflective measurement model was not strongly supported by the data
	5.4.2	Understand age differences in other retirement outcomes	Gain insight on complementary, yet distinct, retirement factors for the purposes of model development and validation	Mediation analysis with path models	Indirect effects were similar to the main path models for FA (null) and LA (significant), although findings for OA were in opposite direction
	5.4.3	Examine potential for interactions not captured in the indirect effect estimates	The presence of different indirect effects for younger versus older age groups and/or interactions between age dimensions might bias the reported effect decompositions	Mediation analysis with potential outcomes	Although interactions may exist, findings were generally consistent with the main analyses in terms of overall proportion mediated by age dimensions (20-30%)

	5.4.4	Understand sex differences in the relationship between chronological age, age dimensions and retirement	Previous studies have found sex differences in the relationship between age dimensions and retirement outcomes, including stronger relationships between life-stage factors for women, yet attenuated estimates for men	Multi-group path models stratified by sex	No sex differences in overall proportion mediated via life-stage age, but greater proportion mediated via organizational age among females versus males.
RTW	5.5.1	Examine mediating role of injury severity in the relationship between age and RTW	Previous studies have found that injury severity is a driver of age-related differences in RTW and disability duration outcomes	Mediation analysis with path models	Chronological age was moderately associated with injury severity, and injury severity was associated with RTW. Indirect pathway was not significant.
	5.5.2	Understand age differences in wage-replacement and mediating role of age dimensions	Age dimensions have been linked with work outcomes in previous studies focusing on general labour market outcomes. However, few studies examine wage-replacement.	Mediation analysis with path models	Chronological age was associated with wage-replacement duration, but age dimensions did not explain these relationships.
	5.5.3	Understand age differences in wage-replacement duration across study follow-up	Examine the phase-specificity of the RTW and recovery process to compare and contrast the findings with the WCB study sample (Study #1)	Survival analysis with time-varying hazard ratios	Consistent with Study #1, older age was associated with greater wage-replacement duration in graded fashion, but pattern not observed consistently across time
	5.5.4	Examine the impact of unmeasured confounding	There may be the potential for unmeasured confounding given the observational design	Calculation of E-values	A moderate level of confounding would be required to explain away some paths

5.3 Study #1 Supplementary

5.3.1 Cross-jurisdictional differences

Background

Study 1 (Section 4.1) aimed to understand age-related similarities and differences in work-disability duration by focusing on how the relationship differs across phases of the claim and recovery process. However, an additional issue of interest is that the literature on age differences in disability duration has not compared effects between geographic regions or jurisdictions (21–23). The workers' compensation system itself may play a role in moderating the association between chronological age and work outcomes (21–24), yet most studies are based on data from single jurisdictions (25). If age differences are mitigated under certain policy settings (after accounting for underlying population differences across settings), then these findings may reflect a 'system' effect that buffers the 'chronological age' effect (26). However, if age-related differences are consistent across contexts, then this might suggest that broader system-level factors are not the primary drivers, and that further disentangling of age-related differences may be required.

To date, only a few studies have examined the overall association between workers' compensation system features and work outcomes (23,27–30), although the literature base has increased in recent years (31,32). The body of evidence suggests that workers' compensation systems with greater generosity of benefits might provide positive workplace environments (i.e., supportive of RTW without fear of losing benefits) and positive treatment environments (i.e., less confusion, less injustice, and less strain on physicians as the gatekeeper for receiving compensation) that lead to shorter time to RTW (23,33). In other words, restrictive waiting periods might lead to longer claim durations or presenteeism effects whereby workers might return to work without access to adequate benefits and recovery time, leading to greater durations overall (34). At the same time, increased generosity of benefits might lead to moral hazard behaviours such as taking fewer safety precautions or more time off work than required for medical recovery (31,35). It is also important to note that increases in disability duration do not necessarily imply worse outcomes from a medical recovery and RTW perspective as injured workers may be taking the appropriate amount of time off work to recover rather than engaging in moral hazard behaviours (36,37).

Although these studies point to system and policy-level factors that may lead to better or worse work outcomes (e.g., no threshold requirements for work incapacity, no waiting periods for entitlement to long-term disability benefits, shorter waiting periods for receipt of benefits), few of the studies explicitly examined their moderating impact on age inequalities. In Canada, there are core similarities in workers' compensation features, yet potential sources of variation that facilitate a comparison across provinces (38,39). The availability of multi-jurisdictional workers' compensation claims databases provides an opportunity to assess the generalizability of findings across contextual settings and identify potential sources of variation for future investigation.

Methods

Median days of wage-replacement duration (with interquartile ranges) were examined across workers' compensation jurisdictions. Using the methodology from Section 4.1.4, flexible parametric survival models were estimated separately for each province. Smoothed plots of time-varying hazard ratios were visually compared across provinces to examine variations in the general pattern age relationships.

Results

Table 5.3.1 presents the unadjusted median days of wage-replacement by age and province. Across provinces, the relative variation in median days ranged from 3 to 4 times greater, comparing the oldest versus youngest age groups. However, there was considerable variation in the absolute number of days of wage-replacement across provinces, with median days ranging from a 6-day difference in ON to a 17- to 18-day difference in BC and AB, comparing the oldest versus youngest age groups.

From the plots of time-varying hazard ratios by age group and province (data not shown), the overall pattern of time-varying hazards was generally consistent across provinces with respect to: age-related gradients in hazard estimates; greater magnitude of hazard differences during the initial phases of follow-up; subsequent attenuation of hazard estimates during the later phases of follow-up (with the exception of AB); and general timing of changes to the hazard function plots.

Discussion

Taken together, findings suggest that overall age gradients in disability duration may not be modified to a great extent by workers' compensation system features (although there was some variation in absolute differences in median days across provinces), and that more proximal-level factors and policies may be driving the differences (21,23,24,40). This may have implications for the development of interventions at the organizational or workplace-level that are focused on providing workplace supports for older versus younger workers (23). In part, consistencies across jurisdictions may be related to broad similarities in compensation systems across Canada (22,25), and thus we were unable to understand the impact of specific policy features or changes over time (23). Future research should investigate the impact of these features using quasi-experimental research designs that account for variations across historical time (31,32).

Table 5.3.1. Median days of cumulative wage-replacement (with interquartile ranges), by age group and province. WCB claims, 2011-2015.

	BC			**AB**		
	Med. (IQR)	***Diff.***	***Ratio***	***Med. (IQR)***	***Diff.***	***Ratio***
Age group						
15-24	7 (3 to 22)	0 (ref.)	1 (ref.)	6 (2 to 19)	0 (ref.)	1 (ref.)
25-34	9 (3 to 38)	2	1.3	8 (3 to 30)	2	1.3
35-44	13 (4 to 49)	6	1.9	10 (3 to 40)	4	1.7
45-54	16 (4 to 56)	9	2.3	14 (4 to 50)	8	2.3
55-64	18 (5 to 60)	11	2.6	16 (4 to 56)	10	2.7
65+	24 (6 to 78)	17	3.4	24 (6 to 70)	18	4.0
Median (IQR)	12 (4 to 47)			10 (3 to 40)		

	SK			**MB**		
	Med. (IQR)	***Diff.***	***Ratio***	***Med. (IQR)***	***Diff.***	***Ratio***
Age group						
15-24	5 (2 to 16)	0 (ref.)	1 (ref.)	4 (2 to 13)	0 (ref.)	1 (ref.)
25-34	6 (2 to 26)	1	1.2	5 (2 to 19)	1	1.3
35-44	8 (3 to 41)	3	1.6	7 (2 to 27)	3	1.8
45-54	10 (3 to 52)	5	2.0	9 (3 to 35)	5	2.3
55-64	12 (3 to 55)	7	2.4	10 (3 to 41)	6	2.5
65+	19 (5 to 77)	14	3.8	15 (4 to 59)	11	3.8
Median (IQR)	8 (3 to 38)			7 (2 to 27)		

	ON			**NB**		
	Med. (IQR)	***Diff.***	***Ratio***	***Med. (IQR)***	***Diff.***	***Ratio***
Age group						
15-24	3 (1 to 10)	0 (ref.)	1 (ref.)	5 (3 to 15)	0 (ref.)	1 (ref.)
25-34	4 (2 to 15)	1	1.3	7 (3 to 36)	2	1.4
35-44	5 (2 to 20)	2	1.7	10 (3 to 58)	5	2.0
45-54	6 (2 to 25)	3	2.0	13 (3 to 63)	8	2.6
55-64	7 (2 to 31)	4	2.3	15 (4 to 71)	10	3.0
65+	9 (3 to 39)	6	3.0	17 (5 to 69)	12	3.4
Median (IQR)	5 (2 to 20)			10 (3 to 54)		

[a] *Differences greater than '0' correspond to greater median days for a given age group compared to the reference age group .*
[b] *Ratios greater than 1.00 correspond greater median days for a given age group compared to the reference age group.*
[c] *BC: British Columbia; AB: Alberta; SK: Saskatchewan; MB: Manitoba; ON: Ontario; NB: New Brunswick.*
[d] *Days are standardized work days across provinces and are not raw calendar counts.*

5.4 Study #2 Supplementary

5.4.1 Creation of age dimensions

Background

For Study 2, we created a simple and parsimonious measure of each age dimension by summing the individual items to create an index score (1,2,6,41). This methodology is consistent with a formative conceptualization of age whereby the hypothesized direction of causality flows *from* the age indicators *to* the age dimension of interest. However, there may be alternative measurement specifications for the age dimensions, including reflective models whereby the age-related items are treated as having the same underlying construct (3,42). In this approach, the hypothesized direction of causality flows *from* the construct of interest *to* each of the indicators.

Methods

To compare these different approaches, we conducted an initial confirmatory factor analysis treating the age dimensions as latent factors with paths drawn towards each of the age dimension items. All age dimensions were included in the measurement model while allowing for covariances between the dimensions. Model fit was assessed using a variety of criteria, including goodness-of-fit indices, presence of statistically significant factor loadings ($|t|>1.96$), non-trivial factor loadings (>0.30), and adequate reliability of factors (composite reliability >0.80, and variance extracted estimates >0.50) (43). Analyses were based on the final study sample for Study 2 (Section 4.5.2), including individuals aged 45-64 years, who were not yet retired and who had worked for pay in the 12-months prior to the survey. Models were run using Mplus 8 using the WLSMV method with factor variances fixed to 1. Latent factors for each age dimension were allowed to covary.

Results

Table 5.5.1 presents the standardized factor loadings for each age dimension. All standardized factor loadings were statistically significant, demonstrating convergent validity of the responses to each item. However, some of the factor loadings were trivial (e.g., less than 0.3). For example, the PASE scale and changes in driving conditions both loaded poorly to the functional age factor. As a result, the reliability of the indicator variables (squared factor loadings) and composite reliability of each factor (internal consistency) was poor overall, with reliability less than 0.70. Variance extracted estimates suggested that less than half of the variance for each factor was captured by the latent construct, with more than half of the variance due to error. Moreover, model fit criteria were not within ideal ranges (CFI<0.94, TLI<0.94, SRMR>0.055), although RMSEA was within the ideal range (<0.055).

Discussion

As noted in Section 5.1.2, we assumed that a formative conceptualization was the most appropriate based the potential for each item to form a defining characteristic of the construct (rather than manifestation of the construct); the lack of need for indicators to be interchangeable or capture the same content; and the potential for each indicator to have differential indirect pathways even within a given age dimension (1,6–8). Considering these various conceptual checks (1,6), it is likely that a formative approach is the most appropriate for measuring each age dimension using data that was not explicitly collected to examine the underlying age dimension. This is supported by the findings that the indicators are not internally consistent and that addition or removal of items might appreciably change the nature of relationships with chronological age. Moreover, age dimensions are determined by a composite of experiences that occur throughout the lifespan (3–5,44,45). For example, life-stage age is externally influenced by environmental, structural and societal determinants that occur throughout the life-course (44). Factors such as having caregiving responsibilities, having children living in the household or having a spouse retired may lead to changes in life-stage age rather than vice versa (i.e., greater life-stage age might not lead to having greater caregiving responsibilities or having a spouse retired).

However, there are also arguments in favor of a mixed reflective/formative approach, especially for functional age or psychosocial age. Functional age is reflected within various indicators of health, physical capacity, cognitive abilities and work performance (44). These indicators may represent a manifestation of the underlying concept of functional age and thus could be represented by a reflective model (1,44). Moreover, some of the individual age indicators, such as physical activity levels, social participation restrictions or activity limitations, can be measured using validated scales that have been developed with psychometric theory (46). On the other hand, the various indicators for functional age are not necessarily interchangeable and may be impacted by environmental or organizational determinants (44), such as work activity limitations. As a result, the meaning of functional age may differ depending upon which indicators are included in the model (1). Such measurement properties might facilitate a mixed formative/reflective conceptualization of functional age (3,47).

Self-perceptions of age also might be considered a mixed formative/reflective construct given that it may be reflected by self-perceptions of how old an individual feels, looks and acts (reflective) or formed by social perceptions or age norms applied towards an individual (44). The measurement and inclusion of additional data on self-perceptions of aging (48–50) might facilitate the incorporation of reflective measures of psychosocial age. The decision to include these items should be balanced with ongoing theoretical and methodological issues that are the subject of current research (23,24), as described in Section 2.5.2 and **6.3.2**.

Taken together, the lack of covariance between the indicators and weak to moderate loadings within each age construct suggest that a reflective measurement model may not be strongly supported by the data, especially when the findings are considered along with theoretical underpinnings (1,6). However, it is also possible that some dimensions could at least include a reflective component, especially for different facets of each age dimension or self-perceptions measured using validated scales (46). Future work should consider the strengths and limitations of the composite index approach presented in this dissertation before replicating the methodology (1).

Table 5.5.1. Standardized factor loadings for confirmatory factor analysis of age dimensions.

	Standardized coefficients	R-square reliability	Residual variance	Composite reliability	Variance extracted
FUNCTIONAL AGE					
FA1 Chronic conditions	0.465	0.216	0.784	0.673	0.279
FA2 Social participation restrictions	0.594	0.353	0.647		
FA3 Physical activity restrictions	0.677	0.458	0.542		
FA4 Activity limitations due to pain	0.777	0.604	0.396		
FA5 ADL and IADL limitations	0.519	0.269	0.731		
FA6 Physical Activity Scale	0.231	0.053	0.947		
FA7 Change in driving abilities	-0.043	0.002	0.998		
PSYCHOSOCIAL AGE					
PA1 Self-rated own healthy aging	0.804	0.646	0.354	0.517	0.383
PA2 Feeling hopeful about the future	0.346	0.120	0.880		
ORGANIZATIONAL AGE					
OA1 Organizational/industry tenure	1.000	1.000	0.000	1.000	1.000
LIFE-STAGE AGE					
LA1 Children living in household	0.278	0.077	0.923	0.452	0.156
LA2 Dwelling ownership status	0.533	0.284	0.716		
LA3 Retirement status of spouse/partner	0.502	0.252	0.748		
LA4 Caregiving responsibilities	0.195	0.038	0.962		
LA5 Years lived in the community	0.358	0.128	0.872		
FACTOR COVARIANCES					
FA with PA	-0.577	0.333	0.667		
FA with OA	-0.025	0.001	0.999		
FA with LA	-0.006	0.000	1.000		
PA with OA	0.061	0.004	0.996		
PA with LA	0.123	0.015	0.985		
OA with LA	0.314	0.099	0.901		

Model fit: RMSEA: 0.042, 90% CI: 0.041, 0.043; CFI: 0.796; TLI: 0.749; SRMR: 0.062.

Estimated using WLSMV method with factor variances fixed to 1.

Organizational age item was included to allow for covariances between all age dimensions.

Estimates are unweighted for survey design.

5.4.2 Other retirement outcomes

Given the breadth of dimensions within the concept of “retirement”, we examined additional retirement outcomes to gain insight on complementary, yet distinct, factors for the purposes of model development and validation (51). These outcomes focused on retirement planning, including whether the respondent prepared for retirement by decreasing work hours or by changing jobs (coded as a yes/no variable). As this outcome was only available for a subset of respondents in the CLSA (i.e., the tracking sample), we included these as a brief supplementary analysis given the main interest in retirement expectations. Findings from these models were similar to the main path analysis for the dimensions of functional age (null associations) and life-stage age (significant mediation). Findings for organizational age were in the opposite direction, whereby greater organizational tenure was associated with a lower likelihood of planning for retirement by reducing hours or changing jobs. Thus, while greater job tenure is linked with earlier retirement intentions, these workers may not necessarily reduce their work hours in response to intentions for retirement as job tenure may serve as a buffer. Workers with greater tenure also may be able to take advantage of organizational resources or seniority (52), thereby allowing them to maintain their current hours and job type prior to retirement.

5.4.3 Potential outcomes approach

Background

The decomposition of mediation effects between an exposure (e.g., chronological age) and outcome variable (e.g., RTW outcomes) in the presence of multiple mediators (e.g., functional, psychosocial, organizational and life-stage age dimensions) can be estimated within the path modelling approach via path tracing rules (15). However, there may be exposure-mediator interactions (i.e., different indirect effects for younger versus older chronological age groups) or mediator-mediator interactions (i.e., interactions between age-related indicators) not captured in the indirect effect estimates, in which case the reported effect decompositions may be invalid (53–56). In the case of exposure-mediator interaction, chronological age and the age dimension mediators would interact with each other such that the mediating effect of each age dimension on work outcomes would differ across chronological age groups (or conversely, the direct effect of chronological age would depend upon the level of the age dimensions). This may be the case for the relationship between chronological age and organizational age, given job tenure may moderate the relationship between age and sickness absence duration (57) such that greater tenure may reduce the duration of disability at younger age groups, but increase the duration of disability at older age groups. These interaction effects would not captured in the indirect effect estimates, resulting in biased effect decompositions (53,54,56).

Other mediation approaches that were considered, but were not used for the main analysis, include the potential outcomes framework, which provides a causally-defined decomposition of the total effects into direct and indirect effects. In this approach, natural direct effects are defined as the difference in outcomes (e.g., non-RTW) between exposed versus unexposed groups (e.g., older versus younger individuals), but with the mediator (e.g., age dimensions) taking the value it would obtain among the reference exposure group of younger age. Similarly, the natural indirect effect would be defined as the difference in outcomes (non-RTW) between exposure groups when the mediator varies from levels it would take in the exposed group (older workers) to levels it would take in the reference exposure group (younger workers). An advantage of the potential outcomes framework is the decomposition of a total effect into direct and indirect effects even in the presence of exposure-mediator interactions and non-linear relationships between variables (18). However, despite these methodological advantages, the decomposition of specific indirect effects in the presence of multiple mediators (e.g., functional, psychosocial, organizational and life-stage age dimensions) remains a challenge given the exponential number of possible decompositions arising from the multiple definitions of causal effects (i.e., pure or total) that are associated with each path-specific effect (54,58,59). Note that in the absence of exposure-mediator interaction, the effects from a potential outcomes approach and path analysis approach would tend to converge (15,54).

Methods

As a supplementary analysis, we estimated the causally-defined direct and indirect effects using an SEM based approach (18,53). Each age dimension was tested separately under the assumption that the mediators were independent and not causally related (17,54). These models decomposed the overall effect into a total direct effect (i.e., picking up the mediated interaction) and a pure indirect effect (i.e., the component just due to mediation, excluding the interaction). The age effects are estimated for the contrast of age at 58 years versus 48 years, which is the mean age plus +1 standard deviation.

Results

Table 5.4.3 presents the total, indirect and direct effects based on causally-defined effects, with each mediator examined separately. The overall proportion of the total effect mediated by the whole of the mediators were generally consistent between the traditional path models and causally-defined models (approximately 20-30%). The pure natural versus total natural indirect effects were not equivalent for life-stage age (i.e., 27% versus 22%), with a proportion of the indirect effect being due to a mediated interaction. However, there was still a significant indirect effect for organizational age and life-stage age. In sum, the findings suggest the possibility of a mediated interaction, but that these interactions resulted in minimal differences in the overall proportion mediated via the age dimensions. These findings are discussed in more detail in **Section 6.5.3**.

Table 5.4.3. Total, indirect and direct effects based on counterfactuals (causally-defined effects), with each mediator examined separately.

	Functional Age		**Psychosocial Age**		**Organizational Age**		**Life-stage Age**	
	Est. (t-value)	**% Med.**	**Est. (t-value)**	**% Med.**	**Est. (t-value)**	**% Med.**	**Est. (t-value)**	**% Med.**
Tot natural IE	-0.001 (-0.4)	1%	-0.001 (-0.7)	1%	0.007 (6.3)	4%	0.046 (11.1)	27%
Pure natural DE	0.162 (27.2)	99%	0.158 (24.2)	99%	0.155 (27.0)	96%	0.124 (18.8)	73%
Total effect	0.161 (26.8)	100%	0.158 (23.1)	100%	0.161 (28.0)	100%	0.169 (24.9)	100%
	Est. (t-value)	**% Med.**	**Est. (t-value)**	**% Med.**	**Est. (t-value)**	**% Med.**	**Est. (t-value)**	**% Med.**
Pure natural IE	0.000 (-0.3)	0%	0.000 (-0.2)	0%	0.005 (8.0)	3%	0.037 (12.9)	22%
Tot natural DE	0.161 (26.7)	100%	0.158 (23.4)	100%	0.156 (27.1)	97%	0.133 (18.5)	79%
Total effect	0.161 (26.8)	100%	0.158 (23.1)	100%	0.161 (28.0)	100%	0.169 (24.9)	100%

Contrasted effects for age at 58 years versus 48 years (mean and +1 SD).
Percent mediated is based on absolute total effect (where coefficients are negative).

5.4.4 Sex/gender differences in retirement expectations

Background

Previous studies have found stronger relationships between life-stage factors and retirement outcomes for women (60), yet attenuated estimates for men (61,62). For example, the impact of having dependents on early retirement may differ by gender, with children having a retirement-promoting effect among women, compared to a retirement-inhibiting effect among men, largely due to financial obligations (60,63). Several explanations have been proposed to account for these sex/gender differences in retirement outcomes, including differences in the balancing of traditional work-life roles, differential care obligations and the impact of potential salary loss (60,61,63).

It is also important to note that each age dimension was based on a summary index score, which may mask the effect of individual mediating pathways (e.g., the relative impact of specific chronic conditions; or spouse/partner working status versus having children in the household) at the gain of model parsimony (41,55). Thus, we also calculated the specific indirect effects via each age dimension indicator.

Methods

I examined the relationship between chronological age, age dimension items and retirement expectations using a multi-group path model comparing males and females. Differences in estimates by sex were indicated by a statistically significant p-value from a Wald chi-square test.

Results

See **Table 5.5.4** for stratified path coefficients. Notably, having children in the household was strongly associated with later retirement expectations for females (but less so for males), accounting for a large proportion of the overall relationship between chronological age and retirement expectations. There also was a greater proportion mediated via organizational age among females versus males. However, sex differences were not statistically significant overall. Given the potential for these sex/gender differences in the mediating role of age dimensions, future studies should continue to contextualize their findings in relation to sex/gender.

Table 5.4.4. Total, direct and specific indirect effects (standardized coefficients) and proportion of total effect mediated between chronological age, age dimension indicators, and retirement expectations, stratified by sex.

	Male		Female		Both		Test
	Coefficient	**% Med.**	**Coefficient**	**% Med.**	**Coefficient**	**% Med.**	**diff.**
INDIRECT VIA FUNCTIONAL AGE							
FA1 Chronic conditions	0.008	4%	0.001	0%	0.005	2%	N.S.
FA2 Social participation restrictions	0.000	0%	0.000	0%	0.000	0%	N.S.
FA3 Physical activity restrictions	-0.001	0%	-0.001	0%	-0.001	0%	N.S.
FA4 Activity limitations due to pain	0.000	0%	0.000	0%	0.000	0%	N.S.
FA5 ADL and IADL limitations	0.001	0%	-0.001	0%	-0.001	0%	N.S.
FA6 Physical activity scale	**-0.003**	**-1%**	0.000	0%	-0.001	0%	**<0.01**
FA7 Change in driving abilities	0.002	1%	0.003	1%	0.003	1%	N.S.
INDIRECT VIA PSYCHOSOCIAL AGE							
PA1 Self-rated own healthy aging	0.000	0%	0.000	0%	0.000	0%	N.S.
PA2 Feeling hopeful about the future	-0.002	-1%	-0.001	0%	-0.001	0%	N.S.
INDIRECT VIA ORGANIZATIONAL AGE							
OA1 Organizational/industry tenure	**0.014**	**6%**	**0.021**	**8%**	**0.017**	**7%**	N.S.
INDIRECT VIA LIFE-STAGE AGE							
LA1 Children living in household	**0.048**	**22%**	**0.080**	**30%**	**0.062**	**25%**	N.S.
LA2 Dwelling ownership status	**0.019**	**8%**	**0.017**	**6%**	**0.018**	**7%**	N.S.
LA3 Retirement status of spouse/partner	0.019	8%	**0.029**	**11%**	**0.023**	**9%**	N.S.
LA4 Caregiving responsibilities	0.004	2%	-0.003	-1%	0.001	0%	N.S.
LA5 Years lived in the community	-0.001	0%	0.001	0%	0.000	0%	N.S.
Sum of indirect	**0.108**	48%	**0.145**	54%	**0.123**	50%	N.S.
Direct	**0.119**	52%	**0.122**	46%	**0.121**	50%	N.S.
Total	**0.227**	100%	**0.267**	100%	**0.244**	100%	**<0.01**

[1] *Specific indirect relationships for each age dimension are displayed in grey shade.*
[2] *P-value from Wald chi-square test for differences in estimates between males and females; significant estimates are in bold font.*
[3] *CLSA baseline data, ages 45-64 years, worked in the past year.*
[4] *Estimates are weighted to account for complex sampling design.*

5.5 Study #3 Supplementary

5.5.1 Role of injury severity

Background

In Study 3 (Section 4.3), we examined the role of age dimensions in explaining the overall association between chronological age and RTW outcomes using longitudinal survey data on injured workers in Victoria, Australia. For analyses, injury severity was conceptualized as a confounder of the relationships between the exposure, mediator and outcome variables. However, injury severity has been conceptualized as an important driver or mediator of age-related differences in RTW and wage-replacement outcomes in previous studies (13,14), with some studies finding that age differences in RTW are no longer significant after adjustment for injury severity and other factors (14). Thus, there may be theoretical situations where a mediator-outcome confounder is affected by exposure. If injury severity served as a confounder of the mediator-outcome relationship (e.g., associated with both functional age items and RTW) while being driven by chronological age, then estimation of mediated effects via age dimensions would be hindered given the conflicting need to control for injury severity as both a confounder and mediator in the path models. However, this situation could be treated as a parallel mediation model with residual covariances specified between the mediators rather than directed paths (15,54). See **Figure 5.5.1** for a path diagram depicting these relationships.

Methods

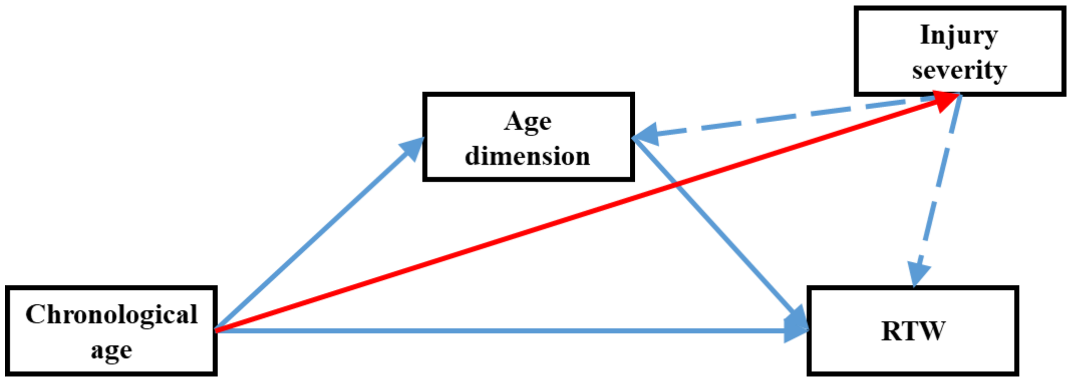
Using the initial models presented in Section 4.3.5, we tested the inclusion of self-reported injury severity as a mediator, rather than confounder, by adding an additional indirect pathway in parallel with the other age dimensions.

Results

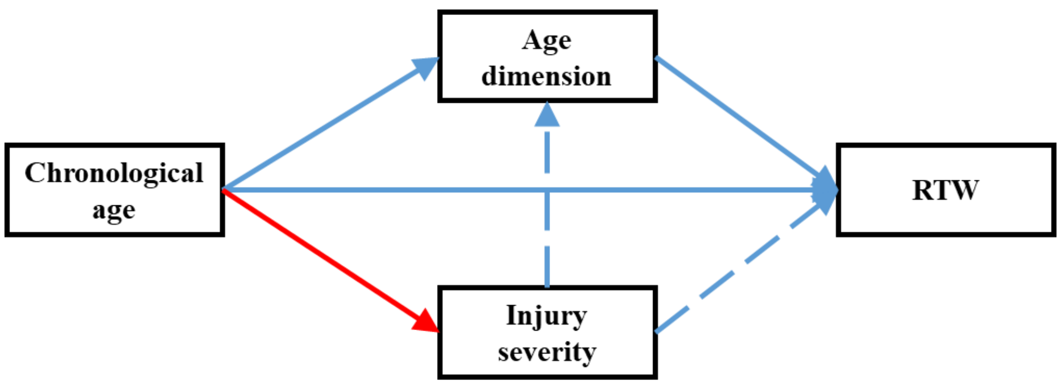
Findings suggest that for non-RTW outcomes at T1, the indirect association (a*b paths) of chronological age on non-RTW via injury severity was standardized beta 0.018 (95% CI: 0.003 to 0.040) and thus there was a statistically significant indirect pathway via injury severity. However, given that chronological age was only moderately associated with greater injury severity in the adjusted models (and not associated with age in the descriptive models), these findings were only marginally significant and did not reach significance with symmetric confidence intervals (p-value 0.069) (64). Moreover, the indirect association of chronological age on non-RTW T1 via life-stage age remained unchanged compared to the model with injury severity as a confounder. Future work could continue to investigate the role of injury related factors and/or incorporate additional measures of severity. These findings are discussed in more detail in **Section 6.4.3**.

Figure 5.5.1. Path diagram of mediation model examining the relationship between chronological age, age dimensions and return-to-work outcomes, with injury severity as an intermediate confounder (mediator-outcome confounder affected by exposure).

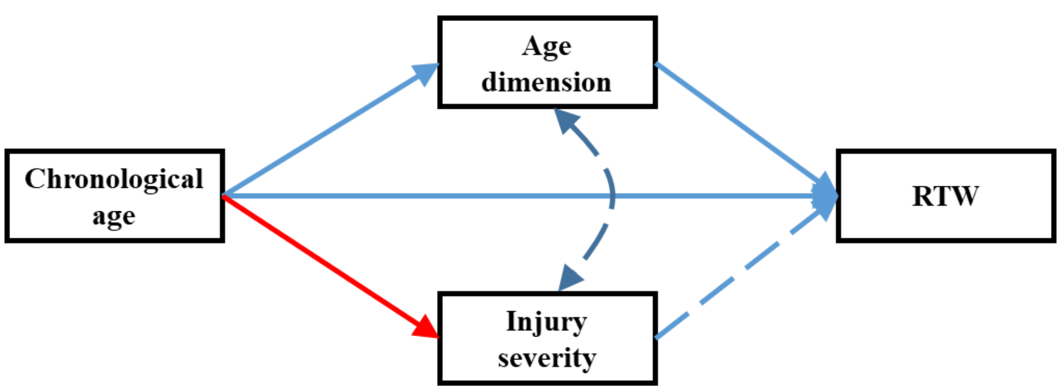
A) Intermediate confounder:



B) Serial mediator specification (equivalent to A):



C) Parallel mediator specification:



5.5.2 Mediation of wage-replacement duration

Background

In Study 3 (Section 4.3), we examined the role of age dimensions in explaining the overall association between chronological age and RTW outcomes using longitudinal survey data on injured workers in Victoria, Australia. Given the availability of linked workers' compensation claims data, we replicated the mediation analyses using wage-replacement duration as the outcome to compare and contrast the findings with RTW outcomes.

Methods

Wage-replacement duration was defined as the cumulative number of days that the worker received temporary benefit payments for time off work due to injury/illness, as captured in the linked claims data. Wage-replacement days were ascertained over a two-year calendar period following the first day of incapacity. The first day of incapacity corresponds to the first day of work absence that is deemed to be due to the current injury or illness, obtained from the medical certificate of incapacity.

Generalized linear regression models to estimate the relative mean difference in days of wage-replacement across chronological age groups, using a Poisson distribution and log link function to account for the skewed distribution of days. All regression models were fully adjusted for covariates, but unadjusted for the age dimension mediators to quantify the total effect of chronological age.

Path analyses examined the mediating role of age dimensions in explaining the total relationships between chronological age and wage-replacement duration. Wage-replacement days were log-transformed to account for the skewed distribution of days.

Results

Table 5.5.2 presents the overall relationship between chronological age and days of wage-replacement benefits. Older chronological age was associated with a greater duration of wage-replacement compared to the youngest age group, with the 55+ age group having the largest difference (i.e., 63% increase in mean days). However, there was no ordinal gradient in point estimates across age groups.

Figure 5.5.2 presents the path models examining the mediating role of age dimensions in explaining wage-replacement outcomes. We found a total association (*c*-path) between older chronological age and greater days of wage-replacement (standardized beta 0.149). We also found that older chronological age was associated with each of the four age dimensions at T1 (*a*-paths), with standardized betas ranging from 0.224 to 0.485 across age dimensions. However, none of the age dimensions were significantly associated with wage-replacement duration (*b*-paths), although collectively, they accounted for a 27% of the absolute total association. As a result, the remaining direct association of older chronological age on wage-replacement duration (i.e., not via age dimensions) was standardized beta 0.145 (0.145 / 0.199 = 73% of the absolute total association).

Table 5.5.2. Relationship between chronological age and non-RTW (proportional odds of being off work versus working for a sustained period) and wage-replacement duration (relative increase in mean days).

	OUTCOME A: NON-RTW STATUS (FROM SECTION 4.3.9)			**OUTCOME B: WAGE REPLACEMENT**
	T1	T2 [2]	T3 [3]	Days from incapacity [4]
	n = 776	*n = 566*	*n = 456*	*n = 660*
	OR (95% CI)	*OR (95% CI)*	*OR (95% CI)*	*Ratio of mean days (95% CI)*
Age group				
18-34 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)	1.00 (ref.)
35-44	**1.75 (1.16, 2.66)**	1.48 (0.83, 2.63)	0.83 (0.42, 1.62)	**1.38 (1.07, 1.80)**
45-54	**2.27 (1.53, 3.38)**	1.28 (0.74, 2.23)	**0.41 (0.21, 0.81)**	**1.39 (1.09, 1.78)**
55+ years	**2.97 (1.91, 4.64)**	**2.08 (1.16, 3.72)**	0.87 (0.44, 1.73)	**1.63 (1.24, 2.14)**

[1] *Adjusted for sex, injury type, injury severity, union status, work hours, psychosocial conditions.*

[2] *Additionally adjusted for lagged RTW status (T1).*

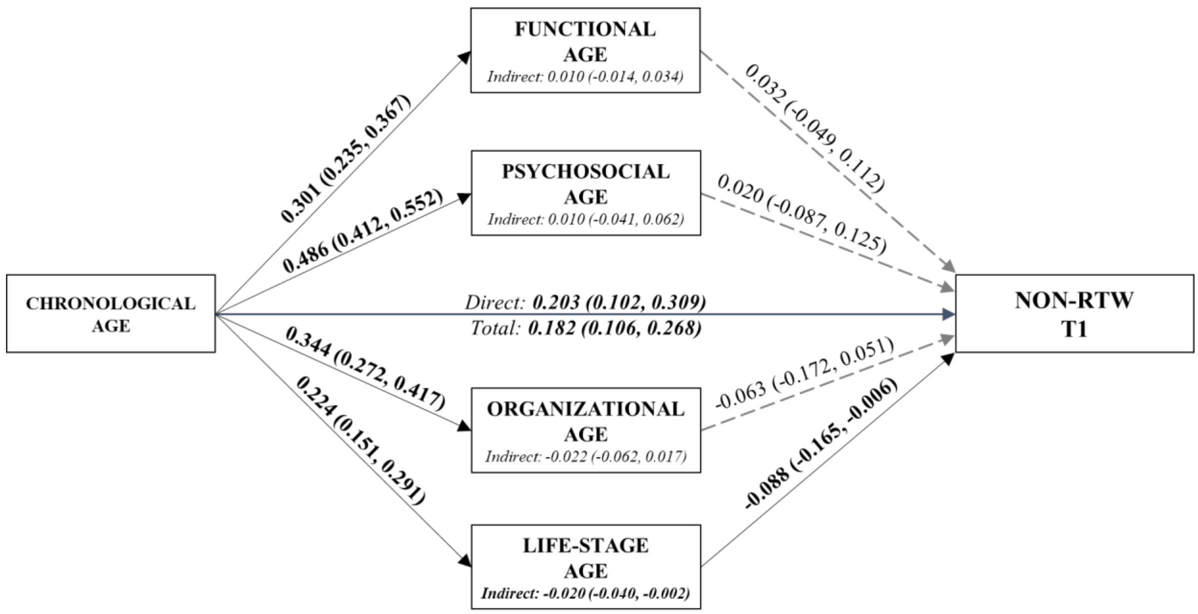
[3] *Additionally adjusted for lagged RTW status (T2).*

[4] *Days of wage-replacement since date of incapacity, censored at 2-years post-incapacity.*

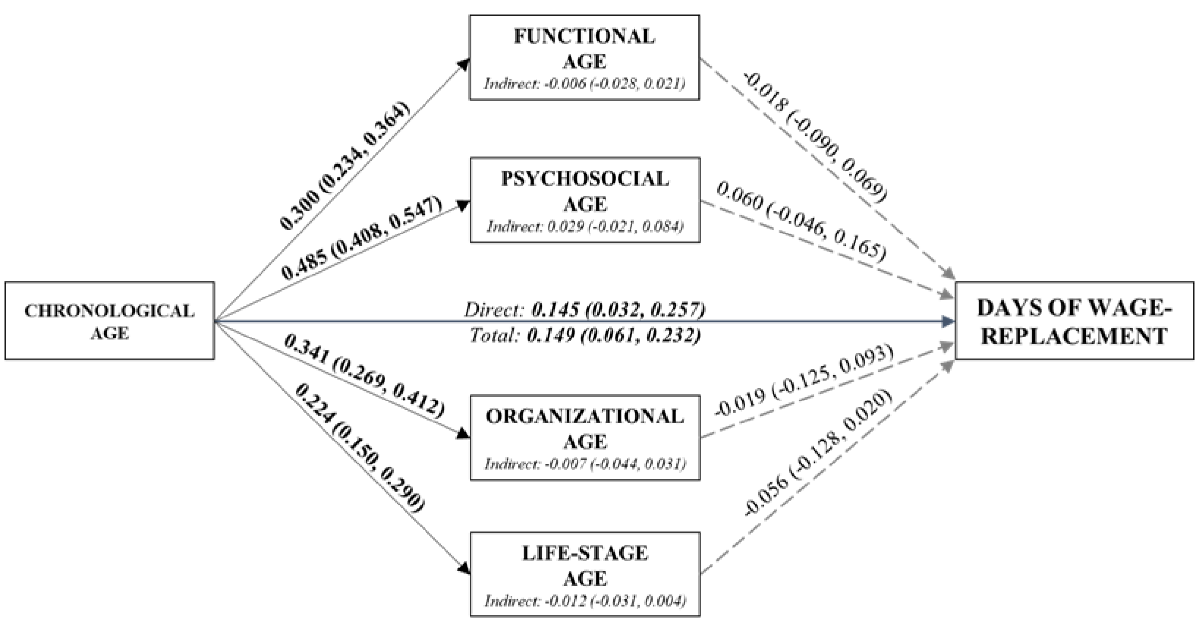
[5] All models adjusted for covariates [1], but exclude the age dimension mediators.

Figure 5.5.2. Path model examining relationship between chronological age, age dimensions and non-RTW outcomes at T1, comparing survey and administrative definitions.

PANEL A: NON-SUSTAINED RTW (FROM SECTION 4.3.9)



PANEL B: WAGE-REPLACEMENT DURATION



[1] *Standardized coefficients with bootstrapped 95% confidence intervals.*
[2] *Adjusted for sex, injury type, injury severity, union status, work hours, work conditions.*
[3] *Model fit Panel A: Chi-Sq 9.4, df 9, p=0.40; RMSEA 0.008, 90% CI: <0.042; CFI 1; TLI 0.99.*
[4] *Model fit Panel B: Chi-Sq 10.9, df 15, p=0.76.*

5.5.3 Time-varying hazards

Background

In Study #1, we examined the phase-specificity of the RTW and recovery process among Canadian workers' compensation claimants by reporting on absolute and relative hazard estimates that allow for time-varying effects of age (rather than a single, pooled summary measure). Given that Study #3 (Victoria RTW longitudinal cohort) had access to linked workers' compensation claims data, we ran similar analyses to compare and contrast the findings across the two study samples.

Methods

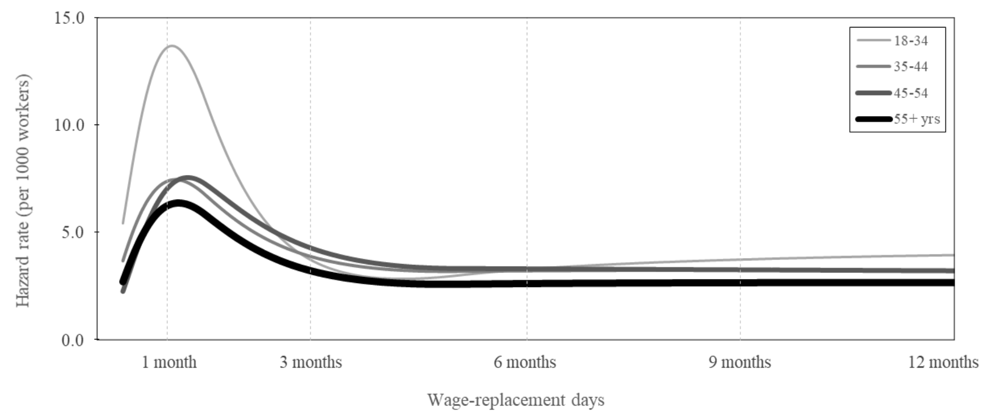
Survival regression was used to estimate the hazard of exit from wage-replacement benefits (i.e., termination of benefits and likely resumption of work duties) across chronological age groups using a flexible parametric specification with restricted cubic splines (10), as described in Section 4.1.4.

Results

Consistent with Study #1, the findings suggest that older chronological age was associated with greater duration of wage-replacement in a graded fashion, but that this pattern was not observed consistently across study follow-up time. **Figure 5.5.3** presents findings on wage-replacement outcomes but allowing for non-proportional hazards by age group. Overall, the hazard rates of wage-replacement exit (**Panel A**) were greatest in the first month of follow-up, with the highest rates observed for the youngest age group (18-34 years: 13.7 exits per 1000 workers) and the lowest rates observed for the oldest age group (55+ years: 6.4 exits per 1000 workers). This was followed by a decrease during the second month, and then a decline to 3 to 4 exits per 1000 workers beyond the third month. As a result, the greatest absolute and relative differences in rates across age groups (**Panels B and C**) were observed only during the initial month of follow-up. However, beyond one month of follow-up, the absolute and hazard differences attenuated to non-significance and fluctuated about the null. Also, while there was an ordered gradient in curves across age groups during the initial month of follow-up, there was a subsequent crossing-over of curves for the middle age groups (35-44 and 45-54 years) beyond this point.

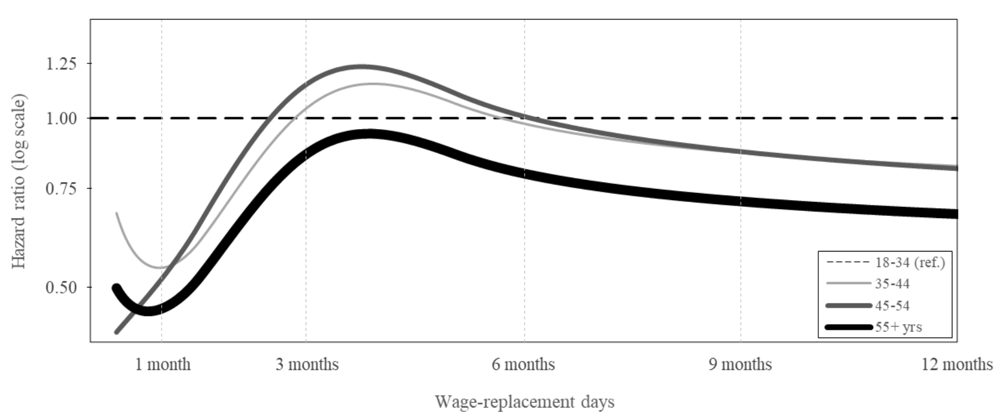
Figure 5.5.3. Adjusted hazard rates, rate differences and rate ratios for wage-replacement exit, by age group and study follow-up time.

A) HAZARD RATES:



B) HAZARD DIFFERENCES:

C) HAZARD RATIOS:



[1] *Adjusted for sex, injury type, injury severity, union status, work hours, psychosocial conditions.*
[2] *Estimated using flexible parametric models with cubic splines at the 33rd and 67th centiles (baseline hazard function) and the 25th, 50th and 75th centiles (time-varying covariates) of uncensored log survival times.*
[3] *Differences <0 and ratios <1.00 correspond to a longer duration for a given age group.*
[4] *Graphs display the first 12-months of follow-up time.*

5.5.4 Unmeasured confounding

As noted in Section 5.1.2, the estimation of total, direct and indirect effects for the path models in Study 3 were based on the assumptions of no unmeasured confounding of the exposure–outcome, mediator–outcome, and exposure–mediator relationships (11,12). However, given the observational study design, there is the potential for unmeasured confounding. To test the robustness of this assumption, we calculated the E-value (65) to describe the maximum strength of association that an unmeasured confounder would need to have in relation to both the exposure and outcome variables in order to completely attenuate the exposure-outcome relationship to the null. Focusing on the total association between older versus younger age groups (55+ vs. 18-34 years) and non-RTW at T1 presented in Table 4.3.3 (OR 2.97, 95% CI: 1.91-4.64), an unmeasured confounder would need to exhibit a relationship with both the exposure and outcome on the order of OR 2.84 (95% CI lower limit: OR 2.11). This suggests that a moderate to strong level of unmeasured confounding would be required to explain away the observed total association between older age and non-RTW.

5.6 Missing data

Across all three dissertation studies, listwise deletion was used to exclude observations with missing data on exogenous covariates. For Study 1, which was based on administrative claims data, the extent of missing data was 1.45% of the total study sample (11,071 / 762,750). For Studies 2 and 3, which were based on survey data, the extent of missing data ranged from 4.6% (833 / 17,938) to 10.7% (93 / 869), respectively, although a broader range of covariates was included in comparison to Study 1. Given that the proportion of missing covariate data was not extensive across the study samples, it is unlikely that the findings will be biased to a great extent based solely on the proportion of missing data alone.

For Studies 2 and 3, there also was missing data on endogenous variables, including the age dimension mediators. For example, in the CLSA, data were missing on functional age (9.0% of the sample), psychosocial age (7.5%) and life-stage age (1.2%). In the RTW cohort, data were missing on psychosocial age (10.0% of the sample) and functional age (1.9%). The RTW cohort also was missing outcome data for individuals who were lost to follow-up across study waves (e.g., 210 / 776 = 23% at 6-months follow-up). To accommodate missing data on these endogenous variables, all path models were estimated using full-information maximum likelihood, which models missing data as a function of both observed covariates and observed outcomes under the assumption that missing data are missing at random.

Note that a separate, but related, issue is the potential for differential loss to follow-up in the RTW cohort (66). Logistic regression examined the odds of participating in follow-up waves in relation to age, gender, injury type, and RTW status at baseline. Analyses found that younger age groups (18-34 , 35-54 years) were more likely to be lost to follow-up compared to the oldest age group (55+ years). The other examined covariates were not associated with participation in follow-up waves. Losses to follow-up were primarily due to inability to contact the claimant, although it is unknown whether non-contact was due to incorrect contact details versus active avoidance by the claimant. Thus, there may be differential losses to follow-up to the extent that younger individuals who did not complete the survey differed from completers on their RTW status. Although this represents a potential limitation, the availability of linked survey and administrative data provided an opportunity to examine a complementary measure of wage-replacement duration (Section 5.5.2), which was ascertained passively over time.

5.7 Synthesis of findings

The aim of this chapter was to provide a focused set of analyses to serve as a methodological complement to the main findings presented in Chapter 4. The first set of analyses on cross-jurisdictional differences in the relationship between older age and wage-replacement duration (Section 5.3) served as a validation and generalizability check for Study #1. However, there were remaining questions on what system and policy-level features may be driving the residual age-inequalities given the lack of attenuation of age gradients by region. Analyses focusing on specific system and policy drivers of age differences in wage-replacement duration are beyond the core scope of this dissertation but are worthy of a separate theme of research on the impact of policies across time and jurisdiction using quasi-experimental research designs (31,32). These issues are discussed in more detail in **Section 6.4.1**.

The results presented in Section 5.4 and 5.5 suggest that the main dissertation findings are methodologically sound and robust to changes in the conceptualization and measurement of outcome variables (i.e., retirement planning activities versus planned age of retirement), inclusion of additional covariates (i.e., injury severity as a mediator versus confounder), and use of various mediation modelling techniques (i.e., use of potential outcomes versus path models). Moreover, the replication of the findings of time-varying hazards (Section 5.5.3) using data from different sources, contextual settings and geographic regions strengthens the conclusion that overall age gradients are not observed consistently across study follow-up time. Taken together, the overall consistency of findings across these methodological changes suggests that the direct effects of chronological age on work outcomes are robust but that age dimensions and timing of follow-up can explain a portion of this relationship. Moreover, the consistency of findings across analytic methods suggests that alternative explanations for these findings may be limited to issues of measurement error of the age dimensions or unmeasured mediators. These issues are discussed in more detail in **Sections 6.5.2** and **6.5.3**.

Finally, although the age dimensions accounted for a similar proportion (approximately 25%) of the overall relationship between age and non-RTW (Section 4.3), and age and wage-replacement duration (Section 5.5.2), the findings were only significant in relation to non-RTW. The lack of mediation findings across both outcomes suggest that age dimensions may be relevant only for some, but not all, measures of disability duration (67,68). On the other hand, we conceptualized cessation of wage-replacement benefits as a proxy measure for RTW (28,67,69), denoting the likely resumption of work duties. Actual work status may differ due to transitions to other benefit types (e.g., vocational rehabilitation) or early claim termination. Thus, we anticipated some discordance between the measures (70) whereby respondents may have returned to work in some capacity while still receiving benefits or have remained off work without receiving any wage-replacement. Moreover, the use of a cumulative measure of disability duration limits the ability to examine the phase-specificity the RTW process across follow-up waves. Future mediation analyses might benefit from a longitudinal approach to provide insight on the potential public health impact of interventions applied during various phases of the RTW process. These issues are discussed in more detail in **Section 6.4.3**.

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Chapter 6
Discussion

6.1 Reader's note

This chapter provides a synthesis of findings and common themes across the three studies; highlights research, scientific and policy implications; discusses methodological limitations; and offers recommendations for future research to address remaining gaps.

6.2 Summary of key findings

The overarching aims of this dissertation were to investigate similarities and differences in work outcomes among older versus younger workers; demonstrate a methodological approach that could be used to create indices of age dimensions using existing data sources that were not originally collected for this purpose; and to better understand whether differences in work outcomes across chronological age groups can be explained via age dimensions. Three distinct research studies were conducted using novel research methods and a variety of administrative and survey data sources to address each of the objectives. Overall, the studies contribute to the epidemiologic literature by addressing existing gaps and data limitations in operationalizing each age dimension using a broader range of data sources with relevant work outcomes where direct measures had not been collected; and by incorporating novel analytic frameworks that had yet to be evaluated in the context of retirement outcomes and RTW. Prior to this dissertation, these analytic models had yet to be evaluated with all four age dimensions in the context of retirement planning and RTW following workplace injury (1). The studies also extend previous work by addressing analytical limitations in the estimation of time-varying hazards across the trajectory of follow-up (2) while examining both self-reported and administrative definitions of work outcomes within one study sample (3,4). Finally, the studies capitalize on recent initiatives in the development of multi-jurisdictional workers' compensation claims databases for research purposes (5–8) by assessing the generalizability of findings across regions and identifying sources of variation for future investigation (5–8).

Study #1 (Objective #1) found that older age groups exited wage-replacement benefits at a slower rate (i.e., greater disability duration) compared to younger age groups in the overall models. However, the greatest age-related differences were observed at earlier event times and were attenuated towards a null difference across later follow-up event times.

Study #2 (Objective #2) found that chronological age was associated with all age dimension scores in expected directions; that chronological age was associated with earlier retirement expectations overall; and that 25-30% of the total relationship between chronological age and retirement intentions was mediated through life-stage and organizational age. The strong links between chronological age and each dimension (as demonstrated by the significant 'a' paths outlined in Figure 2.1), yet low correlations between the dimensions, suggests that the derived measures are a good fit with multidimensional age constructs as proposed in existing models. However, the study also found that the age-related survey used for analyses did not contain enough questions that could be used to adequately assess all the measures of age.

Study #3 (Objective #3) found that older chronological age was associated with non-RTW and greater duration of wage-replacement in a graded fashion, but that differences were only present during the initial waves of follow-up. The study also found that a proportion of the overall relationship between age and non-RTW was explained by functional age and RTW status at earlier time points; that life-stage age had a protective effect on RTW; and that approximately 75% of the overall relationship remained unexplained by age dimensions.

Finally, the sensitivity analyses presented in Chapter 5 provided robustness checks to the main analyses and identified areas for future research initiatives. Analyses confirmed that the time-varying hazards observed in Study #1 were generalizable across different data sources, study samples and geographic regions; and that overall age gradients in disability duration were not modified to a great extent by workers' compensation system factors. The analyses also demonstrated that the mediation findings in Studies #2 and #3 were similar using path analyses versus the potential outcomes framework, suggesting that alternative explanations for these findings are limited to the measurement of age dimensions, additional mediators or persistent direct effects of chronological age (rather than analytic methods or model specification issues).

6.3 Significance

6.3.1 Research and methods

This dissertation demonstrated a methodological approach that could be used to create indices of age dimensions using existing data sources that were not originally collected for this purpose. In developing the age dimensions, we selected sources of data that had a collective focus on understanding aging and age differences as part of their study design (9,10). However, the dissertation also found that the two age-related surveys identified for analyses did not contain enough questions that could be used to adequately assess all the measures of age. Thus, further work is needed to form a more complete understanding of the role of some age dimensions as they relate to worker populations (discussed in more detail in **Section 6.4.2**). This includes the role of psychosocial age, which was challenging to measure using the existing data sources. One implication of this finding is that age dimensions may need to be measured using validated scales as is done currently (11,12) but not consistently across data collection. For example, psychosocial age is measured in surveys such as the US Health and Retirement Study (“What age do you feel?”) and the English Longitudinal Study of Ageing (“How old do you feel you are?”) (11,13), based on earlier work from Kastenbaum (14). The Health and Retirement Study also measures self-perceptions of one’s own aging using items from the Attitudes Toward Own Aging subscale of the Philadelphia Geriatric Center Morale Scale. Accordingly, the most direct way to capture the above age dimensions would be to incorporate these valid and reliable scales developed in previous studies. The decision to include these items should be balanced with ongoing theoretical and methodological issues that are the subject of current research (15,16), as described in Section 2.5.2.

There also was limited data on organizational age factors across the study samples. As a first step, large population-based survey initiatives should strive to capture data on job histories or psychosocial work conditions (17,18) as this information would be useful for basic statistical adjustment or assessment of detailed work exposures. The next step would be to capture additional measures of organizational aging such as career stage, job tenure, skill obsolescence, remaining career opportunities, and contextual age norms within the organization (19). For example, Zacher (20) developed a five-item scale to measure organizational age norms in terms of whether an older (versus younger) employees were viewed within the company as being efficient, flexible, motivated, high in initiative, or reliable. Other studies have used the Career Concerns Inventory (1) to measure organizational age. These measures of career stage or skill obsolescence are especially important to collect in the work context given that organizational stakeholders tend to define “older” workers using an organizational age approach (19).

As demonstrated in this dissertation, age dimensions can interrelate or act in opposite directions for a given outcome. Had the age dimensions not been incorporated, findings would have equated the total effects of chronological age with the underlying direct effects of chronological age and thus would have missed the differential impact of underlying functional versus organizational versus social aspects of aging. Thus, researchers might find value in examining multiple age dimensions within one conceptual model to better understand the magnitude and direction of any competing pathways (21). This can be accomplished using the path model approach that was outlined in Section 3.4. Complex interactions among the exposures, mediators and outcomes also can be incorporated into these models using the potential outcomes approach (22), although decomposition of total effects in the presence of multiple mediators and interactions is a current area of research (23–25). Taken together, the methodological approach validated in our study provide the necessary practical guidance on how to operationalize a stronger conceptualization of age in order to better understand age-inequalities in work-health outcomes.

Finally, findings from this dissertation suggest that the traditional reliance on a single summary measure (e.g., proportional hazards estimates) might overstate the nature of the relationship between age and disability duration by weighting the estimates towards the larger differences observed at earlier follow-up times, while misrepresenting the smaller age effects during the middle to later phases of follow-up. This time-varying nature of RTW suggests that value can be added to the estimation of survival effects by incorporating robust analytic methods to estimate both absolute and relative measures of association, as well as time-varying effects across follow-up (2,26). These methods are underutilized in the research literature despite being readily available in standard software packages (26). Future research and data development initiatives should consider the utility of incorporating linked longitudinal survey data to characterize the time-varying role of work and health outcomes that occur beyond the point of censoring or termination of benefits (27).

6.3.2 Addressing age-related stereotypes

The finding that age differences in work-disability duration may not be consistent across all time periods and contexts demonstrates that a fatalistic view of older workers is not supported by the evidence (15,28,29). Often, there is an unbalanced focus on negative aspects of older chronological age compared to positive aspects, which fuels pessimistic/fatalistic perceptions about older workers. Recent scoping reviews also have identified a number of negative age-related stereotypes in the workplace setting, many of which are lacking empirical evidence to support the claims (30). Instead, a focus on age-related conceptualizations may be advantageous in shifting the conversation away from non-modifiable aspects of the aging process (such as chronological age) while challenging the notion that differences in work outcomes across chronological age groups are consistently observed. Moreover, the structuring of organizations and society around chronological age also carries the risk of encoding negative stereotypes that may lead to discriminatory practices directed towards older workers (19). This is evident in the language used to label older versus younger workers in the research and policy discourse, which carries the risk of perpetuating age-related stereotypes and discrimination (15,19,31). By employing a multidimensional conceptualization of aging, we can discuss aging with more balanced and precise terms.

On a related theme, while this dissertation is focused on understanding age differences in work outcomes among older workers, younger workers also may face distinct challenges to health, safety and age-related stereotyping in the workplace (32). Although age dimensions could be used to understand work outcomes among younger workers, they are typically applied in reference to an older working population (1). However, future research and policy efforts should consider how age dimensions could be defined and conceptualized with relevance to younger workers (19), including a better understanding of the multidimensional nature of age and the underlying risk factors as they apply to younger chronological age groups.

6.3.3 Policy implications

The findings from this dissertation can be used by workers' compensation stakeholders to better understand the time-varying nature of RTW rates and identify individuals that may require early interventions or workplace supports. For example, if large relative effect sizes are present where absolute differences are small, then this may have less impact on the total burden of disability duration among older workers (6). On the other hand, if interventions were targeted towards the earlier phases of recovery (where both absolute and relative differences between older versus younger workers were found to be large), then this would help to address challenges to recovery that workers may encounter if they do not achieve early and sustained RTW (33). As demonstrated in the dissertation, age differences in RTW at later follow-up times may be driven by a cumulative effect of non-RTW across the length of follow-up, highlighting the importance of early intervention. Potential RTW interventions could include vocational rehabilitation and claims management activities, such as return-to-work planning, worker education/training, active workplace communication or modified work duties (34,35). While these interventions tend to be consistent with general best practices for all workers (36), there may be an additional benefit of having greater effectiveness among older versus younger workers in some settings, as demonstrated in previous studies (37).

The findings also have implications for the development of interventions at the organizational or workplace-level that are focused on providing workplace supports for older workers (38,39). Across the dissertation studies, there was a minimal role of health and functioning factors in explaining the overall relationship between chronological age and work and health outcomes.

This suggests the importance of, and continuing need to, ensure adequate workplace accommodations and fit between the person and their job (36,39–41), as these may serve as a buffer for underlying health limitations and facilitate early and safe RTW (36,39). On the other hand, the significant mediating role of life-stage age and organizational age demonstrates the importance of identifying the underlying drivers of these differences rather than focusing on chronological age differences alone. Although many of the age dimension items (such as having a spouse not working, no children in the household, caring for family members, or greater years of organizational tenure) are natural life-course events that would not be targeted for interventions, there may be a case for developing policies to support these individuals with flexible working arrangements to alleviate workplace stress and improve workplace supports and accommodations (36,39,42,43).

It is important to note that the dimensions developed in this dissertation only provide some exploratory directions for the development of individual and workplace interventions (39), and thus policy makers should consider the strengths and limitations of the methodological approach before using the findings to inform any policies or practices. While the age dimensions provide a useful next step in understanding the underlying factors that may contribute to age inequalities in work outcomes (39,44,45), the collection of additional age dimension indicators could provide more information on specific target points for intervention. This data could include direct assessments of psychosocial age or organizational age to provide a fuller assessment of age dimensions. For example, while greater job tenure may be a proxy for greater organizational age, measures of career stage or skill obsolescence (1) would help policy makers understand how “older” workers are defined as such within the work context (19). Similarly, measures of organizational age norms (20) would provide a better understanding of how older (versus younger) employees are viewed within the company in terms of being efficient, flexible, motivated, high in initiative, or reliable. By better understanding how an individual is conceptualized as being "older" in the workplace in terms of more advanced career stage or implicit age biases (19,28), organizations and policy makers can begin to address how these individuals could be better supported with flexible working arrangements, control over job scheduling, or re-training opportunities (39). Moreover, the importance of early intervention has been noted in previous studies (27,46), yet previous research examining workers' compensation claimants (47) found that older workers may be less likely to receive offers of modified work duties compared to younger workers. Thus, the collection of organizational age indicators could be useful in the workers' compensation setting by better targeting individuals that may require support with workplace accommodations or anti-discriminatory policies (36,39). Taken together, the dissertation findings provide useful information on areas for future intervention research, although existing data sources may not contain enough questions that could be used to adequately assess all the measures of age. This calls for the collection of better data on age dimensions to gain a more detailed understanding of the mechanisms that produce inequalities across age groups.

6.4 Interpretation

The findings outlined in Section 6.2 and 6.3 emphasize the distinct contributions of the research studies towards gaining a better understanding of the relationship between chronological age and work outcomes. The following section discusses the study contributions from an analytic perspective, highlighting key themes and addressing discrepancies in findings.

6.4.1 Overall age differences in RTW outcomes are not consistent

Variations across phase of recovery

An overarching theme across the three studies is that, while older chronological age was associated with differences in work outcomes, this relationship was not consistent given the noted variations across time and context. The process of recovery following a work-related injury or illness is complex. Within the workers' compensation system, the process is embedded not only within health needs and treatment, but also within organizational and social contexts that may change over time (27,46,48). Thus, one explanation for the lack of sustained association between age and wage-replacement outcomes across follow-up could be due to unique contextual factors that operate during later phases of the recovery and claim process (49,50). Offers of modified duties and early contact with care providers may be important factors that facilitate the RTW process following a workplace injury (27,33–35). If younger workers are more likely to receive offers of modified work duties compared to older workers during the initial phases of follow-up (47), then these greater work accommodations might be one explanation for why younger workers had the greatest likelihood of returning to work and a reduced duration of wage-replacement benefits during the initial months of follow-up. On the other hand, older workers may be able to take advantage of organizational resources or seniority (51), thereby allowing them to maintain their current hours and job type during later phases of recovery. Previous studies have found that older workers may be more likely to be on modified work duties throughout the recovery process (52), potentially due to differences in job tenure or engagement in types of work that are more amenable to modifications than the work of younger workers. As such, limited offers of modified duties during the initial phases of recovery may play less of a role as the claim progresses.

Experiences with the claim process also might attenuate age differences in RTW. For example, previous studies (53) have found that claim experiences are rated more positively among older versus younger workers and that positive experiences are associated with greater likelihood of sustained RTW. If claim experiences were rated more positively during later phases of recovery, then these experiences might serve as a buffer of any negative pathways between chronological age and work outcomes, resulting in an attenuation of age inequalities. In contrast, differences in claim processing times during the initial period of recovery might exacerbate age differences in work outcomes, given that processing times (and thus the total disability duration window) may be shorter among younger versus older workers (54).

Variations by jurisdictional context

The supplementary analyses in Section 5.3.1 aimed to document and describe differences across jurisdictional setting, given that most studies examining age and work outcomes are based on data from single jurisdictions (5). Although there was some variation in absolute differences in wage-replacement outcomes across provinces, the general consistency in relative age gradients has several interpretations. The first is that overall age gradients may not be modified to a great extent by broader factors at the level of the workers' compensation system. This finding was counter to the dissertation hypotheses, which anticipated some effect modification given variations in compensation policies across provinces (55). On the other hand, the findings were consistent with studies suggesting that older workers may be less sensitive to differences in sickness absence requirements given that absenteeism may be due, in part, to health-related factors rather than financial incentives (56). Moreover, changes to sickness absence benefits tend to impact shorter duration claims (57). This might have the net effect of exacerbating age-related inequalities as younger workers tend to have shorter durations than older workers (57).

The second interpretation is that proximal-level factors may be driving the differences rather than broader system-level workers' compensation factors (27,38,49,53,58). This is consistent with a study by Anema and colleagues (38) that examined the role of compensation policy variables on

RTW outcomes across six countries. The authors concluded that cross-country differences were mainly driven by differences in applied work interventions (i.e., workplace adaptations, job redesign, and modified duties) rather than structural features of the workers' compensation system. Some of these workplace factors are described above in the previous section.

A final interpretation is that the key contextual factors that are responsible for exacerbating age differences in work outcomes are actually ubiquitous across jurisdictions (28,29). For example, potential variations in negative age-related stereotypes would not be picked up with adequate specificity by the broad adjustment for workers' compensation jurisdiction. These difficulties in comparing the effect of policies across compensation settings, even within one country, have been noted in the literature (59). Given the greater role of proximal factors in explaining variations in RTW (60), future research could examine the modifying role of age-related contextual factors at more detailed levels of resolution, including organizational-level factors (e.g., workplace supports, co-worker interactions or psychosocial work characteristics) or firm types (e.g., unionized versus non-unionized). We also were unable to understand the impact of specific policy features or changes over time within a given jurisdiction (5,38,59). Future research should investigate the impact of these features using quasi-experimental research designs as a separate theme of research (61,62).

6.4.2 Age as a multi-dimensional construct

This dissertation is one of the first to examine the role of different conceptualizations of age in explaining chronological age-inequalities in retirement planning and RTW within one conceptual model. Findings from Studies #2 and #3 demonstrated the strong links between chronological age and each age dimension (i.e., concurrent validity) using two distinct study samples, one of which focused on a general working-age population of older Canadians while the other focused on a sample of workers' compensation claimants with a work injury in Australia. However, some of the age dimensions exhibited stronger associations with chronological age than others. For example, life-stage age varied widely across age groups in the general sample of older workers, and thus had the strongest association with chronological age compared to functional, psychosocial and organizational age. Yet, in the injured worker sample, there was a relatively moderate association between chronological age and life-stage age compared to the other age dimensions.

One potential explanation for these differential findings is the use of different items to measure each of the age dimensions. For example, there was a greater availability of life-stage items in the general worker cohort compared to the injured worker cohort (i.e., additional measures of dwelling ownership status and caregiving responsibilities). Each of these items represents a unique facet of the age dimension that informs the overall content of the age dimension. However, if additional relevant items were to be added to the dimension, then this would be reflected in a changing relationship between chronological age and the given dimension. This is a function of the formative conceptualization that we adopted to define the age dimensions. It is also possible that each item has different weightings or varying levels of "importance" to the overall concept of age across study samples, thus leading to differences in the relationship between chronological age and the summary age index scores.

In contrast, psychosocial age had the strongest relationship with chronological age in the injured worker sample but the weakest relationship in the general working sample. Given the challenges in measuring psychosocial age as noted in Section 6.3.2, this finding is not unexpected. The two measures were not based on validated scales and likely tapped in to different facets of psychosocial age, with one measure focusing on self-perceptions of age in relation to the speed of recovery (injured worker cohort) and the other measure focusing on self-perceptions of general healthy aging (general worker cohort). As discussed in Section 2.5.2, there are ongoing theoretical and methodological issues that are the subject of current research (15,16).

Finally, while there were eight items for functional age across the two cohorts, the injured worker cohort was the only one that contained specific information on functioning for a broader range of individuals (aged 18+ years). The inclusion of a generally healthy working population with narrower age ranges likely led to differences in baseline functioning and reduced item variability across the two study groups. Measurement issues also might play a role in the different associations between chronological age and age dimensions across studies. To the extent that each item is measured imperfectly, then differences in the distribution of the factors across study samples would be reflected in the strength of associations. Thus, the use of consistently measured indicators across studies would be necessary to ensure comparability of the construct across study samples.

In developing the measures, we selected two distinct sources of data that had a collective focus on understanding aging and age differences as part of their study design (9,10). The availability of at least one indicator for each age dimension across the two dissertation study samples highlights the feasibility of creating a measure of underlying age dimensions using existing survey data that was not initially designed to measure age. The indicators within each study also were checked for face validity by the research team and were demonstrated to have concurrent validity with chronological age (particularly functional age and life-stage age indicators). Thus, the available indicators may contribute to a well-developed measure of a given age dimension. However, the dissertation also found that the two age-related surveys identified for analyses did not contain enough questions that could be used to adequately assess all the measures of age.

Taken together, researchers interested in implementing a similar age index should consider the above measurement properties given that the index would be dependent upon the availability and selection of items, differences in cohort inclusion criteria, and item conceptual content. Future research and survey initiatives will likely require the inclusion of direct survey measures for a fuller assessment of age. Future work also should validate any newly created age dimensions (as well as additional indicators) within other samples to understand the variation in items across a broader range of chronological age groups than was available for Study #2 (i.e., ages other than 45-64 years) and other working-age populations than was available for Study #3 (i.e., non-worker's compensation samples).

6.4.3 Age dimensions explained a proportion of the relationship, although there is the potential for inconsistent mediation

The dissertation studies found that a moderate proportion of overall age differences in work outcomes could be explained via the multi-dimensional age constructs. However, there were differences in the specific indirect effects across studies, with life-stage age playing opposite roles for retirement expectations (i.e., earlier retirement intentions) and RTW (i.e., sustained RTW); organizational age and functional age playing a role only for retirement expectations and RTW outcomes, respectively; and psychosocial age playing a minimal role across the two studies.

The opposite direction of mediated effects via life-stage age highlights the differential role in promoting earlier retirement outcomes yet inhibiting non-RTW outcomes following work injury. For retirement outcomes, having a retired spouse/partner may influence a respondent's retirement planning by changing the relative values placed on earnings and leisure time (8,9,12), with a greater emphasis on spending leisure time with a retired spouse (9). Similarly, having no children at home may place less of an impact on economic resources and lead to earlier retirement plans, whereas having financial responsibilities for children or other caregiving responsibilities may lead to delayed retirement plans (63–65). Greater housing wealth and home equity also may provide psychosocial, economic and material resources (66), which in turn may impact subsequent work outcomes (67).

On the other hand, greater life-stage scores were associated with RTW in the protective direction. Findings from previous studies are mixed in terms of the significance of the role of family status or number of dependents in explaining RTW outcomes (49,68), although the association seems to be in the direction of reduced disability duration and earlier RTW among those with a spouse/partner off work or no children in the household (68–71). Support from the family, including both material and emotional support, may be one reason for facilitation of RTW among injured workers with spouses (42).

Although organizational age was associated with greater proximity to retirement and earlier intentions to retire among the general working-age sample, it was also associated with RTW outcomes in the protective direction (albeit not significantly). One explanation for the difference in findings across outcomes may be the importance of financial resources or pension availability among those with greater work tenure, which may facilitate earlier retirement (72). Skill obsolescence or career plateau, which may be correlated with greater organizational tenure, may also reduce motivation to continue working, which in turn may lead to earlier retirement intentions (1,73). Yet, these factors may play an opposite role in RTW among injured workers who are receiving workers’ compensation benefits for wage-replacement or rehabilitation. For example, older workers with greater tenure might be subjected to restrictions in labour market mobility, delayed RTW or job-lock due to the desire to maintain the benefits required to address underlying health conditions (74,75). In contrast, previous studies have found that older workers with greater tenure may be able to take advantage of organizational resources or seniority (51), thereby allowing them to maintain current hours and job types while receiving the necessary amount of disability benefits required for sustained RTW (75,76). Thus, while organizational age may be important to include as part of a multi-dimensional age construct, there are unique differences in causal theory across each of the study outcomes that may explain some of the discrepancy in findings.

The finding that functional age played less of a role for both retirement and initial RTW outcomes is consistent with previous studies demonstrating a weaker link between health and functioning-related factors (40,77–80). For example, while retirement planning decisions may be influenced by health-related factors (81), workers with functional limitations or health conditions may be able to receive adequate supports in the workplace to address these limitations (40,41). The lack of specific measures on work-related functioning in the retirement sample (as described in Section 6.4.2) may also explain why functional age had a limited role in explaining retirement outcomes, yet a moderate role in explaining RTW outcomes at T2. The finding of a lack of mediation via psychosocial age also is consistent with previous studies questioning the predictive role of psychosocial age (82). However, the lack of mediation via psychosocial age items is likely also due to incomplete measurement of the underlying age dimension (as noted in Section 6.4.2).

Finally, as demonstrated in Section 5.5.2, we found no evidence of mediating pathways between chronological age, age dimensions and duration of wage-replacement. The cessation of wage-replacement benefits was conceptualized as a proxy measure for RTW and resumption of work duties (3,8,83). However, actual work status may differ given that respondents can either return to work in some capacity while still receiving benefits, or remain off work without receiving any wage-replacement (4), leading to some discordance between the measures. Moreover, as found in Study #3 and Section 5.5.3, there was an attenuation of age estimates and lack of consistent age gradient across follow-up time. Thus, another explanation for the lack of mediation in wage-replacement duration could be the time-varying nature of age estimates which would average out the mediation effect across the entire period of follow-up given the use of a cumulative measure of disability duration. This is supported by the finding that age dimensions played a minimal role in RTW outcomes at later time points, with indirect effects operating only via baseline RTW status.

Together, these findings suggest that while age dimensions may reflect the underlying aging process across multiple study settings and populations, there may be important differences when linking chronological age to these age dimensions (‘a’ paths) and each age dimension to different study outcomes (‘b’ paths) in relation to specific mediating pathways. As noted above, the age dimensions were developed using data from two distinct studies that had a collective focus on understanding aging and age differences as part of their study design (9,10), Although the available indicators were strongly associated with chronological age and work outcomes (i.e., concurrent validity) and assessed for face validity by the research team, future research and survey initiatives may require the inclusion of direct survey measures for a fuller assessment of age. These newly created age dimensions (as well as additional indicators) should then be validated within other samples to assess the extent to which each age dimension explains the overall relationship between chronological age and work outcomes. Future research also should continue to examine multiple age dimensions in one model rather than examining separate models (21), since the age dimensions can interrelate or act in opposite directions as noted above.

6.4.4 Remaining pathways: non-age factors and direct effects of chronological age

Given the moderate proportion of age differences in retirement expectations and RTW that was found to be mediated via age dimensions, but large remaining direct effects, the question remains, what other factors can explain these differences (84)? These other factors include inequalities in non-age mediators or actual direct effects due to chronological age.

Non-age mediators

The findings from this dissertation suggest that there may be residual age-related inequalities that are currently captured in the residual direct effect in the models (84). These other factors might be unrelated to the concept of age (i.e., not due to aging per se) but related to individual or workplace factors that could be identified and addressed with targeted interventions. As noted in Section 6.4.1, potential age-related factors include the provision of offers of modified duties and early contact with care providers, experiences with the claim process or claim processing times (27,33–35,53,54), which have been shown to be important factors that facilitate the RTW process following a workplace injury. Older workers may also be less likely to receive employability training from their employers (85), which in turn, might influence the availability of modified RTW options or bridge employment opportunities. It is also possible that residual direct effects may be due to age-based stereotypes (86,87). Previous studies have shown that negative stereotypes may lead to reductions in hiring and promotion (86), which might have implications for the retirement planning process. Finally, recent studies note the importance of supervisor responses to injury and RTW planning follow workplace injury (88), although it is unknown how these factors may differ across age groups. While some of these concepts have been measured in previous survey initiatives using study-specific questionnaires (86) or validated scales (89), they were not included across all of the data sources used for analyses. These factors were beyond the scope of the age dimensions and thus were not considered as key mediators for the dissertation.

Direct effects of chronological age

The persistent direct effects of chronological age in the mediation models also suggest a different explanation where the remaining inequalities in work outcomes across age groups are attributable to a chronological age effect. Chronological age denotes the achievement of important life events throughout the life course which, in turn, serves as the basis for provision of services and the structuring of institutions (1,19,90). For example, retirement eligibility is defined by chronological age thresholds even though there may be differences in underlying health status or organizational tenure (1). Definitions of older versus younger workers are based on chronological age, typically using cut-points of 55 or 65 years of age (19). This structuring of society around age may lead to important differences in work and health outcomes at the individual level that persist even after accounting for underlying age related changes (90). Thus, chronological age will likely continue to be used as an index variable that encodes both direct effects of chronological age, as well as any residual indirect effects due to unmeasured mediators or measurement issues (90). The combined use of chronological age and age dimensions might be required to gain a better understanding of age differences in work outcomes.

6.5 Strengths and Limitations

This dissertation has a number of overarching strengths in addition to those presented under each individual research study in Chapter 4. The main strength is the use of data from three complementary sources that, when synthesized together, allowed for a varied analysis across study populations, geographic regions and follow-up time points. This provided multiple scenarios to examine the ubiquity of age differences and validity of age dimensions across contexts. The availability of linked survey and administrative data also provided a unique opportunity to create a comprehensive research database with passive ascertainment of wage-replacement duration outcomes over time. This allowed for an analysis of complementary, yet distinct, study outcomes to address existing limitations in the measurement of disability duration (3,4). In contrast, previous studies have tended to examine wage-replacement duration as a sole indicator of RTW (27), despite noted discrepancies between survey and administrative data sources (4). Moreover, as described in Section 5.4 and 5.5, various sensitivity analyses demonstrated that the main dissertation findings were methodologically sound and robust to various changes in the measurement of study variables and use of various modelling techniques. However, as all three analyses were based on an observational study design using existing data sources, there were some overall methodological considerations that need be considered when interpreting the dissertation findings. These issues are discussed in more detail below.

6.5.1 Study design

The key methodological consideration relates to the timing of measurement of the age dimension scores and outcomes. For Study #3, only the baseline wave of CLSA data was available for analysis at the time the dissertation was proposed. Although the included age dimensions can be conceptualized as being “downstream” from chronological age, the retirement planning outcomes were measured contemporaneously. As such, causal-ordering assumptions between the mediators and retirement outcomes may not be satisfied. For example, changes in retirement status may precede changes in health status or caregiving obligations (80,91), rather than vice versa. However, the findings between chronological age and retirement planning are consistent with the literature (72), and thus there is little reason to doubt the robust overall age gradients observed with retirement planning outcomes. Moreover, as discussed in Section 2.5.3, this dissertation adopts a relaxed theoretical approach that allows for decomposition of effects into the proportion that would be eliminated after equalizing mediators across chronological age groups (i.e., indirect effects) and the proportion that would remain even if mediators were equalized (i.e., remaining age-related inequalities in work outcomes) (45,92). Further, these limitations were addressed in Study #3, which complemented the findings from Study #2 with an analysis of longitudinal RTW and wage-replacement outcomes.

6.5.2 Measurement

Although the dissertation was able to able to create summary index scores for each age dimension that were strongly associated with chronological age, there were some limitations in the selection of items each dimension. These limitations are discussed in detail in Section 6.4.2, but can be summarized by a lack of variation in some functional age items, and a lack of availability of indicators for organizational age and psychosocial age. It is important to note that any measurement errors among mediator variables could bias the indirect effects towards the null and the direct effects away from the null, such that the proportion mediated would be underestimated (93). These measurement errors are currently captured as residual direct effects in the models. On the other hand, these limitations had minimal impact on the robustness of the exposure-mediator portion of the path diagram (i.e., ‘a’ paths). Specifically, the selected items appeared to track well with older chronological age in expected directions (i.e., concurrent validity). As a result, the remaining residual direct effects in the models may not be entirely due to measurement errors in the age dimensions, but rather due to additional mediators and persistent direct effects of chronological age, as discussed in Section 6.4.4. However, as noted in

Section 6.4.2 and 6.4.3, while the available indicators may contribute to a well-developed measure of a given age dimension, future research and survey initiatives will likely require the inclusion of direct survey measures for a fuller assessment of age, followed by validation of the extent to which each age dimension explains the overall relationship between chronological age and work outcomes.

6.5.3 Internal validity

A general limitation of observational study designs is the potential for unmeasured or residual confounding of the key relationships required to estimate and interpret the parameters for each of the pathways in the path and survival models. This is most relevant for the age dimension studies, in which the interpretation of relationships between exposure–mediator, mediator–exposure, and exposure–outcome variables depends upon the adequate control of confounders for each of these respective pathways (94,95). These assumptions were likely satisfied in the two studies using survey data given the inclusion of important sociodemographic, psychosocial, injury and workplace-level factors identified from a scoping review of the literature. However, there may be unmeasured confounders in some studies. For example, in the CLSA study, data were not available on physical and psychosocial work conditions, job satisfaction, or personal attitudes towards retirement (96–100). However, across each study, the base-model estimates were only minimally changed after adjustment for the full set of covariates. Thus, it is more likely that any residual direct effects are due to unmeasured mediators, rather than unmeasured confounders, as discussed in Section 6.4.4. Future work might benefit from the collection of data on work conditions within population-based health surveys.

6.5.4 External validity

Finally, the observed relationships between chronological age, age-related indicators, and work outcomes may not be generalizable to other age groups (e.g., less than 45 years for the retirement expectations study) or study populations (e.g., non-workers' compensation populations for the wage-replacement studies). However, this dissertation used a variety of data sources and methods that enhance the overall generalizability to other populations and settings, including the use of administrative claims data from six provincial-level workers' compensation systems across Canada; the use of population-based data at the national level in Canada; and the use of survey and administrative data from a state-level sample of injured workers in Victoria, Australia. Moreover, findings from the sensitivity analyses presented in Chapter 5 demonstrate that the overall findings of time-varying hazards were generalizable across different data sources, study samples and geographic regions; and that age dimensions were important to understand for both general worker populations and injured worker cohorts.

6.6 Conclusions

The analyses presented throughout this dissertation indicates that both individual and contextual factors play key roles in explaining relationships between older age and RTW outcomes. The findings demonstrate that a more nuanced conceptualization of age can be developed using a variety of data sources that were not explicitly collected to examine the underlying age dimension. These age dimensions provided a better understanding of the underlying changes that are indexed by chronological aging, as well as the resulting impact that these changes may have (both positive and negative) on work outcomes. The developed methodological approach proved to be feasible and scalable using data from two different study populations and jurisdictional contexts. However, the dissertation also found that the two age-related surveys identified for analyses did not contain enough questions that could be used to adequately assess all the measures of age, and that research and survey initiatives will likely require the inclusion of direct survey measures for a fuller assessment of age. Taken together, this dissertation highlights that age differences are not found across all contexts, but rather, they vary by time and can be explained, in part, by other underlying age-related factors. Future research should continue to understand the residual differences in work outcomes across age groups that operate through other non-age factors, measurement considerations or chronological age effects.

6.7 References

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