Depressive Symptoms as a Mediator of the Association Between Functional Social Support and Executive Function: A Moderated Mediation Analysis of the Canadian Longitudinal Study on Aging's Comprehensive Cohort

by

Laura Marie Lupoi

A thesis

presented to the University of Waterloo

in fulfilment of the

thesis requirement for the degree of

Master of Science

in

Public Health Sciences

Waterloo, Ontario, Canada, 2024

Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract

BACKGROUND: Social support and depression are modifiable factors that can affect cognition. Social support and depression may be related through the influence of close relationships on emotional regulation; however, few studies have investigated whether depression mediates the relationship between social support and key domains of cognition, such as executive function.

OBJECTIVES: To explore whether depressive symptoms mediate the association between functional social support and executive function, and to ascertain if age and sex moderate this mediation.

METHODS: Analyses were based on baseline and three-year follow-up data (n=16,421) from the Comprehensive cohort of the Canadian Longitudinal Study on Aging, a population-based study of adults aged 45–85 years at baseline. Baseline functional social support was measured with the Medical Outcomes Survey-Social Support Survey, follow-up executive function with a combined z-score of five cognitive tests, and follow-up depressive symptoms with the 10-item Centre for Epidemiological Studies Depression Scale. Conditional process analysis, a robust strategy based on a linear regression framework, was used to evaluate moderated mediation.

RESULTS: After adjusting for sociodemographic, health, and lifestyle covariates, depressive symptoms at baseline significantly mediated the association between functional social support and executive function. This mediated effect was significant across most age and sex subgroups, with the exception of males and females 65–74 years old.

CONCLUSION: At least some of the benefits of social support on executive function depend on the positive effects of social support on depressive symptoms. Social support interventions with components addressing depression may be effective at promoting executive function in middle-aged and older adults.

Acknowledgements

I would like to express my deepest gratitude to my supervisor Dr. Suzanne Tyas for her mentorship. Thank you for your unwavering patience and empathy, as well as your invaluable guidance and feedback. It has truly been a privilege to be your student and I will carry the lessons you taught me, both academically and personally, for the rest of my life.

I am tremendously grateful to my committee members Dr. Colleen Maxwell and Dr. Mark Oremus. You generously provided your expertise, knowledge, and time to this project, which I am immensely appreciative of.

I would like to extend my sincere thanks to the colleagues and friends I have met throughout this program. Emily, Kim, Carrie, Cindy, and Kirsten, sharing this experience with you all has been a pleasure and a gift. From our writing groups to our coffee breaks, and everything in between, completing this degree with support from all of you all has truly been a blessing.

I'd also like to recognize my family and my friends outside of the program. Thank you all for always believing in me and being my biggest supporters. Your love and support throughout this journey have been instrumental to my success, and words cannot describe how very lucky I am to have you all in my life.

Table of Contents

List of Figures

List of Tables

List of Abbreviations

CES-D-10	Centre for Epidemiological Studies Short Depression Scale
CI	Confidence Interval
CLSA	Canadian Longitudinal Study on Aging
DCS	Data Collection Site
FSS	Functional Social Support
MOS-SSS	Medical Outcomes Survey – Social Support Survey
P_M	Proportion Mediated
SSS	Structural Social Support
Stroop	Stroop Neurological Screen Test-Victoria Version
T0	Baseline
T1	Follow-up 1
T2	Follow-up 2

Chapter 1
Introduction

Population aging is a global phenomenon. The number of older adults worldwide has increased due to greater survival, and the proportion of individuals 65 years or older globally has experienced an upward shift due to decreasing fertility. The proportion of older adults worldwide in 2022 was 10%, but this is predicted to increase to 16% by 2050, when the number of individuals ≥ 65 years old worldwide will be approximately equal to the number of children 12 years old and under, and greater than the number of children aged 5 and under (United Nations Department of Economic and Social Affairs, 2022). Similar trends in aging can be seen with the Canadian population. As of July 1, 2023, 18.9% of Canadians were 65 years of age or older, which is greater than the proportion of individuals under 14 years of age (15.4%) (Government of Canada, 2020). By 2040, the population of older adults in Canada is predicted to increase to about 10.7 million individuals, almost a quarter of the overall Canadian population (Public Health Agency of Canada, 2021).

The rapid growth in the number of older individuals in Canada and worldwide stresses the importance of promoting healthy aging. Maintaining the ability to perform everyday tasks and functions and participate in society are hallmarks of healthy aging. When supporting healthy aging within the context of activities of daily living, it is important to understand that older adults vary in their functional abilities (United Nations Department of Economic and Social Affairs, 2023). Within the Canadian context, with increasing age, both the incidence of developing a chronic disease and the prevalence of chronic diseases increases, and over a third of older persons have two or more chronic diseases (Public Health Agency of Canada, 2021).

A health condition whose risk increases with age is cognitive impairment (United Nations Department of Economic and Social Affairs, 2023). Cognition is a spectrum that ranges from normal cognition to the severe decreases in cognitive abilities seen in dementia, and cognitive impairment encompasses any changes in cognition that differ from normal cognitive abilities. Globally, there are 50 million individuals who are living with dementia (United Nations Department of Economic and Social Affairs, 2023). In Canada, dementia is a leading cause of death (Public Health Agency of Canada, 2021), upwards of 650,000 Canadians have dementia, and this number is expected to increase by 187% in the next 30 years (Alzheimer Society of Canada, 2024). Dementia is a cause for concern not only because it impairs people's ability to carry out daily tasks (Murman, 2015), but also because it places a significant responsibility on care partners of individuals living with dementia, and

adversely affects the quality of life and safety of those living with dementia and those who care for them (Alzheimer Society of Canada, 2022). Understanding incidence and prevalence estimates for cognitive impairment is important, as prevalent cases will require health and social services while incident cases denote the importance of service planning to care for future cases.

Both non-modifiable and modifiable factors affect the possibility of a person developing cognitive impairment. Modifiable risk factors are targets for intervention because they can be acted upon. Further, by addressing 12 specific modifiable risk factors for cognitive impairment, up to 40% of all dementias can be prevented or, at the very least, have a delayed onset. These risk factors include depression and social isolation. Adjusting for the overlapping of risk factors, a 4% reduction in worldwide dementia cases would occur if social isolation was eliminated; an additional 4% reduction would be seen if depression was eradicated (Livingston et al., 2020).

Evidence shows that some of the effect of social support on cognition could be mediated through depression. Social support is a concept closely related to social isolation; social support is comprised of structural and functional components and social isolation is often conceptualized as the absence of a structural type of social support (refer to Section 2.1 for more details regarding social support). However, more research is needed to understand this complex relationship between social support, depression, and cognition (Gow et al., 2013; Kumar et al., 2022; Pillemer & Holtzer, 2016; Q. Wang et al., 2022). Both social support and depression are modifiable factors (Livingston et al., 2020), which means programs can potentially intervene in the relationship between social support, depression, and cognition to help promote cognitive function. The purpose of this study was to identify whether depression is a mediator of the association between functional social support (a type of social support), and executive function (a cognitive domain), and to ascertain if this mediation is moderated by age group and sex. By better understanding the relationship between these factors, interventions can be created that help improve cognition, which in turn helps maintain quality of life and independence in older adults.

Chapter 2
Background

2.1 Social Support

Social support is a fundamental characteristic of social interaction. It supports mental health and cognitive function by helping individuals cope with stressful situations and increases self-esteem (Canadian Mental Health Association, 2018; Eisele et al., 2012; Ozbay et al., 2007). Social support is a broad concept that can be divided into two main categories: structural social support (SSS) and functional social support (FSS). SSS is a quantitative, objective measure of social support. Number of friends, marital status, and group membership are all examples of SSS (Sherbourne & Stewart, 1991). In contrast, FSS is related to the qualitative aspects of social interactions, and has been defined as the extent to which someone perceives they can rely on other people and communities for help, care, and comfort in a time of need (Holtzman et al., 2004; Sherbourne & Stewart, 1991). FSS encompasses a range of different types of support, such as emotional social support (e.g., expressing caring, love, and empathy, as shown by having someone in which to confide your most private worries or fears), informational social support (e.g., having someone give you advice and guidance when going through a crisis), tangible social support (e.g., having someone to provide material aid, such as bringing you to a doctor's appointment), affectionate social support (e.g., expressing love and affection through having someone to hug), and positive social interactions (e.g., having people in your life you can have fun or relax with) (Sherbourne & Stewart, 1991).

Making the distinction between the objective and subjective aspects of social relationships is important as there is an argument that they differ conceptually (Newall & Menec, 2020). An individual may have low SSS (i.e., have few social contacts and be unmarried), but their relationships align with their desires (i.e., they don't feel loneliness, and they report high FSS, both of which are defined as subjective measures). Conversely, a person may have a large number of relationships, but may experience loneliness or low FSS since their relationships do not match with their wants (Newall & Menec, 2019). These differences in defining the objective versus subjective aspects of relationships are reflected in health outcomes. Both SSS and FSS are significantly associated with health (Vila, 2021), but FSS generally has a stronger association with both mental health (Lynch et al., 1999; Rippon et al., 2022) and physical health (Hakulinen et al., 2016). These differences in health-related outcomes may be due to how FSS captures the substance of support a person receives from their

relationships, as this perceived social support may be of larger consequence when a person is in a difficult situation and in need of support to help deal with the hardship (Li et al., 2021; Moak & Agrawal, 2010).

2.2 Cognition

Slight changes in cognition are characteristic of normal aging (Harada et al., 2013). However, distinctions are made between declines in cognition that are a part of normal aging and more severe changes in cognition that may reflect disease processes (Denver & McClean, 2018). Given these differences, it is imperative to promote healthy cognition in aging, helping to ensure the quality of life and independence of older adults (Bamidis et al., 2014).

Cognition can be studied as a global measure or subdivided into specific individual domains. These cognitive domains include perceptual-motor function, language, learning and memory, complex attention, social cognition, and executive function (American Psychiatric Association, 2013; Harada et al., 2013; Sachdev et al., 2014). Experiencing declines in each of these domains has distinct implications for healthy aging (Harada et al., 2013). Declines in executive function specifically affect older adults' ability to carry out daily tasks and thus maintain independence (Overdorp et al., 2016).

Executive function is defined by top-down processes involved with concentrating and paying attention. Specific examples of executive functions include thinking before acting, meeting new challenges, exerting resistance over temptations, and maintaining focus (Diamond, 2013). Higher-order executive function skills include reasoning, inhibition, shifting ability, problem solving, and planning (Diamond, 2013; Sims et al., 2011). The importance of executive function cannot be stressed enough, since executive function is important to mental and physical health (Davis et al., 2010; Diamond, 2013; Overdorp et al., 2016).

The prefrontal cortex and frontal-subcortical areas of the brain are associated with executive function (Diamond, 2013; Verreckt et al., 2022), with age-related alterations in the prefrontal cortex related to declines in executive function (Dempster, 1992; West, 1996; Zanto & Gazzaley, 2019). These declines are in turn associated with a range of age-related health outcomes including falls, frailty, functional impairment, and important age-related diseases such as Alzheimer's disease, as impaired executive function is part of the diagnosis for Alzheimer's disease and other dementias (Overdorp et al., 2016; Verreckt et al., 2022). Greater executive function is linked to better quality of life for older adults (Davis et al., 2010). The importance of executive function in aging can also be

seen in relation to other domains of cognition. In older adults, memory and executive function are associated, such that executive function helps to compensate for declines in memory related to aging (Bouazzaoui et al., 2014).

2.3 Functional Social Support and Cognition

FSS has been found to have protective effects on cognitive decline (Amieva et al., 2010; Mogic et al., 2023; Seeman et al., 2001), and studies have demonstrated that in middle-aged and older adults, a positive association exists between social support and cognitive function (Bassuk et al., 1999; Costa-Cordella et al., 2021; Dickinson et al., 2011; Ellwardt et al., 2013; Joyce et al., 2022; Millán-Calenti et al., 2013; Ohman et al., 2023; Oremus et al., 2019, 2020; Pillemer & Holtzer, 2016; Yoo et al., 2023; Zunzunegui et al., 2003). In general, the positive association between social support and cognition appears to be more pronounced in females/women compared to males/men (Joyce et al., 2022; Oremus et al., 2019; Pillemer & Holtzer, 2016; Zunzunegui et al., 2003). However, there are inconsistencies when cognition overall is the outcome of interest versus memory, an important domain of cognition. In community-dwelling middle-aged and older Canadians, both cross-sectional and prospective associations between FSS and memory showed no evidence of effect modification by sex (Ohman, 2020; Yoo et al., 2023). Thus, the association between FSS and cognition may vary by cognitive outcome.

Similarly to memory, executive function is a key domain of cognition and as such, studies that have examined the association between FSS and cognition have used executive function as their cognitive outcome. These studies have demonstrated that an association exists between FSS and executive function (Mogic et al., 2023). In a cross-sectional study with a community-based sample of middle-aged African Americans, greater FSS predicted higher executive function. The four specific dimensions of FSS defined in the study (belonging, appraisal, tangible, and self-esteem) were all associated with greater inhibition ability, and tangible social support was associated with greater cognitive shifting ability (Sims et al., 2011). In a cross-sectional study consisting of a sample of community-dwelling middle-aged and older Canadians, Rutter (2019) found a significant association of low affectionate FSS, emotional/informational FSS, and positive social interactions with low executive function. When stratified by sex, low tangible FSS and low positive social interactions were significantly associated with low executive function in females after adjusting for key sociodemographic, health, and social covariates, whereas no subtype of FSS was significantly

associated with cognitive function in males (Rutter, 2019). These results directly contrast with sex differences found for memory (Ohman, 2020; Yoo et al., 2023), which is further evidence that sex differences in the association between FSS and cognition may vary by cognitive domain.

Although social support is associated with cognition, the exact mechanisms through which this relationship occurs has not been determined. Possible explanations for the association between social support and cognition can be found in the stress hypothesis and the cognitive reserve hypothesis. The *stress hypothesis* is related to the emotional aspects of social support, and states that greater perceived social support is related to increased self-esteem and confidence (Eisele et al., 2012). These higher levels of self-esteem help to buffer stress in physiologically arousing situations, which is key as this psychological arousal is associated with damage to the hippocampus and resultant conditions such as Alzheimer's disease (Eisele et al., 2012). Thus, under the stress hypothesis, emotional support indirectly reduces physiological stress in anxious circumstances through producing a calming effect during these situations (Eisele et al., 2012; Sims et al., 2011). In contrast, the *cognitive reserve hypothesis* claims that engaging in supportive relationships increases brain stimulation and thereby helps to preserve cognitive capacities. Through the perspective of this hypothesis, social support is a determinant of cognition due to the mental stimulation that arises from social activities (Eisele et al., 2012; Ellwardt et al., 2013).

2.4 Depression

In addition to social support, depression is an important modifiable risk factor for cognitive impairment (Livingston et al., 2020). Depression is a mood disorder characterized by feelings of sadness and loss of interest (Chand & Arif, 2024). Depression accounts for 4% of the global burden of disease and is one of the largest causes of disability (World Health Organization, 2021). Clinical depression and depressive symptoms are both measures that fall under the broad category of depression. Clinical depression is a disease defined by experiencing a depressive episode lasting at least two weeks in duration, paired with symptoms such as mood changes, decreased interest or pleasure in activities, vegetative symptoms, and changes in cognition. Depressive symptoms are implicated in a variety of disorders, including clinical depression, but an individual can exhibit depressive symptoms without reaching the threshold for a clinical diagnosis (Otte et al., 2016). Both clinical depression and depressive symptoms are associated with poor health outcomes in older adults (Agustini et al., 2020, 2022; Blazer, 2003; Meeks et al., 2011), including decline in overall cognition,

as well as in specific domains such as executive function (Byers & Yaffe, 2011; Formánek et al., 2020; Jung et al., 2023; Lugtenburg et al., 2017; Mackin et al., 2023). There are, in turn, many risk factors for depression, including low social support (Otte et al., 2016).

2.5 Effect of Social Support on Cognition Mediated by Depression

The fundamental idea of exploring mediation is to more comprehensively understand the mechanisms behind the effect an exposure has on an outcome. The mediated effect can be divided into two different paths: 1) the association between the exposure (FSS) and mediator (depression), and 2) the association between the mediator (depression) and outcome (executive function). Evidence of associations on both these paths is support for a specific variable being a mediator of the association between an exposure and outcome.

2.5.1 Social Support and Depression

Both giving and receiving social support are important social interactions in middle-aged and older adults, as this reciprocity in support aids the mental health of this population (Braun et al., 2018; de Brito et al., 2017; Fyrand, 2010). Greater SSS and FSS has been found to be associated with fewer depressive symptoms in middle-aged adults (Almquist et al., 2017) and older adults (Chao et al., 2018; Lee & Shinkai, 2005; Mohd et al., 2019; Muramatsu et al., 2010; Rote et al., 2015).

There is potential for bidirectionality in the relationship between social support and depression (Gariépy et al., 2016; Kupferberg & Hasler, 2023), as well as specifically in the association between FSS and depression (Almquist et al., 2017; Stafford et al., 2019). The relatively few longitudinal studies examining the relationship between social support and depression (Almquist et al., 2017; Gariépy et al., 2016) and heterogeneity across the literature regarding the measurement of social support (Gariépy et al., 2016) means that it is difficult to confidently establish the direction of the association. Higher levels of social support have been found to be an important protective factor against depression (Gariépy et al., 2016), and lower FSS has been shown to be a predictor of depressive symptoms (Song et al., 2023; Stafford et al., 2019). Bidirectional effects of FSS and depressive symptoms have also been found over time (Almquist et al., 2017). However, more longitudinal studies are needed to better understand the temporal associations between social support and depression (Gariépy et al., 2016).

2.5.2 Depression and Cognition

Depression and cognition are associated with one another, as studies where depression is the exposure and cognition are the outcome have shown a relationship between these factors. Having a major depressive episode is associated with deficits in cognitive functioning such that relative to healthy controls, having a greater number of previous depressive episodes is correlated with greater deficits in cognition (Semkovska et al., 2019). Studies have shown that in middle-aged and older adults, depressive symptoms and clinical depression are associated with cognitive impairment (Dotson et al., 2020; Huang et al., 2022; Muhammad & Meher, 2021; Ouellet et al., 2016).

In studies where depression was the exposure of interest and executive function was the outcome, both clinical depression and depressive symptoms were found to be associated with lower executive function (Snyder, 2013). This relationship between depression and executive function extends to older adults (Dotson et al., 2020; Ha, 2019). In individuals with clinical depression, experiencing executive dysfunction is common (DeBattista, 2005). Persons with depression experience deficits in multiple subdomains of executive function, such as working memory, planning, and cognitive flexibility (DeBattista, 2005; Snyder, 2013).

Similar to the association between FSS and depression, there is evidence to suggest bidirectionality in the association between depressive symptoms and cognition (Desai, Charlesworth, et al., 2020; Guo et al., 2023). Existing evidence suggests that the direction of the association may be from depressive symptoms to cognition, as depressive symptoms have been shown to be a predictor of cognition impairment in older adults (Desai, Charlesworth, et al., 2020; Guo et al., 2023). Conversely, there is evidence that the direction of the relationship may be from cognition to depression. In older adults, cognitive impairment is a risk factor for geriatric depression (Zhao et al., 2018) and, a predictor of depressive symptoms; depression may itself be a prodromal feature of dementia (Desai, Charlesworth, et al., 2020; Jorm, 2000; Guo et al., 2023). Although there is evidence of bidirectionality, there is a body of biological, epidemiological, and theoretical evidence that shows that the direction of the association may primarily be from depression to cognition (see Section 2.5.3 for further details).

2.5.3 Evidence for Depression as a Mediator of the Association Between Social Support and Cognition

Preliminary evidence indicates that a relationship exists between social support, depression, and cognition. Mediation studies have demonstrated that depression mediates the association between various social factors (i.e., loneliness, social participation, social engagement, and social health) and cognition in middle-aged and older adults (Chen et al., 2024; Gow et al., 2013; Kim et al., 2020; Kumar et al., 2022; Stafford et al., 2024; Q. Wang et al., 2022). However, only two of these studies examined FSS. Additionally, the listed studies included cognitive function more broadly or examined subdomains of cognition such as memory and processing speed rather than executive function. Another study using the same measures, sample, and analytic design as that conducted in this thesis found that after controlling for covariates at baseline, FSS was a statistically significant mediator of the association between depression (depressive symptoms or history of clinical depression) and executive function in women aged 75 years or older (Iacono et al., 2023). In a sample of community-dwelling older adults from Spain, satisfaction with social support was associated with co-occurring symptoms of depression and cognitive impairment (Millán-Calenti et al., 2013). Although these latter results are not from a mediation analysis, they serve as evidence that a relationship does exist between the qualitative aspects of social support, depression and cognition (Millán-Calenti et al., 2013).

Mediation models are built on causal inferences for the path between exposure and mediator and the path between mediator and outcome (Pieters, 2017). Social causation theory, the interpersonal theory of depression, the risk factor hypothesis, and the prodromal hypothesis all provide a theoretical rationale for mediation analysis. While these theories provide the causal inferences to support investigating a model where depressive symptoms mediate the association between FSS and executive function, causality cannot necessarily be inferred from correlations found in mediation models (Pieters, 2017).

The theories that support the association between FSS and depression are the social causation theory, the interpersonal theory of depression, and the social transduction theory of depression. These theories help to explain the mechanisms through which social support acts on depression.

The *social causation theory* states that social support precedes well-being and that lacking social support leads to psychological distress (Kaniasty & Norris, 2008; Ren et al., 2018). Under social causation theory, interpersonal emotional regulation is one possible mechanism that connects social

support and depression. Interpersonal relationships can affect how a person regulates their emotions. When a person experiences depression, their emotions are dysregulated. The processes responsible for regulating emotion may be influenced by our relationships with others. Thus, it is plausible that the effect of social support on depression occurs through a person's receptiveness to interpersonal emotional regulation (Marroquín, 2011).

The *interpersonal theory of depression* also links social support with depression. The theory states that depressed individuals exhibit maladaptive social behaviours, such as hostility, heightened sensitivity to rejection, and rumination on negative social events. Decreased social support is one consequence of such behaviours, and lacking this support can exacerbate depressive symptoms and worsen social functioning (Kupferberg & Hasler, 2023). Within the framework of this theory, the relationship between social support and depression is bidirectional.

The s*ocial transduction theory of depression* provides a plausible biological explanation for the association between social support and depression. When an individual is in a situation where they experience social threats and adversity, pro-inflammatory cytokines are activated as part of an immune response. These pro-inflammatory cytokines are also involved in behavioural changes that are akin to depressive symptoms, such as sad mood, fatigue, and socio-behavioural withdrawal (Slavich & Irwin, 2014).

The risk factor and prodromal hypotheses provide evidence for the relationship between depression and cognition. Both theories provide their own hypothesis for the pathophysiological mechanisms that link depression with executive function.

The *risk factor hypothesis* relates depression to cognition, as it proposes that depression is a causal risk factor for cognitive decline (Desai, Charlesworth, et al., 2020; Jorm, 2000). It may be that depression leads to damage in the brain that is associated with cognitive decline and dementia. It is also plausible that depression does not affect the neuropathophysiological processes involved in cognitive impairment, but rather depression decreases the threshold for developing dementia. Depression is associated with cognitive and motivational deficits, and these deficits may work in combination with other factors that cause dementing diseases to bring forth the clinical manifestation of dementia (Jorm, 2001). The *prodromal hypothesis* suggests that depression is an early symptom, or prodrome, of cognitive decline or dementia (Desai, Charlesworth, et al., 2020; Jorm, 2000).

Several potential biological mechanisms link depression with cognitive decline. These biological mechanisms include vascular disease, increased production of glucocorticoid steroids that leads to hippocampal damage, increases in amyloid plaque formation, pro-inflammatory changes, and decreases in nerve growth factors (Byers & Yaffe, 2011). These mechanisms may work together to causally link depression with brain alterations that in turn result in cognitive decline (Butters et al., 2008).

2.6 Potential Moderators of the Mediated Effect of Depression Between Social Support and Cognition

It is plausible that the potential mediating effect of depressive symptoms on the association between FSS and executive function may be moderated by age group and sex. More specifically, the association between social support and depression could be moderated by age group and sex and similarly, the relationship between depression and cognition may be moderated by these same factors. An overview of the evidence for moderation by age of the mediated relationship between social support and cognition through depression can be found below, followed by a discussion of potential moderation of this relationship by sex.

2.6.1 Moderation by Age

The experience of social support and depression varies with age, and these differences are outlined below. Given these variations, age is an important factor to consider when examining the mediated association between social support and cognition.

FSS differs in younger adults versus older adults. FSS has been shown to be especially important to the health and well-being of older adults (Mo et al., 2022). FSS increases with age, and this increase is seen despite the higher risk of living alone and not having any friends or confidants as you become older (Schnittker, 2007). As one ages, social networks may decline in size, but it is the qualitative aspects of relationships that are more important (Charles & Carstensen, 2010). Older adults optimize positive relationships and reduce the number of negative social experiences by avoiding conflict (Luong et al., 2011).

Evidence suggests that the presentation of depression in older adults and younger adults differs (Fiske et al., 2009; Hegeman et al., 2012). Older adults with clinical depression demonstrate general and gastrointestinal somatic symptoms, increased agitation, and hypochondriasis, while younger

adults display symptoms such as feelings of guilt (Hegeman et al., 2012). As mentioned previously, depressive symptoms are a different measure than a diagnosis of clinical depression, but they are still key to consider given their importance to health outcomes (Agustini et al., 2020, 2022; Blazer, 2003; Byers & Yaffe, 2011; Formánek et al., 2020; Jung et al., 2023; Meeks et al., 2011). Depressive symptoms have been shown to increase with age (Chui et al., 2015), and older age is positively and significantly associated with depressive symptoms (Dong et al., 2014; Zenebe et al., 2021).

Ha (2019) found that the association between depression and executive function differed by age group. The positive association between depressive symptoms and low executive function was significant in the 45–54 and 55–64 age groups, but nonsignificant in the 65–74 age group. In the ≥ 75 age group, FSS was a moderator of the relationship between depressive symptoms and executive function. For participants ≥ 75 with low FSS, there was a negative, but non-significant association between depressive symptoms and low executive function (Ha, 2019). Results from meta-analyses found that the association between depression and executive function deficits was stronger in studies whose samples had an older mean age (Dotson et al., 2020). Compared to younger adults, older adults are underdiagnosed for depression due to their negative attitudes towards mental illness as well as being less likely to receive support from mental health services (Conner et al., 2010; Fässberg et al., 2012; Kok & Reynolds, 2017; Mitchell & Subramaniam, 2005; Segal et al., 2005). Additionally, depression would be more likely to present as a prodrome of dementia in later life than in younger adulthood (Byers & Yaffe, 2011). These differences may help to explain the greater magnitude of the effect of depression on cognition in older adults in comparison to younger adults.

Altogether, the evidence shows that the mediated association between social support and cognition may vary by age. Thus, age is an important factor to consider when analysing moderation of the mediated effect of depression on relationship between social support and cognition.

2.6.2 Moderation by Sex

The mediated relationship between social support and cognition may also be moderated by sex. Similarly to age, sex is an important factor to consider when examining the mediated effect of depression on the association between FSS and cognition.

There is evidence in the literature for the experience of *social support* differing by sex. Males are more likely to report having close relationships with family, while females are more likely to report close relationships with both family and friends (Belle, 1987; Pillemer & Holtzer, 2016).

Additionally, females are more likely to give and receive social support than males (Eagly, 1987; Pillemer & Holtzer, 2016). Receiving emotional social support is associated with fewer depressive symptoms in females but not in males, but providing emotional support is associated with lower depressive symptom levels across both sexes (Fiori & Denckla, 2012). The magnitude of the effect of both qualitative and quantitative aspects of social support on well-being is greater in females in comparison to males (Antonucci & Akiyama, 1987).

There is evidence that the experience of *depression* differs by sex. Males and females diagnosed with major depressive disorder differ in the biological markers they present (Labaka et al., 2018) and compared to males, females report greater psychological and somatic anxiety, increased feelings of guilt, and lower quality of life (Olsen et al., 2023; Vetter et al., 2021). Additionally, females are more likely than men to experience symptoms such as loss of interest, thoughts of death, greater tearfulness, more rumination, and higher chronic strain (Nolen-Hoeksema et al., 1999; Romans et al., 2007). The prevalence of depression is two times greater in females compared to males (Bekker & van Mens-Verhulst, 2007; Labaka et al., 2018), and females report more depressive symptoms than males (Best et al., 2021; Olsen et al., 2023).

Additionally, there is evidence that the *effect of depression on cognition* differs by sex. Ha (2019) found that the strength of the association between depressive symptoms and executive function was stronger in females compared to males. Females with mental health symptoms, such as depression, have a greater risk of cognitive decline (Gong et al., 2021). Research has also shown that the effect of depressive symptoms on executive function through FSS was significant only in females (Cohrdes & Bretschneider, 2018; Iacono et al., 2023). A possible explanation for these observed sex differences could be attributed to coping styles, self-esteem, and biological reasons such as responses to stress that are unique to females (Nolen-Hoeksema, 2001).

Altogether, the evidence demonstrates that the mediated association between social support and cognition may be moderated by sex. Given this, when examining the mediated effect of depression on the association between social support and cognition, it is key to examine sex as a moderator of this association.

2.7 Potential Confounders of the Mediated Effect of Depression Between Social Support and Cognition

There are several sociodemographic, health, and lifestyle variables that may confound the mediated association between FSS and cognition. *Sociodemographic* covariates that may confound this association include age, sex, province, urban/rural residence, education, income, marital status, and living arrangements. Both age and sex are associated with FSS (Antonucci & Akiyama, 1987; Jiang et al., 2018; Kendler et al., 2005; Olsen et al., 1991), depression (Barrenetxea et al., 2022; Labaka et al., 2018; Yeretzian et al., 2023), and cognition (Tuokko et al., 2020; Yang et al., 2023). Previous studies have demonstrated that the association between FSS and cognition differs by province and by urban/rural residence (Oremus et al., 2019), and that urban/rural residence is associated with social support (Airaksinen et al., 2015) and cognitive function (Harris et al., 2023). Lower education and lower income are both associated with low emotional and instrumental support (Weyers et al., 2008), and lower educational level and lower income are both risk factors for depression and cognitive impairment (Bennett & Thomas, 2014; Ren et al., 2018; Zhou et al., 2021). Marital status and living arrangements are both structural measures of social support (Mohd et al., 2019) and are related to cognition (Desai, John, et al., 2020).

Health variables, such as self-rated health, chronic conditions, and functional impairment, may also confound the mediated association between FSS and cognition. Self-rated health, chronic conditions, and functional impairment have all been found to be individually associated with loneliness and isolation (Menec et al., 2019; National Institute on Ageing, 2022), which are concepts closely related to FSS (National Institute on Ageing, 2022). A relationship also exists between self-rated health, chronic conditions, and functional impairment with cognition (Bennett & Thomas, 2014; Bourassa et al., 2017; Riddle et al., 2015).

Lifestyle factors, such as smoking status and alcohol use, may also confound the mediated effect of depression on the association between FSS and cognition. Both smoking status and alcohol use are associated with loneliness and social isolation (National Institute on Ageing, 2022), as well as with cognitive function (Benito-León et al., 2023; Yen et al., 2022; Zhang et al., 2020).

Altogether, there are several different sociodemographic, health, and lifestyle variables that have the potential to confound the mediated association between FSS and cognition. Thus, these factors are important to consider when performing mediation analysis.

2.8 Conclusion

FSS and depression are both key factors related to cognition. There are established associations between FSS, depression, and cognition, including key domains such as executive function, and these relationships are both bidirectional and complex. The association between FSS and cognition may be mediated by depressive symptoms, as demonstrated by theoretical, epidemiological and biological evidence. There are also indications in the literature that this mediated association may be moderated by age and sex. Altogether, preliminary evidence indicates that depressive symptoms may mediate the association between FSS and executive function. A better understanding of depressive symptoms as a mediator of the association, and moderation by age and sex of this mediated association, is relevant to public health initiatives to support cognitive health. A more comprehensive understanding of the potential role of depression as a mediator of the association between FSS and executive function may inform development of interventions to promote cognitive health by determining whether these interventions should include components that help to reduce depressive symptoms. Knowledge regarding *moderated* mediation helps with targeting programs to vulnerable subgroups in the population defined by age group and sex.

Chapter 3
Study Rationale and Research Questions

3.1 Study Rationale

Key limitations in the literature examining the relationships between social support, depression, and cognition include lack of temporality, a shortage of validated tools to measure social support, examination of cognition overall rather than specific cognitive domains, study samples consisting only of older adults, limited control of potential confounders, and assessment of mediation only rather than moderated mediation.

Most of the previous mediation studies that have examined the mediated effect of depression on the association between social factors and cognition have been cross-sectional in nature (Chen et al., 2024; Gow et al., 2013; Kumar et al., 2022; Q. Wang et al., 2022). There is also evidence for bidirectionality in the association between social support and depression (Gariépy et al., 2016; Kupferberg & Hasler, 2023), including FSS (Almquist et al., 2017; Stafford et al., 2019), and in the association between depression and executive function (Desai, Charlesworth, et al., 2020; Guo et al., 2023); longitudinal studies are needed to help ascertain the directionality of these associations.

It has been emphasized in the literature that studies are not using validated tools to measure social support. In a systematic review of the relationship between social support and depression, less than half of the 31 included studies used a validated measurement tool to assess social support (Gariépy et al., 2016). Similar concerns regarding unvalidated tools to measure social support were also noted in a systematic review on social support and cognition (Costa-Cordella et al., 2021). A lack of validated tools to measure social support creates knowledge gaps in our understanding of the relationships that social support has with depression and cognition, as unvalidated tools may not accurately measure social support (Gariépy et al., 2016) and using these measures can therefore reduce the validity of results (Costa-Cordella et al., 2021).

Previous studies have also looked at cognition more broadly, and few studies that have examined the mediated effect of depression on the association between social factors and cognition have explored specific cognitive domains (Chen et al., 2024; Kim et al., 2020; Kumar et al., 2022; Q. Wang et al., 2022), which are implicated in healthy aging in their own distinct ways. These differences are apparent when comparing the different impacts of FSS across memory and executive

function (Ohman et al., 2023; Rutter, 2019; Sims et al., 2011; Yoo et al., 2023). Thus, it is important to examine key domains of cognitive function to better understand how factors such as social support and depression affect specific cognitive domains in aging.

Many studies within the literature have samples that consist of only older adults (Costa-Cordella et al., 2021; Dotson et al., 2020; Mogic et al., 2023). By limiting study samples to older adults, the evidence regarding associations between social support, depression, and cognition are limited to this subset of the population. However, middle-aged adults are an important population to consider when creating interventions to promote cognitive health in aging. There is evidence to suggest that declines in cognition occur as early as age 45 (Singh-Manoux et al., 2012), which stresses the need to understand the associations of interest in middle adulthood.

Previous studies in the literature that have examined the association between social support and cognition (Costa-Cordella et al., 2021), including FSS (Mogic et al., 2023), as well as the association between social support and depression (Gariépy et al., 2016) have adjusted for only a limited number of covariates in their analyses. By failing to account more broadly for potential confounders, results from these studies are more likely to be affected by confounding, hindering interpretation.

Most studies that have examined the association between social factors, depression, and cognition have assessed mediation rather than moderated mediation (Gow et al., 2013; Kim et al., 2020; Kumar et al., 2022; Q. Wang et al., 2022; Y. Wang et al., 2022). Compared to mediation analyses, moderated mediation is a more rigorous analytical technique. Assessing moderators of the mediated association helps further our understanding of the effect that depression has on the association between social factors and cognition within specific subgroups.

The current study helps to address the aforementioned limitations outlined in a variety of ways. By using data from two distinct timepoints to examine longitudinal associations at each path of the mediated effect, this study helps to address issues with the lack of temporality in current studies. The English 19-item version of the Medical Outcomes Survey – Social Support Survey (MOS-SSS) is a validated measurement tool to measure FSS, and is recommended for use in both research and practice (Dao-Tran et al., 2023). Thus, this study is adding to the limited body of research that uses a validated tool to measure social support. The current study measured executive function, a domain of cognition important in the aging process (Diamond, 2013). By examining this specific domain of cognition, this study is adding to the limited body of literature that has examined depression as a

mediator of the association between social support and specific domains of cognition. The CLSA included adults 45–85 years at baseline, which meant that the current study was able to examine associations in middle-aged and older adults. By using data from the CLSA, this study adds knowledge to our limited understanding of the mediated effect of depressive symptoms on the association between FSS and executive function in middle and older adulthood. Another benefit of the CLSA was that the CLSA collected data on many potential confounding variables, which were included in the analyses for the current study. By accounting for these confounders, the current study was able to provide a clearer picture of the association between FSS, depression, and executive function with less impact of confounding compared to other studies that adjusted for fewer potential confounders.

Conditional process analysis was used to assess moderated mediation. By going a step further than most previous studies and examining *moderated* mediation, the current study investigated variation in mediation within specific subgroups. This information helps to identify the subgroups where depressive symptoms impact the relationship between FSS and executive function. Thus, inclusion of moderators helps to fill the gaps in our knowledge of the complex relationship between social factors, depression, and cognition.

Altogether, evidence suggests that FSS and depressive symptoms are potential factors to target to promote cognitive health. The relationship between these factors is complex, but there are established associations in the literature; FSS is associated with depressive symptoms, and both FSS and depressive symptoms are associated with executive function. However, to the author's knowledge, this is the first study to examine whether depressive symptoms mediate the association between FSS and executive function in a large sample of community-dwelling, middle-aged and older adults. Additionally, this study will be the first to explore whether the mediated effect is moderated by age group and sex. Understanding the mediating effect of depression on the relationship between social support and cognition, as well as identifying vulnerable subgroups where this association is significant, will help inform targeted interventions to promote cognition.

3.2 Research Questions

The research questions for the study were:

1. Do depressive symptoms at follow-up mediate the association between overall FSS at baseline and executive function at follow-up, adjusting for sociodemographic, health, and lifestyle covariates?
2. Is the above association moderated by baseline age group and sex?

Chapter 4
Methods

4.1 Sample

4.1.1 Data Source

Analyses were based on data from the Canadian Longitudinal Study on Aging (CLSA), a population-based, prospective cohort study. The CLSA has a sample of approximately 50,000 community-dwelling, Canadian men and women between the ages of 45 and 85 at baseline. Data are collected from these participants every three years for a planned minimum of 20 years or until the participant ceases to participate in the study (Raina et al., 2009).

The CLSA divided their study sample into two cohorts: the Tracking cohort and the Comprehensive cohort. In the Tracking cohort, information is collected from participants using telephone interviews. In contrast, data for the Comprehensive cohort is being collected via in-person interviews and visits to data collection sites (DCS) to gather more detailed information on biological, physical, psychological, and cognitive functioning. Regarding information collected on executive function, the neuropsychological assessment was divided into two batteries. The core neuropsychological test battery was administered to both Tracking and Comprehensive participants. A second battery, which included additional executive function measures that can only be assessed in person, was administered to Comprehensive cohort participants during their DCS visits. The current study used data from the Comprehensive cohort to undertake a broader assessment of executive function, which was made possible by the additional set of tests administered at the DCS (Raina et al., n.d.).

The Comprehensive cohort sample was recruited from three different sources: provincial health registries, random digit dialling, and the Quebec Longitudinal Study on Nutrition and Aging (*Quebec Network for Research on Aging*, n.d.). A stratified sampling design was used to recruit the participants in the Comprehensive cohort at baseline. Sampling was stratified based on age group (45–54, 55–64, 65–74, and 75–85 years), sex (male and female), and province (seven provinces were included in the Comprehensive cohort), such that the target numbers for each age and sex stratum were established by province (Canadian Longitudinal Study on Aging, 2023). Eligibility was further restricted by distance, as Comprehensive participants needed to live within 25–50 kilometres of 1 of

the 11 DCS. When recruiting the study sample, early indicators demonstrated that the proportion of participants with low education was below the levels found in the population. Thus, to help create a study sample reflective of the population, the CLSA oversampled individuals with no formal education beyond high school. To do this, the CLSA identified areas where the proportion of people with lower education was higher and restricted sampling to those areas (Canadian Longitudinal Study on Aging, 2023).

Baseline (T0) Comprehensive cohort data were collected between December 2011 and July 2015, and follow-up (T1) information was collected from July 2015 to December 2018 (Canadian Longitudinal Study on Aging, n.d.). Follow-up 2 (T2) cognition data were unavailable at the time of analysis; hence, only T0 and T1 data were used.

When recruiting the CLSA study sample, the following individuals were excluded: residents of the three territories and certain remote regions, people living in federal First Nations reserves and other types of First Nations settlements within the provinces, full-time members of the Canadian Armed Forces, individuals living in long-term care institutions, and persons unable to give responses in English or French. Potential participants were also excluded at baseline if they were deemed cognitively impaired through being unable to comprehend the purpose of the CLSA or provide reliable data. The CLSA recruiting staff made judgements regarding the presence of overt cognitive impairment based on whether potential enrolees understood the purpose of the study and provided answers to basic questions, such as their age.

4.1.2 Analytic Sample

Of the 51,338 CLSA participants at baseline, 30,097 were in the Comprehensive cohort at T0 (Canadian Longitudinal Study on Aging, n.d.). Participants who did not complete a regular DCS visit at T0 (n = 225), as well as individuals with a self-reported history of being diagnosed with Alzheimer's disease or memory problems at T0 (n = 646), were excluded from the sample. The analytic sample was further reduced by excluding those with missing data for the outcome, mediator, and exposure in the following order: executive function at T1 (n = 9965) and then T0 (n = 2564), depressive symptoms at T1 (n = 43) and then T0 (n = 23), and FSS at T0 (n = 80). People with missing data for executive function or depressive symptoms at T1 rather than T0 were excluded first, as those were the variables that were used in the main analyses. Individuals who switched between speaking English and French on tests of executive function were also excluded from the study (see

Section 4.2.2 for further information on derivation of the executive function measure). Refer to Figure 1 below for the analytic sample flowchart.

To address missing data for covariates, a 'missing' category for each covariate was created if a covariate had more than 1% missing data; participants missing data on these covariates were then retained in the study sample. Marital status (n = 3), education (n = 16), self-rated health (n = 9), chronic conditions (n = 74), and functional impairment (n = 28) all had less than 1% missing data and thus insufficient numbers of participants missing data on these variables to make a 'missing' category analytically feasible. Thus, these participants were removed from the analytic sample. After applying these exclusions, the final analytic sample comprised 16,421 individuals.

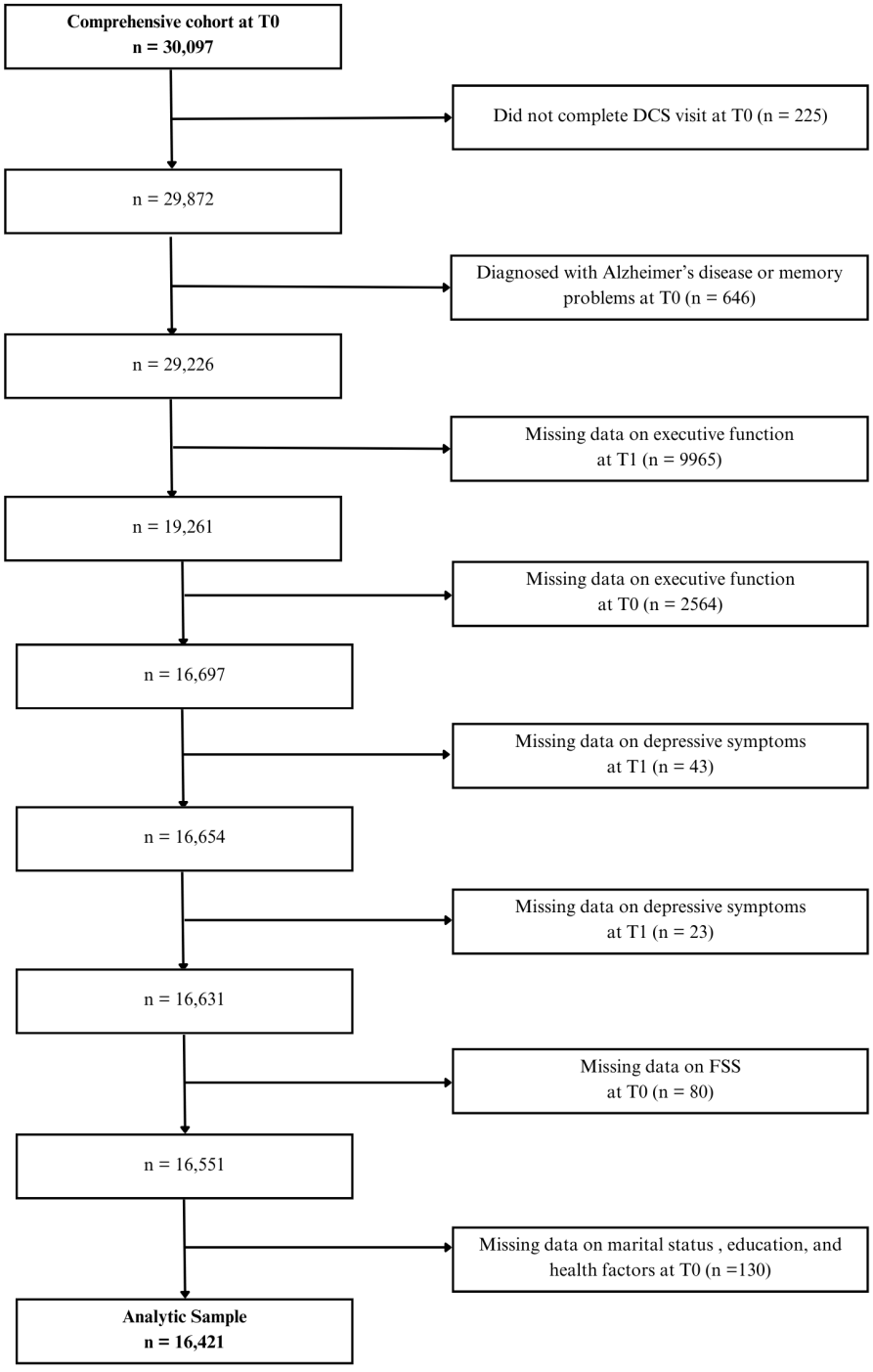

Figure 1. Flowchart of the Derivation of the Analytic Sample

Note. DCS = data collection sites; FSS = functional social support; T0 = baseline; T1 = follow-up

4.2 Measures

4.2.1 Exposure: Functional Social Support

The exposure of interest for the study is FSS at T0, as measured by the Medical Outcomes Survey – Social Support Survey (MOS-SSS) (Sherbourne & Stewart, 1991). The MOS-SSS is a 19-item questionnaire used to assess an individual's perceived level of FSS (Sherbourne & Stewart, 1991). For each item in the survey, there are five different response choices: none of the time (1), a little of the time (2), some of the time (3), most of the time (4), and all of the time (5). Higher scores on the MOS-SSS are indicative of higher levels of support. FSS was explored as both a continuous and categorical variable. As the distribution of scores was highly skewed, the FSS variable was categorized dichotomously. As a dichotomous variable, FSS was conceptualized as low social support (yes/no). The cut-off score for dichotomizing the FSS variable was determined based on the distribution of scores on the MOS-SSS, such that a score ≤ 3 indicated having social support available only 'some', 'a little' or 'none' of the time. This cut-off score for low social support of ≤ 3 has been used previously in work using CLSA data (Rutter, 2019; Yoo et al., 2023).

To reduce the amount of missing data, mean imputation was used to derive FSS values for participants missing data on the MOS-SSS. As the MOS-SSS includes four different subscales, mean imputation was performed within each subtype, with one exception: when imputing the missing values for an additional item not included in the subscales, mean imputation was done using all MOS-SSS items. When imputing within a subscale, a maximum of one item was permitted to be missing from the subscale, and when imputing the additional item, up to one item from the MOS-SSS was allowed to be missing.

Once mean imputation was completed within subscales and for the additional FSS item that did not belong to a subscale, the overall FSS variable was computed. When computing FSS, a maximum of one item was allowed to be missing from the MOS-SSS. If one item was missing, then FSS was computed as the mean of the corresponding imputed variable for the missing item and the remaining 18 items on the MOS-SSS. For further details on how the overall FSS variable was calculated, see Appendix C.

4.2.2 Outcome: Executive Function

Executive function at T1 is the outcome of interest for the study. The detailed reasoning behind which cognitive tests were chosen for inclusion in the CLSA as measures of executive function can be found in Tuokko et al. (2017). In brief, the psychometric properties, appropriateness for the CLSA, cost and duration of administration, and relevance to middle-aged and older adults aided in the selection of measures (Tuokko et al., 2017). Furthermore, the instruments could not be copyrighted and had to be available in both English and French. Cognitive performance of CLSA participants was similar to participants in previous studies involving English and French-speaking individuals aged 45–85 years old, which supports the use of these cognitive measures in large-scale epidemiological studies of aging (Tuokko et al., 2020).

A standardized executive function score was created by combining the results of five different cognitive tests assessing the three common executive function subdomains: cognitive flexibility, prospective memory, and inhibition (Tuokko et al., 2017). The Animal Fluency Test (Read, 1987), the Mental Alternation Test (Teng, 1995), and the Controlled Oral Word Association Test (Lezak et al., 2004) were used to measure cognitive flexibility. Although the latter two tasks measure verbal fluency, these tests can also be useful when measuring cognitive flexibility (Diamond, 2013; Tuokko et al., 2017). The Time-based Prospective Memory Test (Loewenstein & Acevedo, 2004) was used to assess prospective memory and the Stroop Neurological Screen Test-Victoria Version (Stroop) (Bayard et al., 2009, 2011; Moroni & Bayard, 2009; Troyer et al., 2006) was used to evaluate inhibition (Tuokko et al., 2017). The Stroop test was modified for the CLSA such that when participants completed the test, errors were recorded but not corrected and, as a result, errors made in the test were not captured in the score (O'Connell et al., 2023). The raw scores from each of the five cognitive tests were converted into z-scores and then summed together, thus creating a standardized executive function score. Z-scores were calculated for English speakers and French speakers separately to account for differences in the performance on cognitive tests due to language (Tuokko et al., 2020). The rationale for using a combined executive function score rather than individual test scores is that a composite score may be a more reliable measure of executive function since it reduces measurement error (Amaefule et al., 2021). Additionally, previous work using cognitive data from both the Tracking and Comprehensive cohorts of the CLSA have also used similar methods to create a combined cognition score (Hosseini et al., 2023; Iacono et al., 2023; Oremus et al., 2019).

Executive function was measured as a continuous variable. When categorizing a continuous measure, statistical power is reduced due to a loss of information and variation in the outcome between groups can be underestimated (Altman & Royston, 2006). Further, PROCESS, the analytic technique used in multivariable analyses to estimate moderated mediation, uses ordinary least squares (OLS) regression to estimate model coefficients and thus requires a continuous outcome variable (see Section 4.4.1 for further information on PROCESS).

4.2.3 Mediator: Depressive Symptoms

Depressive symptoms at T1 were examined as a mediator of the association between FSS and executive function. The Centre for Epidemiological Studies Short Depression Scale (CES-D-10) was used to measure depressive symptoms (Andresen et al., 1994; Radloff, 1977). The CES-D-10 is a 10-item questionnaire used to measure the frequency of depressive symptoms within the past week. The CES-D-10 is a reliable and valid tool to screen for depression in community-dwelling older adults (Irwin et al., 1999; Mohebbi et al., 2018). Within the context of the CLSA, the CES-D-10 has shown measurement invariance across language of administration, age, sex, education, ethnic background, and cognitive status (O'Connell et al., 2018). For each item on the questionnaire, there are four response options: all of the time/5–7 days per week (1), occasionally/3–4 days per week (2), some of the time/1–2 days per week (3), and rarely or never/less than 1 day per week (4). The possible range of scores for the CES-D-10 is 0–30, where higher scores indicate having more depressive symptoms (Andresen et al., 1994). Given the advantages of keeping the continuous nature of a variable (as discussed in Section 4.2.2), depressive symptoms were analysed as a continuous variable. The depressive symptoms variable was created by summing together each item from the CES-D-10. Items 5 ("How often did you feel hopeful about the future?") and 8 ("How often were you happy?") from the CES-D-10 required reverse coding before summation. If there was one missing item from the scale, then the item's value was imputed by taking the mean of the 9 remaining items. However, if there was more than one missing item, then the score for the depressive symptoms variable was set to missing (Canadian Longitudinal Study on Aging, 2018b).

4.2.4 Moderators: Age Group and Sex

Baseline age group and sex were assessed as moderators of the mediated effect. The categories for age group are 45–54 years, 55–64 years, 65–74 years, and ≥ 75 years. The CLSA measured sex at baseline with the question, "Are you male or female?". Data on gender were not collected at baseline.

4.2.5 Covariates

The decision regarding which covariates to include was partially supported by earlier research with CLSA data that examined social support, depression, and executive function (Ha, 2019; Iacono et al., 2023; Ohman et al., 2023; Oremus et al., 2020; Rutter, 2019; Yoo et al., 2023). The literature further informed the selection of covariates (see Section 2.7 for more information). The covariates used in the study can be classified as sociodemographic, health, and lifestyle factors.

The sociodemographic covariates chosen for inclusion in the study were age group, sex, province (Alberta, British Columbia, Manitoba, Newfoundland and Labrador, Nova Scotia, Ontario, Quebec), rural/urban residence, education (less than high school, high school graduate, some post-secondary, post-secondary degree/diploma), annual household income (< $20,000, ≥ $20,000 to < $50,000, ≥ $50,000 to < $100,000, ≥ $100,000 to < $150,000, and ≥ $150,000), marital status (single/never married, married/living with a partner in a common-law relationship, widowed, divorced/separated), and living arrangements (lives alone, lives with others). The health covariates included are self-rated health (poor, fair, good, very good, excellent), chronic conditions (reported no chronic conditions, reported at least one chronic condition) (Canadian Longitudinal Study on Aging, 2018a) and functional impairment (yes, no). The lifestyle covariates included smoking status over the last 30 days (current smoker, former smoker, never smoker) and alcohol use over the past 12 months (regular drinker, occasional drinker, non-drinker).

4.3 Descriptive Analysis

Descriptive analyses are reported for unweighted data (Section 5.1); results from weighted analyses are summarized in Appendix D. Frequencies were calculated for categorical variables; means, standard deviations, and standard errors were computed for normally distributed continuous variables; and medians and interquartile ranges were estimated for continuous variables with skewed distributions. Bivariate analyses provided an overall description of the analytic sample. Pearson correlation coefficients were calculated when both variables were continuous, a t-test statistic was estimated or an ANOVA test with Tukey post-hoc tests was performed when one variable was continuous and the other was categorical, and when both variables were categorical, a chi-square test was conducted.

The relationship between self-rated health and depressive symptoms was examined in bivariate analyses due to the potential for these variables to be highly correlated in older adults (Peleg &

Nudelman, 2021). The decision to include self-rated health as a covariate was based on the strength of the relationship between self-rated health and depressive symptoms, which was assessed using the variance inflation factor (VIF). Since the two variables were not strongly related, reflected by a VIF < 10 (Kim, 2019; Kleinbaum et al., 2013; Marcoulides & Raykov, 2019), self-rated health was retained as a covariate in multivariable analyses.

4.4 Multivariable Analysis

When conducting multivariable analyses, only unweighted data were used. The analytic strategy used to assess mediation is unable to incorporate sample weights, and thus a weighted mediation analysis could not be performed. See Appendix D for further discussion of the use of weights in descriptive and multivariable analyses.

4.4.1 Estimating Mediation and Moderated Mediation Using Conditional Process Analyses

Conditional process analysis is an analytic strategy that combines mediation and moderation analysis both conceptually and analytically (Hayes, 2022), and was used to address the research questions. Based on an ordinary least squares (OLS) regression framework, conditional process analysis is used to estimate and interpret the observed indirect and direct effects of the exposure variable (X) on the outcome variable (Y) in a causal pathway. The indirect effect of FSS (X) on executive function (Y) through depressive symptoms (M) is equivalent to the product of *a* by *b*. The regression coefficient for the effect that FSS (X) has on depressive symptoms (M) is denoted by *a*, while *b* is equal to the regression coefficient for the effect of depressive symptoms (M) on executive function (Y), when controlling for FSS (X). The indirect effect can be split into two paths; the association between FSS (X) and depressive symptoms (M) can be defined as Path I (the ‘a’ path), and the association between depressive symptoms (M) and executive function (Y) can be labelled as Path II (the ‘b’ path). The direct effect, *c’*, is equivalent to the effect of FSS (X) on executive function (Y), while controlling for the effect of depressive symptoms (M). The total effect is equal to the indirect and direct effects added together (Hayes, 2022). Refer to Figure 2 for a visual depiction of this model.

The PROCESS macro version 4.3.1 in SAS (SAS Institute, Cary, NC) was used to estimate the 95% bootstrap confidence interval (CI). The CI is generated by comparing the observed indirect effect to a bootstrapped sampling distribution created from 10,000 parallel data sets. To create the

10,000 parallel data sets, random sampling with replacement from the observed sample is performed 10,000 times. In each dataset that is created, the indirect effect is estimated. The distribution of the indirect effect from the 10,000 data sets is used to estimate the sampling distribution of the indirect effect. From this sampling distribution, a CI is generated. If the 95% bootstrap CI does not contain 0, then it can be said that the indirect, or mediated effect, is statistically significant.

Model 4 in PROCESS was used to estimate simple mediation. To assess the presence of mediation, both the joint significance test and the index test were used. The joint significance test involves examining the 95% CI for the regression coefficient at Path I (*a*) and at Path II (*b*). Mediation is present if both CI's do not contain the null value of 0. The index test consists of examining the regression coefficient for the mediated effect (*ab)* and concluding if mediation is present based on whether the 95% CI contains the null value.

There is debate regarding whether the joint significance test or the index test is better suited to evaluate mediation. Those in favour of the joint significance test argue that the index test produces more Type I errors since it relies on a single test to evaluate mediation. Additionally, the joint significance test encourages individuals to critically examine the individual estimates from the paths that make up the mediated effect (Yzerbyt et al., 2018). The rationale behind using the index test is that the indirect effect is *ab* and thus, statistical significance for both *a* and *b* is not required to establish if mediation is present (Hayes & Rockwood, 2020). Supporters of the index test argue that statistical tests are fallible and conducting multiple tests decreases power (Hayes, 2015, 2022; Montoya & Hayes, 2017). By using the index test, one may increase statistical power and decrease Type II errors (Yzerbyt et al., 2018). Given the debate regarding the use of each test, this thesis followed the recommendations of Yzerbyt et al. (2018), which was to use the joint significance test to ascertain if each path of the mediated effect is significant. If the results from the joint significance test indicate that mediation is significant, then the next step is to move forward with using the index test to understand the indirect effect.

In addition to estimating the mediated effect, PROCESS was used to estimate moderated mediation, i.e., to determine if the strength of the indirect effect of FSS on executive function was dependent on age group and sex (moderators). A visual depiction of moderated mediation can be found in Figure 2. When estimating moderated mediation, T0 measurements for depressive symptoms and executive function were controlled for at Path I. The same variables, with the addition of T0 FSS,

were controlled for at Path II as Hayes (2022) recommends. The analytic plan, which is based on the conceptual moderated mediation model in Figure 2, can be found in Table 1.

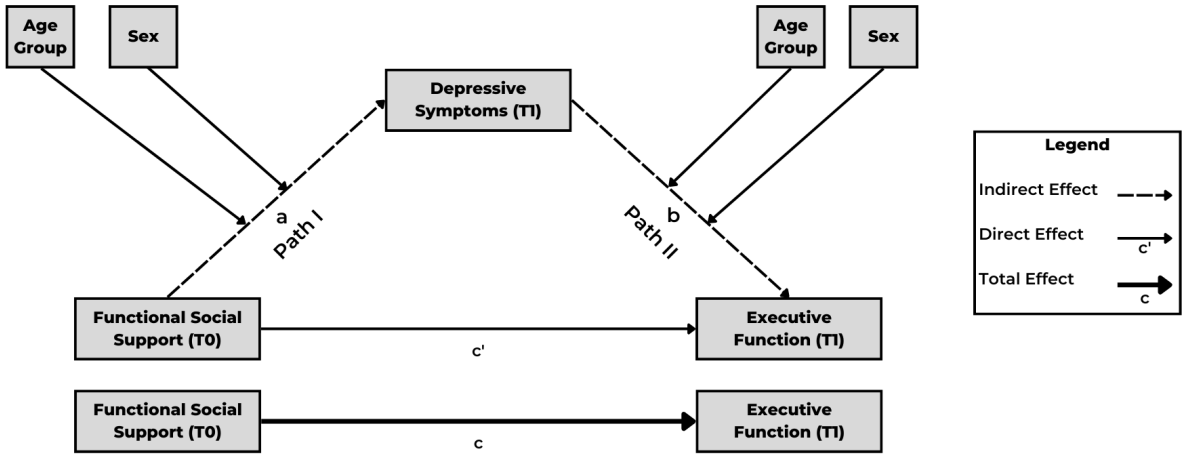

Figure 2. Conceptual Moderated Mediation Model

Note. Age group and sex are shown as potential moderators of the effect of functional social support on executive function mediated by depressive symptoms.
T0 = baseline; T1 = follow-up; a = regression coefficient for the effect of FSS on depressive symptoms; b = regression coefficient for the effect of depressive symptoms on executive function, controlling for FSS.

Table 1. Analytic Plan Based on Conceptual Moderated Mediation Model

Measure	Model 1 Base Model	Model 2 Final Model
	Path I: FSS → Depressive symptoms	
Exposure (T0)	FSS	FSS
Outcome (T1)	Depressive symptoms	Depressive symptoms
Moderators (T0)	Age group and sex	Age group and sex
Baseline mediator and outcome (T0)	Depressive symptoms[a] and executive function[a]	Depressive symptoms[a] and executive function[a]
Sociodemographic covariates (T0)	--	Marital status, living arrangements, province, education, annual household income, and rural/urban residence
Health covariates (T0)	--	Self-rated health, chronic conditions, and functional impairment
Lifestyle covariates (T0)	--	Smoking status and alcohol use
	Path II: Depressive symptoms → Executive function	
Exposure (T1)	Depressive symptoms	Depressive symptoms
Outcome (T1)	Executive function	Executive function
Moderators (T0)	Age group and sex	Age group and sex
Baseline mediator and outcome (T0)	Depressive symptoms[a] and executive function[a]	Depressive symptoms[a] and executive function[a]
Sociodemographic covariates (T0)	--	Marital status, living arrangements, province, education, annual household income, and rural/urban residence
Health covariates (T0)	--	Self-rated health, chronic conditions, and functional impairment
Lifestyle covariates (T0)	--	Smoking status and alcohol use

Note. FSS = functional social support; T0 = baseline; T1 = follow-up.
[a]Baseline measures of mediator and outcome are controlled for as per Hayes (2022).

4.4.2 Approach to Building a Moderated Mediation Model

The first step in building the moderated mediation model was to create a conceptual diagram, which included age group and sex as potential moderators of the mediated effect of FSS on executive function through depressive symptoms (Figure 2). Interactions with age group and sex were then tested in fully adjusted models at both paths. If there were significant interactions, a moderated mediation model was created based on which interaction terms were significant on each specific path, and the indirect effect was estimated based on different levels of moderator(s). If no interactions were found to be significant on either path, a simple mediation model would be estimated where only the overall indirect effect was calculated.

To test interactions at each path, multiple linear regression models were run. At each path, three-way interactions were tested in fully adjusted models and were included in the final model if statistically significant. If the three-way interaction term was not significant, two-way interactions were tested in fully adjusted models and included in the final model if they were found to be significant. To aid with testing interactions, fully adjusted moderated mediation models with moderation by sex and/or age group at Path I, Path II, or both paths were tested. The results from these models can be found in Appendix E. After testing interactions, the final step in model building was to conduct sensitivity analyses (see Section 4.4.4.).

4.4.3 Calculating the Proportion Mediated

The proportion mediated (P_M) is a statistic used to quantify the indirect effect (Miočević et al., 2018; Rijnhart et al., 2021). It has intuitive appeal (Rijnhart et al., 2021) and was used to help interpret the proportion of the total effect of FSS on executive function mediated by depressive symptoms. The P_M is calculated by dividing the indirect effect by the total effect ($P_M = ab/c$) (Miočević et al., 2018). The sample was stratified based on age group and sex, as the P_M can only be calculated after stratification by the moderators of the mediated effect. In each subsample, unmoderated mediation analyses were run, which generated the indirect and total effect. These estimates were then used to calculate the P_M within each subgroup.

4.4.4 Sensitivity Analysis

To provide a clear temporal association between exposure, mediator, and outcome, the study would have needed to include FSS at T0, depressive symptoms at T1, and executive function at T2.

However, cognitive data at T2 were not available when analyses began. Thus, when estimating moderated mediation, both depressive symptoms and executive function were measured at T1.

In the main analyses, Path I (FSS at T0 and depressive symptoms at T1) was assessed longitudinally, whereas Path II (depressive symptoms and executive function both at T1) was assessed cross-sectionally. The evidence supported measuring depressive symptoms at T1, as Path I is more likely to be affected by reverse causality compared to Path II. Additionally, previous mediation analysis work with FSS, depression, and executive function has measured the path between depression and FSS prospectively.

However, as there is also evidence to support examining a prospective association between depressive symptoms and executive function, sensitivity analyses explored modelling Path II longitudinally (depressive symptoms at T0 and executive function at T1). Comparing the cross-sectional association with the prospective association between depressive symptoms and executive function provided insight into how the results were influenced by only having two time points.

4.5 Ethics

Ethics approval for this research project has been given by the University of Waterloo's Office of Research Ethics (#44802). Access to the data was granted by the CLSA, with the student researcher signing the data access agreement between the University of Waterloo and the CLSA.

Chapter 5
Results

5.1 Descriptive Analyses

Results reported in the main text are based on unweighted analyses; Table D1 in Appendix D includes results based on weighted descriptive analyses.

5.1.1 Univariate Analyses

FSS at T0 (Figure 3) and depressive symptoms at T1 (Figure 4) both have a skewed distribution. Executive function at T1 has little skewness (Figure 5), as the executive function variable is a standardized score. When FSS was analysed as a dichotomous variable, individuals with low FSS at either timepoint were in the minority (Table 2). There was a larger proportion of participants with low FSS at T1 than at T0 (6.03% vs 5.49%, $p < 0.003$). The overall sample did not experience high levels of depressive symptoms (Table 2) because, at both timepoints, the mean and median were below 10: a score ≥ 10 on the CES-D-10 is the cut point for clinically significant depressive symptoms (Andresen et al., 1994). Note that for all other analyses, depressive symptoms was treated as a continuous variable. Participants had slightly higher levels of executive function at T0 compared to T1 (Table 2). When examining distribution of the moderators (Table 3), slightly more than half of the sample was female (50.68%) and more than one-third (37.07%) of participants were 65 years or older. The sample consisted of participants who were highly educated (80.13% of participants had a post-secondary degree/diploma), had a mid-to-high income (72.75% of individuals had a household income $\geq$ $50,000), and were healthy (over 90% reported their health as good, very good, or excellent).

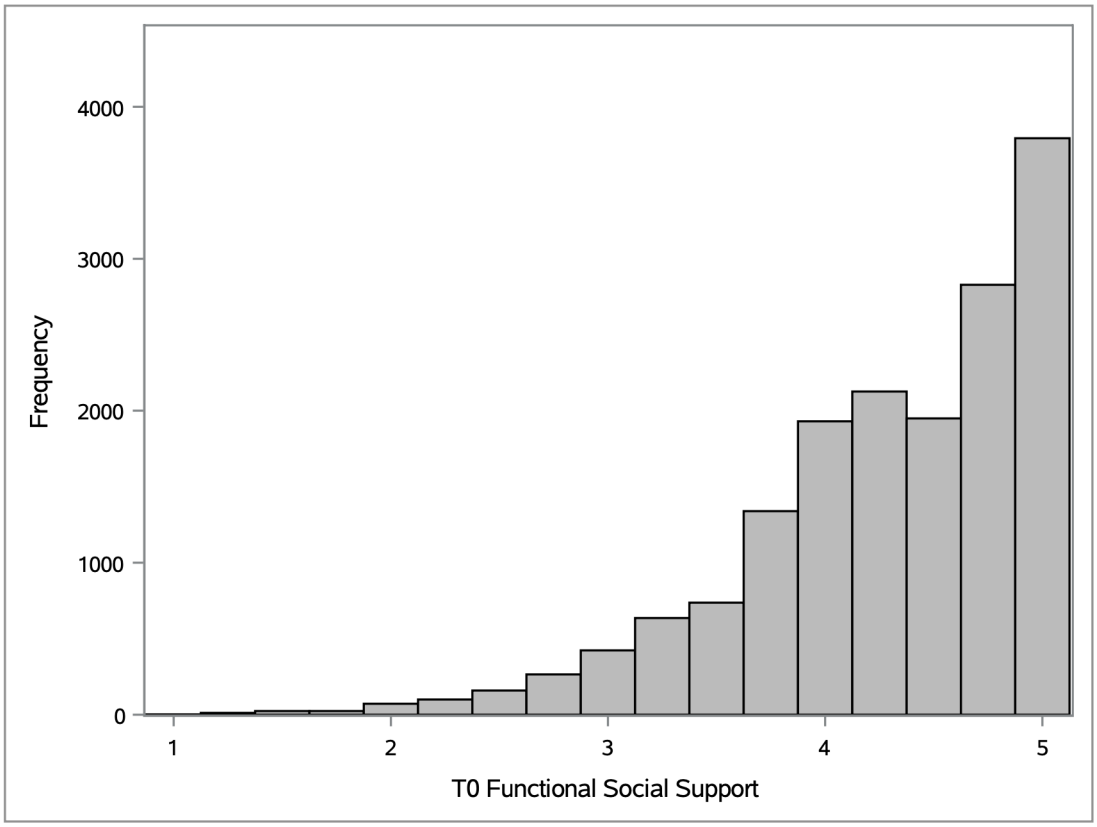

Figure 3. Distribution of Functional Social Support at Baseline (T0), Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

Note. The Medical Outcomes Survey – Social Support Survey was used to assess the perceived level of social support available to an individual. A higher value on the scale indicates higher levels of perceived support.

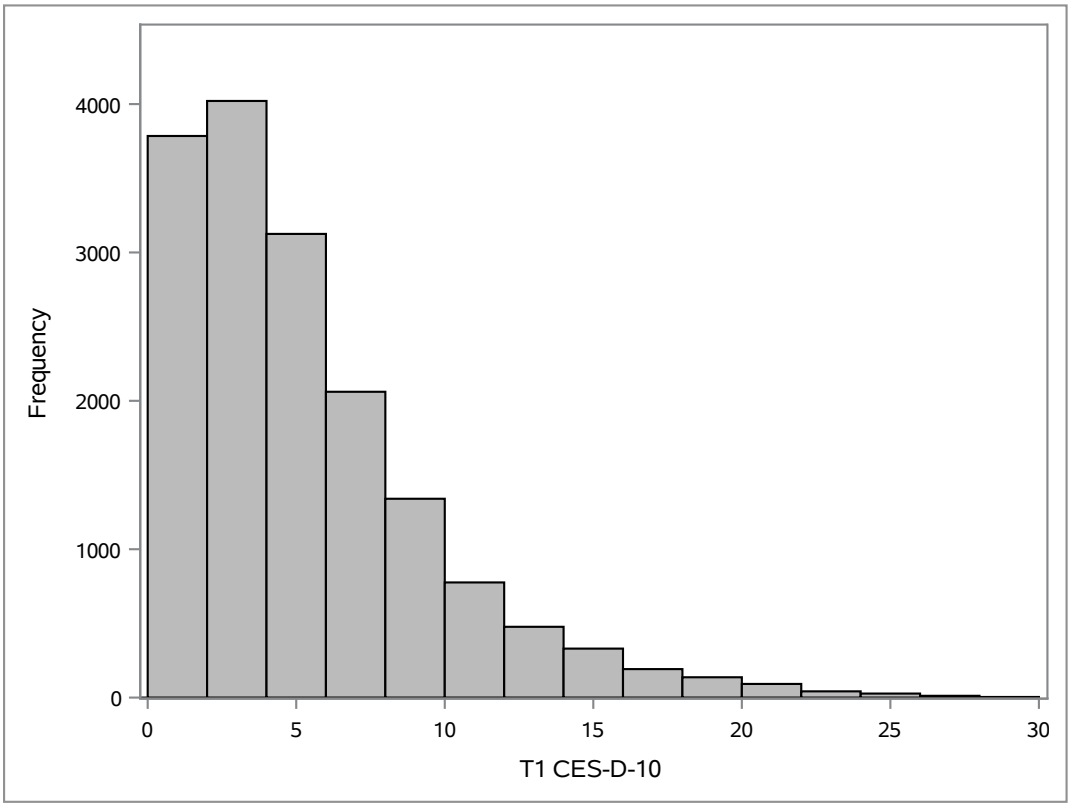

Figure 4. Distribution of Depressive Symptoms at Follow-up (T1), Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

Note. The frequency of self-reported depressive symptoms within the past week were measured using the Centre for Epidemiological Studies Short Depression Scale (CES-D-10), with higher values indicating higher levels of depressive symptoms.

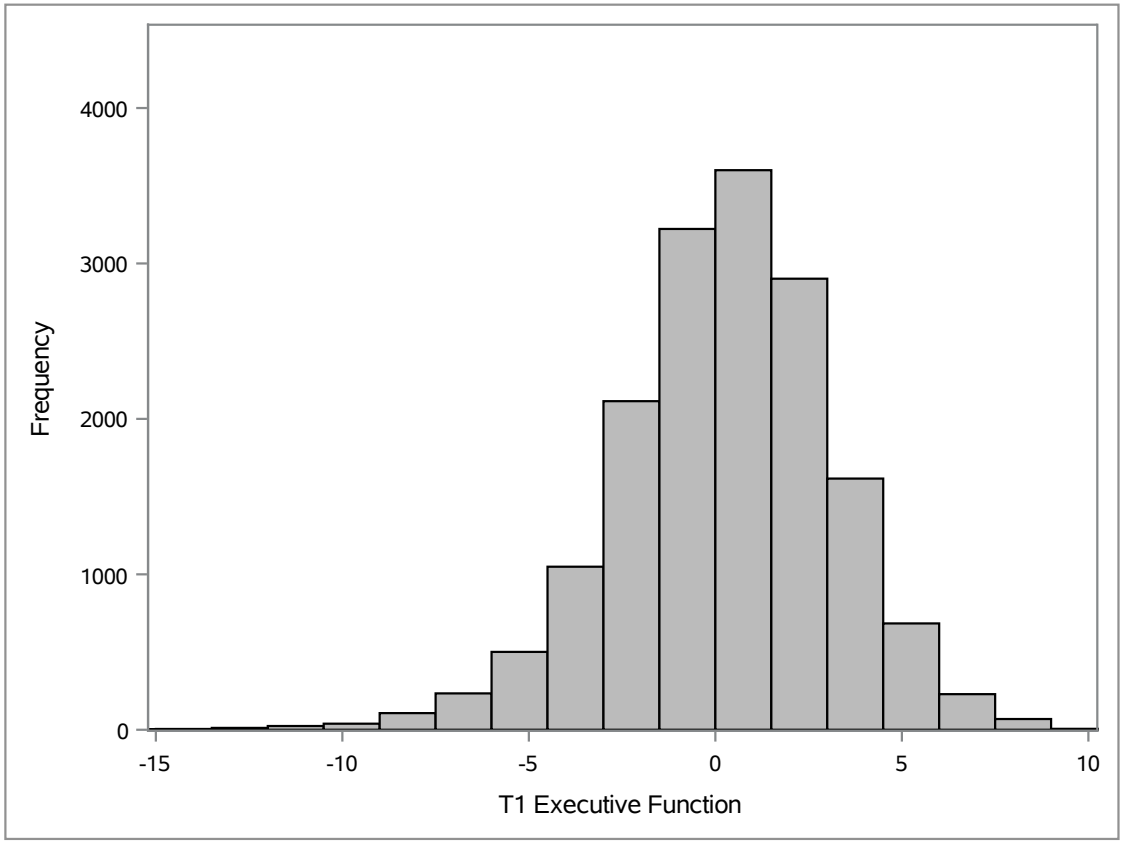

Figure 5. Distribution of Executive Function at Follow-Up (T1), Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

Note. An executive function score was created by standardizing and then combining the results from the Animal Fluency Test, the Mental Alternation Test, the Controlled Oral Word Association Test, Time-based Prospective Memory Test, and the Stroop Neurological Screen Test-Victoria Version.

Table 2. Functional Social Support, Depressive Symptoms, and Executive Function at Baseline and Follow-Up, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

Measure	Prevalence (%)			
Low FSS[a]				
T0		5.49**		
T1		6.03		
	$\bar{x}$	*SD*	*Md*	*IQR*
FSS[a]				
T0	4.29***	0.66	4.42	0.95
T1	4.30	0.67	4.42	0.95
Depressive symptoms[b]				
T0	4.99***	4.45	4.00	5.00
T1	4.81	4.32	4.00	5.00
Executive function[c]				
T0	0.40***	2.76	0.52	3.52
T1	0.23	2.96	0.37	3.63

Note. McNemar's test and paired t-tests were used to compare each individual measure at T0 versus T1.

FSS = functional social support; IQR = interquartile range; MD = median; SD = standard deviation; T0 = baseline; T1 = follow-up; $\bar{x}$ = mean.

[a]FSS was measured using the Medical Outcomes Survey-Social Support Survey. Scores range from 1–5 and low FSS = ≤ 3.

[b]Depressive symptoms were measured using the Centre for Epidemiological Studies Short Depression Scale. The possible range of scores is 0–30.

[c]An executive function score was created by standardizing and then combining the results from five different cognitive tests evaluating executive function.

*p < .05, **p < .01, ***p < .001

Table 3. Participant Characteristics at Baseline by Depressive Symptoms and Executive Function at Follow-up, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

Characteristics (T0)	Total	Mediator (T1)		Outcome (T1)
		Depressive symptoms[b]		Executive function[c]
	%	$\bar{x}$ *(SD)*	*MD (IQR)*	$\bar{x}$ *(SD)*
Low FSS[a]				
Low	5.49	8.33 (5.62)***	7.00 (8.00)	-0.65 (3.30)***
Other	94.51	4.61 (4.14)	4.00 (4.00)	0.28 (2.93)
Sociodemographic factors				
Age group				
45–54	28.10	4.89 (4.44)^{***1}	4.00 (5.00)	1.45 (2.52)^{***1}
55–64	34.83	4.75 (4.41)^{1,2}	4.00 (5.00)	0.72 (2.61)^{2}
65–74	23.57	4.60 (4.15)^{2}	4.00 (5.00)	-0.61 (2.76)^{3}
≥ 75	13.50	5.20 (4.11)^{3}	4.00 (5.00)	-2.07 (3.23)^{4}
Sex				
Female	50.68	5.32 (4.61)***	4.00 (5.00)	0.15 (2.95)***
Male	49.32	4.29 (3.93)	3.00 (5.00)	0.31 (2.96)
Marital status				
Single/never married	8.36	6.00 (4.93)^{***1}	5.00 (6.00)	0.25 (2.89)^{***1}
Married/common-law	71.90	4.43 (4.04)^{2}	3.00 (5.00)	0.45 (2.82)^{1,2}
Widowed	7.63	5.54 (4.53)^{3}	4.44 (6.00)	-1.53 (3.46)^{3}
Divorced/separated	12.11	5.79 (4.96)^{1,3}	4.00 (6.00)	0.03 (3.06)^{1}
Living arrangements				
Lives alone	19.90	5.72 (4.71)***	5.00 (6.00)	-0.56 (3.19)***
Lives with others	80.10	4.59 (4.19)	4.00 (4.00)	0.43 (2.86)
Province				
Alberta	8.71	4.84 (4.19)	4.00 (5.00)	0.35 (2.93)^{***1}
British Columbia	22.37	4.80 (4.17)	4.00 (5.00)	0.66 (2.83)^{2}
Manitoba	9.79	4.84 (4.27)	4.00 (5.00)	0.24 (3.11)^{1}
Newfoundland and Labrador	8.78	4.64 (4.33)	4.00 (4.89)	-0.36 (2.85)^{3}
Nova Scotia	9.57	4.91 (4.34)	4.00 (5.00)	-0.18 (2.90)^{3}
Ontario	23.21	4.82 (4.44)	4.00 (5.00)	0.23 (2.90)^{1}
Quebec	17.57	4.82 (4.43)	4.00 (5.00)	0.15 (3.11)^{1}
Education				
Less than secondary school	4.09	6.24 (5.21)^{***1}	5.00 (7.00)	-2.69 (3.15)^{***1}
Secondary school graduate	8.47	5.30 (4.51)^{2}	4.00 (6.00)	-0.81 (3.02)^{2}
Some post-secondary education	7.31	5.31 (4.48)^{2}	4.00 (5.00)	-0.31 (2.82)^{3}
Post-secondary degree/diploma	80.13	4.64 (4.21)^{3}	4.00 (4.00)	0.54 (2.84)^{4}
Total household income				
< $20,000	3.76	7.67 (5.53)^{***1}	6.00 (7.00)	-1.52 (3.58)^{***1}
≥ $20,000 and < $50,000	18.42	5.80 (4.74)^{2}	5.00 (6.00)	-1.01 (3.12)^{2}
≥ $50,000 and < $100,000	33.74	4.74 (4.14)^{3}	4.00 (5.00)	0.13 (2.73)^{3}
≥ $100,000 and < $150,000	20.38	4.23 (3.89)^{4}	3.00 (5.00)	0.90 (2.63)^{4}
≥ $150,000	18.63	3.86 (3.74)^{5}	3.00 (4.00)	1.47 (2.48)^{5}

Characteristics (T0)	Total	Mediator (T1) Depressive symptoms[b]		Outcome (T1) Executive function[c]
	%	$\bar{x}$ *(SD)*	*MD (IQR)*	$\bar{x}$ *(SD)*
Missing	5.07	5.39 (4.77)^{2}	4.00 (6.00)	-0.57 (3.44)^{6}
Rural/urban residence				
Rural	7.64	4.53 (4.31)*	3.00 (5.00)	0.20 (2.82)
Urban	92.36	4.84 (4.32)	4.00 (5.00)	0.23 (2.97)
Health factors				
Self-rated health				
Poor	0.94	10.78 (6.45)^{***1}	10.00 (9.00)	-0.87 (3.11)^{***1}
Fair	6.14	8.25 (5.53)^{2}	7.00 (8.00)	-0.85 (3.37)^{1}
Good	27.90	5.74 (4.51)^{3}	5.00 (6.00)	-0.16 (3.06)^{2}
Very good	43.33	4.37 (3.84)^{4}	3.00 (4.00)	0.42 (2.83)^{3}
Excellent	21.67	3.26 (3.35)^{5}	2.00 (4.00)	0.71 (2.78)^{4}
Chronic conditions				
Reported none	6.44	3.20 (3.17)***	2.00 (3.00)	1.06 (2.50)***
Reported at least one	93.56	4.92 (4.37)	4.00 (5.00)	0.17 (2.98)
Functional Impairment				
Yes	7.33	7.08 (5.20)***	6.00 (7.00)	-1.26 (3.18)***
No	92.67	4.63 (4.19)	4.00 (4.00)	0.35 (2.91)
Lifestyle factors				
Smoking status				
Never	49.47	4.58 (4.20)^{***1}	3.00 (4.00)	0.47 (2.90)^{***1}
Former	42.70	4.84 (4.25)^{2}	4.00 (5.00)	-0.01 (3.01)^{2}
Current	7.83	6.10 (5.17)^{3}	5.00 (6.89)	0.05 (2.87)^{2}
Alcohol use				
No	9.91	5.63 (4.97)^{***1}	4.00 (6.00)	-0.45 (3.21)^{***1}
Occasional	11.33	5.66 (4.86)^{1}	4.00 (6.00)	-0.39 (2.94)^{1}
Regular	76.85	4.58 (4.11)^{2}	4.00 (4.00)	0.43 (2.89)^{2}
Missing	1.92	4.89 (4.39)^{2}	4.00 (5.00)	-0.60 (3.26)^{1}

Note. T-tests and ANOVA with Tukey post-hoc tests were used. Means with different numerical superscripts differ significantly at the $p < 0.05$ level. The median and interquartile range were calculated for depressive symptoms because the distribution of the data is skewed.
FSS = functional social support; IQR = interquartile range; MD = median; SD = standard deviation; T0 = baseline; T1 = follow-up; $\bar{x}$ = mean.
[a]FSS was measured using the Medical Outcomes Survey-Social Support Survey. Scores range from 1–5 and low FSS = ≤ 3.
[b]Depressive symptoms were measured using the Centre for Epidemiological Studies Short Depression Scale. The possible range of scores is 0–30.
[c]An executive function score was created by standardizing and then combining the results from five different cognitive tests evaluating executive function.
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

5.1.2 Bivariate Analyses: Associations with Depressive Symptoms

FSS as a dichotomous variable or a continuous variable at T0 were both significantly associated with depressive symptoms at T1. As a dichotomous variable (Table 3), individuals with low FSS had greater depressive symptoms compared to individuals without low FSS (8.33 versus 4.61, $p < 0.0001$). When FSS was analysed as a continuous variable (Table 4), a negative correlation between FSS and depressive symptoms was found ($r = -0.32$, $p < 0.0001$).

All T0 covariates, apart from province, were significantly associated with T1 depressive symptoms (Table 3). The nature of the bivariate associations between T0 covariates and depressive symptoms were all positive. Mean depressive symptoms decreased as individuals became older, except for the ≥ 75 age group, which had the highest depressive symptoms. However, median depressive symptoms did not share a similar pattern, as the median was equivalent in all age groups. With respect to sex, females had a higher level of depressive symptoms compared to males. The association between non-users and occasional users of alcohol with depressive symptoms had a similar magnitude of effect, and the results of Tukey's post-hoc test showed no significant difference between non-users and occasional users of alcohol.

5.1.3 Bivariate Analyses: Associations with Executive Function

FSS at T0 was significantly associated with executive function at T1. When analysed as a dichotomous variable (Table 3), those with low FSS had lower executive function compared to individuals who did not have low FSS (-0.65 versus 0.28, $p < 0.0001$). As a continuous variable (Table 4), FSS was significantly and positively correlated with executive function ($r = 0.12$, $p < 0.0001$). Further, depressive symptoms at T0 were significantly and negatively correlated with executive function at T1 ($r = -0.09$, $p < 0.0001$).

Apart from rural/urban residence, all covariates were significantly associated with executive function (Table 3). The nature of the associations differed across covariates, as well as within the categories for each covariate. Regarding sociodemographic factors, the ≥ 75 age group had the lowest level of executive function and with each subsequent decrease in age group, executive function increased. Female participants had lower executive function compared to males. With respect to alcohol use, the magnitude of the association between non-users and occasional users of alcohol with executive function was similar, and the results of post-hoc testing showed no significant difference in executive function between non-users and occasional users of alcohol.

Table 4. Correlation Between Baseline and Follow-up Measures of Depressive Symptoms and Executive Function, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

Baseline (T0)	Follow-up (T1)	
	Depressive Symptoms (M)	**Executive Function (Y)**
	r	***r***
FSS (X)[a]	-0.32***	0.12***
Depressive symptoms (M)[b]	0.59***	-0.09***
Executive function (Y)[c]	-0.10***	0.74***

Note. The test used was Pearson's correlation coefficient (*r*).
M = mediator; X = exposure; Y = outcome.
[a]s was measured using the Medical Outcomes Survey-Social Support Survey. Scores range from 1–5 and low FSS = ≤ 3.
[b]Depressive symptoms were measured using the Centre for Epidemiological Studies Short Depression Scale. The possible range of scores is 0–30.
[c]An executive function score was created by standardizing and then combining the results from 5 different cognitive tests evaluating executive function.
*p < .05, **p < .01, ***p < .001

5.2 Multivariable Analyses

The content covered in this section includes building the finalized moderated mediation model (Section 5.2.1); estimating mediation, moderated mediation and the proportion mediated (Section 5.2.2 and 5.2.3); examining effects at each path of the mediated effect (Sections 5.2.4 and 5.2.5); performing sensitivity analyses (Section 5.2.6); and verifying model diagnostics (Section 5.2.7).

5.2.1 Building the Moderated Mediation Model

5.2.1.1 Testing Interactions at Path I: The Effect of Low FSS on Depressive Symptoms

To test interactions at Path I, multiple linear regression models were run with low FSS at T0 as the exposure and depressive symptoms as a continuous variable at T1 as the outcome. All models were fully adjusted for sociodemographic, health, and lifestyle factors, as well as T0 measurements for depressive symptoms and executive function. The three-way interaction term (low FSS*age group*sex) was the first interaction to be tested for significance. In a fully adjusted model that included the three-way interaction term, the interaction term was not significant (R^2 change = 0.0001, p-value = 0.7134). Thus, two-way interaction terms were subsequently tested.

The two-way interaction terms that were tested at Path I were an interaction term between low FSS and age group (low FSS*age group) and an interaction term between low FSS and sex (low FSS*sex). In a model where both two-way interaction terms were included, the joint test of interaction between low FSS*age group and low FSS*sex was not statistically significant (R^2 change = 0.0002, p-value = 0.2419) and thus these two-way interactions were assessed separately. In these models, either age group or sex was controlled for as a covariate, depending on which two-way interaction term was being modelled. When the low FSS*age group interaction term was tested, it was nonsignificant (R^2 change = 0.0001, p-value = 0.7146). In the model that tested for the two-way interaction term between low FSS and sex, the interaction term was significant (R^2 change = 0.0002, p-value = 0.0432). Thus, the two-way interaction term between low FSS and sex was included in the final model on Path 1.

5.2.1.2 Testing Interactions at Path II: The Effect of Depressive Symptoms on Executive Function

Interactions at Path II were tested in a similar manner as testing the interactions at Path I, but with three key differences: the exposure was depressive symptoms at T1 instead of low FSS at T0, the

outcome was executive function at T1 instead of depressive symptoms at T1, and fully adjusted models also controlled for measurements of low FSS at T0. The first interaction term that was tested was the three-way interaction between depressive symptoms, age group, and sex (depressive symptoms*age group*sex). In the fully adjusted model, the depressive symptoms*age group*sex interaction term was found to be nonsignificant (R^2 change = 0.0001, p-value = 0.5137, and was not included in the final model.

As the three-way interaction term was not significant, the two-way interaction term between depressive symptoms and age group (depressive symptoms*age group), and the interaction term between depressive symptoms and sex (depressive symptoms*sex) were tested next. In a model that included the depressive symptoms*age group interaction and the depressive symptoms*sex interaction, the joint test of interaction was nonsignificant (R^2 change = 0.0002, p-value = 0.0661). In a fully adjusted model that only included the depressive symptoms*age group interaction, the interaction term was significant (R^2 change = 0.0002, p-value = 0.0327). Conversely, when testing the depressive symptoms*sex interaction, the interaction term was found to be nonsignificant (R^2 change = 0.0000, p-value = 0.8189) in fully adjusted models. As only the depressive symptoms*age group interaction term was found to be significant, it was the only interaction term added to Path II.

5.2.1.3 Finalized Moderated Mediation Model

Based on the results of testing interactions at Path I and Path II, a final moderated mediation model was created. In this model, Path I is moderated by sex, as the low FSS*sex interaction term was found to be significant. At Path II, moderation by age group was included, as the depressive symptoms*age group interaction term was significant. In the PROCESS macro, Model 21 allows for the user to estimate moderated mediation with one moderator at Path I and another moderator at Path II. A finalized conceptual diagram of the moderated mediation model can be found in Figure 6 and a revised analysis plan based on the results of testing interactions can be found in Table 5.

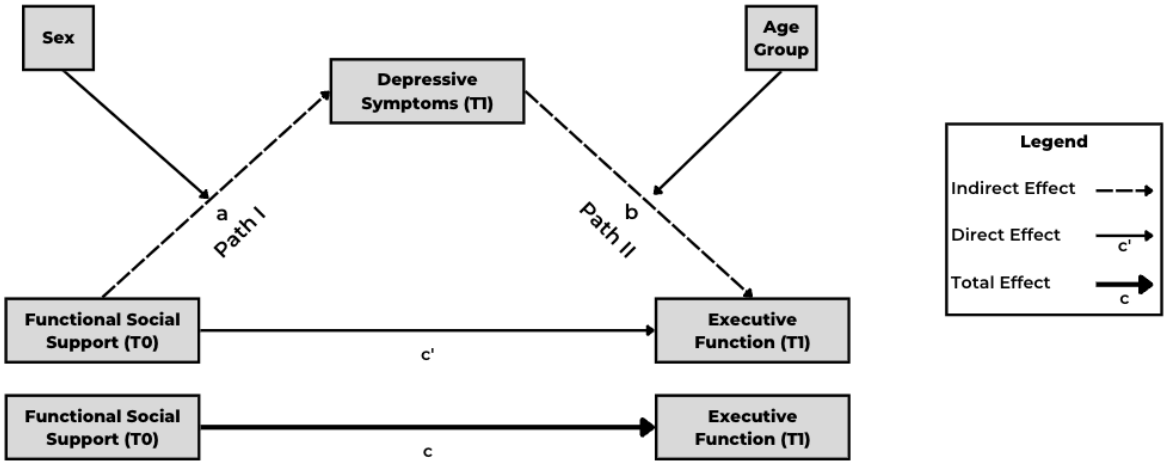

Figure 6. Finalized Moderated Mediation Model

Note. The Medical Outcomes Survey – Social Support Survey was used to assess the perceived level of social support. Depressive symptoms were measured using the Centre for Epidemiological Studies Short Depression Scale. An executive function score was created by standardizing and then combining the results from five different cognitive tests evaluating executive function. Sex is shown as a moderator of Path I and age group is shown as a moderator of Path II.
T0 = baseline; T1 = follow-up.

Table 5. Analysis Plan Based on Finalized Moderated Mediation Model

Measure	Model 1 Base Model	Model 2 Final Model
	Path I: FSS → Depressive symptoms	
Exposure (T0)	FSS	FSS
Outcome (T1)	Depressive symptoms	Depressive symptoms
Moderators (T0)	Sex	Sex
Baseline mediator and outcome (T0)	Depressive symptoms[a] and executive function[a]	Depressive symptoms[a] and executive function[a]
Sociodemographic covariates (T0)	--	Marital status, living arrangements, province, education, annual household income, and rural/urban residence
Health covariates (T0)	--	Self-rated health, chronic conditions, and functional impairment
Lifestyle covariates (T0)	--	Smoking status and alcohol use
	Path II: Depressive symptoms → Executive function	
Exposure (T1)	Depressive symptoms	Depressive symptoms
Outcome (T1)	Executive function	Executive function
Moderators (T0)	Age group	Age group
Baseline mediator and outcome (T0)	Depressive symptoms[a] and executive function[a]	Depressive symptoms[a] and executive function[a]
Sociodemographic covariates (T0)	--	Marital status, living arrangements, province, education, annual household income, and rural/urban residence
Health covariates (T0)	--	Self-rated health, chronic conditions, and functional impairment
Lifestyle covariates (T0)	--	Smoking status and alcohol use

Note. FSS = functional social support; T0 = baseline; T1 = follow-up.
[a]Baseline measures of mediator and outcome are controlled for as per Hayes (2022).

5.2.2 Estimating Mediation

Depressive symptoms were a significant mediator of the association between low FSS and executive function. The indirect effect was statistically significant in both the base model, which adjusted for T0 measurements of depressive symptoms and executive function, and the final model, which also adjusted for T0 sociodemographic, health, and lifestyle covariates (Table 6 and Figure 7). The proportion mediated provides an estimate of the magnitude of the effect of low FSS on executive function that is mediated through depressive symptoms (Table 6). The presence of mediation was assessed using the joint significance test and the index test. Significant mediation was shown by the joint significance test: CIs for both Path I (β = 0.9411, 95% CI = 0.6977, 1.1846) and Path II (β = -0.0154, 95% CI = -0.0239, -0.0068) excluded the null value (Table 7). As both regression coefficients were significant, the index test was used to examine the indirect effect. For the index test, significant mediation was shown by the 95% CI for the indirect effect excluding the null value (β = -0.0144, 95% CI = -0.0250, -0.0056) (Table 6).

In the base model, all three effects measured were found to be statistically significant and as mentioned above, the indirect effect remained significant in the final model. However, this finding was not replicated for the direct effect and total effect (Table 6 and Figure 7). In the final model, neither the direct nor the total effect were found to be statistically significant.

Table 6. Mediated Effect of Depressive Symptoms on the Association Between Low Functional Social Support and Executive Function, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

	Indirect Effect β (95% Bootstrap CI)	**Direct Effect** β (95% CI)	**Total Effect** β (95% CI)	**Proportion Mediated (%)**
Base model[a]	-0.0288* (-0.0427, -0.0172)	-0.2175** (-0.3540, -0.0810)	-0.2463*** (-0.3825, -0.1100)	11.69%
Final model[b]	-0.0144* (-0.0250, -0.0056)	-0.0782 (-0.2150, 0.0586)	-0.0927 (-0.2293, 0.0439)	15.53%

Note. β = regression coefficient; CI = confidence interval; FSS = functional social support; T0 = baseline; T1= follow-up.
[a]Included T0 depressive symptoms and T0 executive function.
[b]Included the same terms as the base model, with the addition of sociodemographic, health, and lifestyle covariates at T0.
*p < .05, **p < .01, ***p < .001

Table 7. Effect of Low Functional Social Support on Path I and Effect of Depressive Symptoms on Path II, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

	Path I: Low FSS → Depressive Symptoms β (95% CI)	
	Base Model[a] $R^2 = 0.3546$	**Final Model**[b] $R^2 = 0.3813$
Low FSS[c]	1.1539^{***} (0.9140, 1.3937)	0.9411^{***} (0.6977, 1.1846)
	Path II: Depressive Symptoms → Executive Function β (95% CI)	
	Base Model[a] $R^2 = 0.5558$	**Final Model**[b] $R^2 = 0.5841$
Depressive symptoms[d]	-0.0250^{***} (-0.0336, -0.0163)	-0.0154^{***} (-0.0239, -0.0068)

Note. The possible range of scores is 0–30.
β = regression coefficient; CI = confidence interval; FSS = functional social support.
[a]Included T0 depressive symptoms and T0 executive function.
[b]Included the same terms as the base model, with the addition of sociodemographic, health, and lifestyle covariates at T0.
[c]FSS was measured using the Medical Outcomes Survey-Social Support Survey. Scores range from 1–5 and low FSS = ≤ 3.
[d]Depressive symptoms were measured using the Centre for Epidemiological Studies Short Depression Scale. The possible range of scores is 0–30.
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

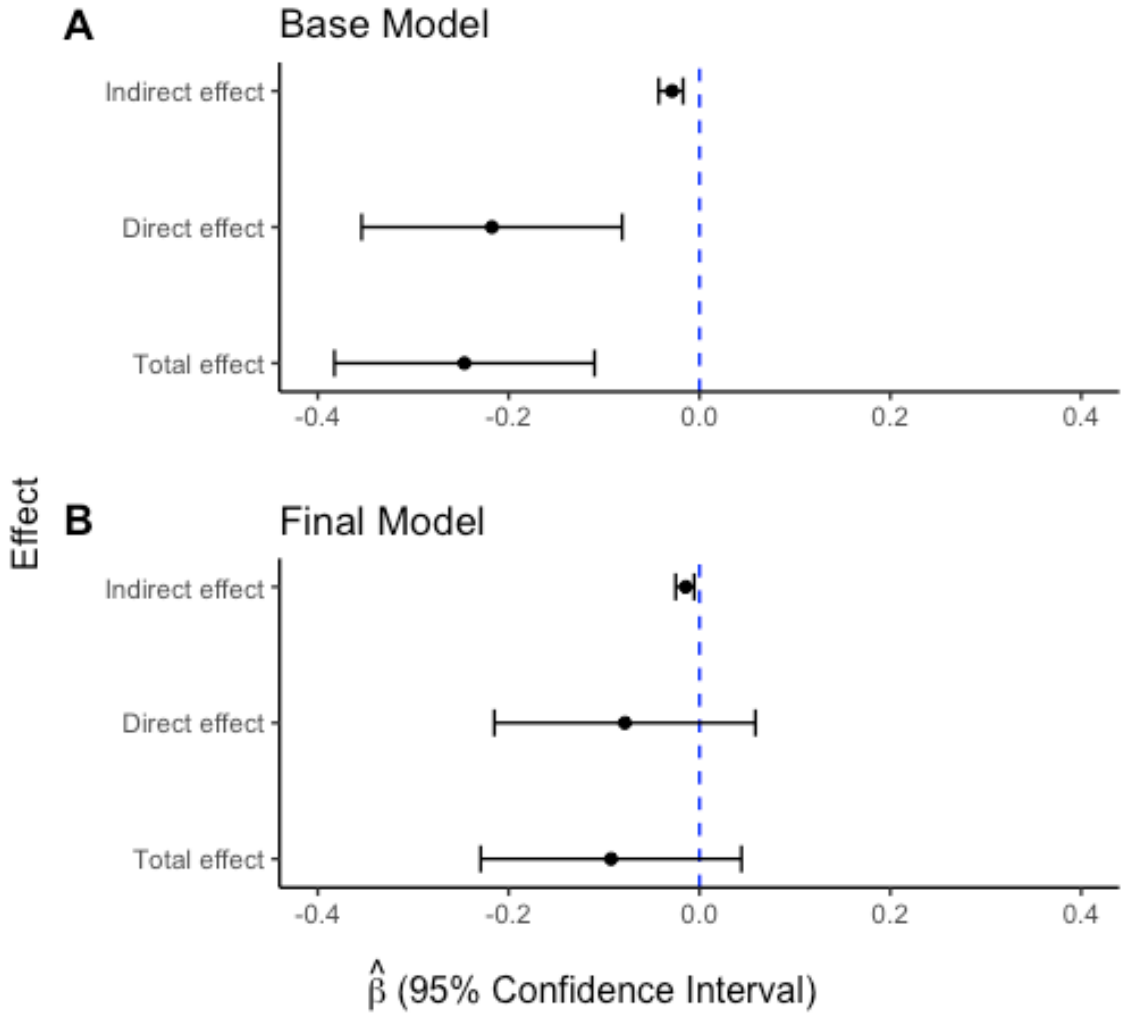

Figure 7. Forest Plot of the Indirect, Direct, and Total Effects of Low Functional Social Support on Executive Function Mediated Through Depressive Symptoms, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

Note. The base model included T0 depressive symptoms and T0 executive function. The final model included the same terms as the base model, with the addition of sociodemographic, health, and lifestyle covariates at T0.

$\hat{\beta}$ = regression coefficient.

5.2.3 Estimating Moderated Mediation and Proportion Mediated

The mediated (indirect) effect was significant in all subgroups except males and females 65–74 years old, although for males 45–54 (β = -0.0092, 95% CI = -0.0212, -0.0002) and females 45–54 (β = -0.0154, 95% CI = -0.0337, -0.0003), the upper limits for the 95% CI were close to zero (Table 8 and Figure 8). In the subgroups where the indirect effect was significant, the magnitude of the effect within each sex increased with increasing age (Table 8). When comparing the indirect effect in males versus females within the same age group, the magnitude of the mediated effect was consistently greater in females (Table 8). Despite this suggestion that moderation of low FSS on executive function differed by age group and sex, it only reached statistical significance in males aged 65–74 years old (Figure 9), where the mediated effect was not significant.

After estimating moderated mediation, the proportion mediated was calculated (Table 9). This measure helped quantify the proportion of the total effect of low FSS on executive function mediated by depressive symptoms. The P_M varied across the subgroups. Depressive symptoms had a substantial effect on the association between low FSS and executive function in males 55–64 years (34.65%) and females 45–54 years (48.90%). In contrast, depressive symptoms explained a smaller amount of the effect of low FSS on executive function in males ≥ 75 years (17.51%) and females 55–64 (7.38%) and 65–74 years (1.90%). There was a large decrease from the P_M in the base model to that in the final model for males 45–54 years old (46.41% in the base model and -4.79% in the final model). For some models (the final model for males aged 45–54 years, and base and final models for males 65–74 years and females ≥ 75 years), the estimate for the proportion mediated was a negative value, as the total effect and indirect effect were in opposing directions (Table 9). A negative proportion mediated is not an estimate that has a meaningful interpretation (Carter et al., 2019; Yoshida et al., 2023) and thus these values were provided for reference rather than interpretation. Further, caution must be taken when interpreting the proportion mediated, as the estimate is not robust (Alkabbani et al., 2024; VanderWeele, 2016).

Similar to final mediation models, many of the direct and total effects in the final moderated mediation models for many subgroups were not statistically significant. An exception to this finding was in males 65–74 years, where both the direct and total effects were significant in the final model.

Table 8. Indirect Effect of Low Functional Social Support on Executive Function through Depressive Symptoms by Age Group and Sex, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

Moderators		Indirect Effect β (95% Bootstrap CI)	
Sex	**Age Group (years)**	**Base Model**[a]	**Final Model**[b]
Male	45–54	-0.0183* (-0.0342, -0.0054)	-0.0092* (-0.0212, -0.0002)
	55–64	-0.0287* (-0.0456, -0.0141)	-0.0161* (-0.0293, -0.0056)
	65–74	-0.0074 (-0.0239, 0.0079)	0.0010 (-0.0104, 0.0129)
	≥ 75	-0.0361* (-0.0676, -0.0115)	-0.0206* (-0.0443, -0.0030)
Female	45–54	-0.0268* (-0.0488, -0.0081)	-0.0154* (-0.0337, -0.0003)
	55–64	-0.0419* (-0.0668, -0.0215)	-0.0267* (-0.0466, -0.0107)
	65–74	-0.0109 (-0.0345, 0.0114)	0.0017 (-0.0171, 0.0211)
	≥ 75	-0.0527* (-0.0962, -0.0172)	-0.0343* (-0.0697, -0.0056)

Note. β = regression coefficient; CI = confidence interval; FSS = functional social support.
[a]The model included T0 depressive symptoms and T0 executive function.
[b]Included the same terms as the base model, with the addition of sociodemographic, health, and lifestyle covariates at T0.
*p < .05, **p < .01, ***p < .001

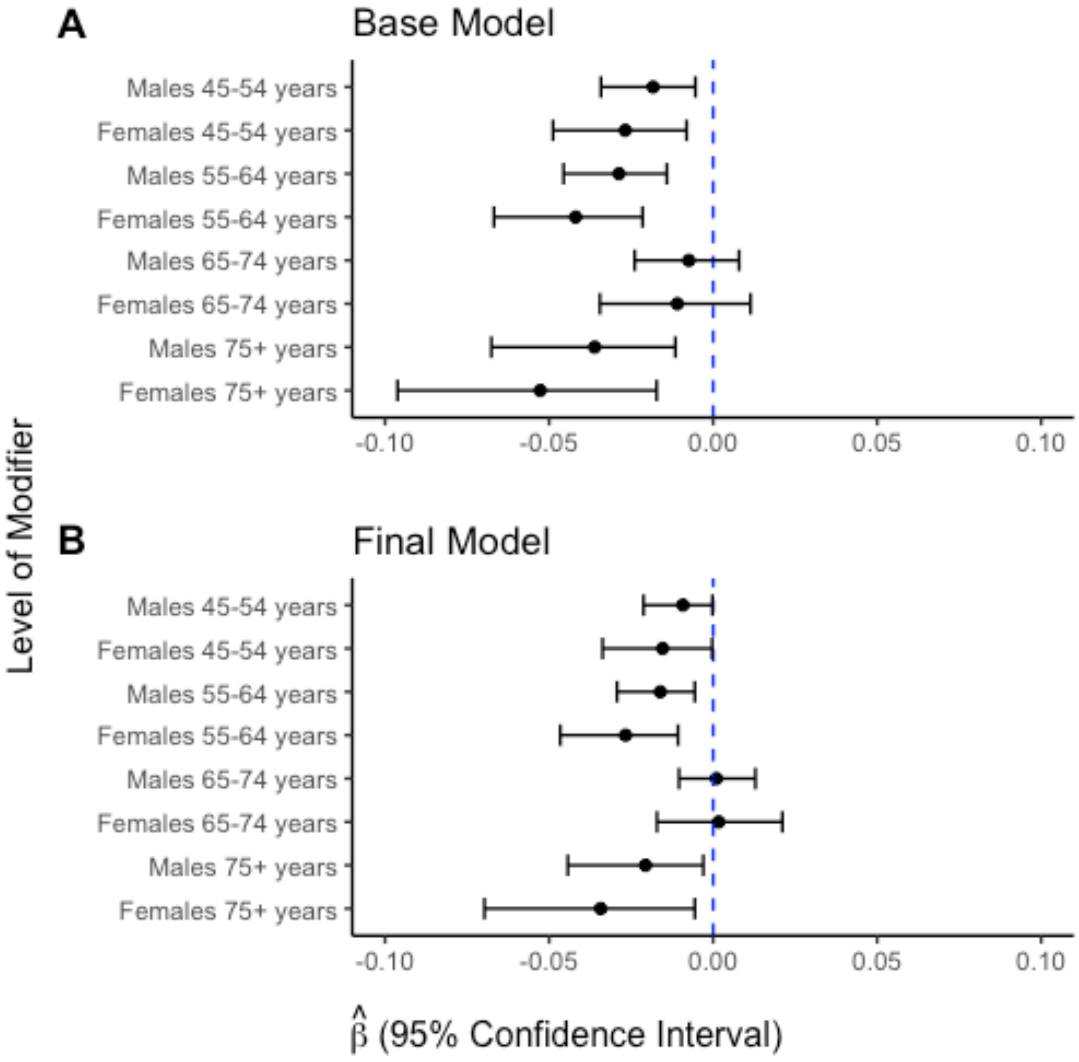

Figure 8. Forest Plot of the Indirect Effect of Low Functional Social Support on Executive Function through Depressive Symptoms by Age Group and Sex, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

Note. The base model included T0 depressive symptoms and T0 executive function. The final model included the same terms as the base model, with the addition of sociodemographic, health, and lifestyle covariates at T0.
$\hat{\beta}$ = regression coefficient.

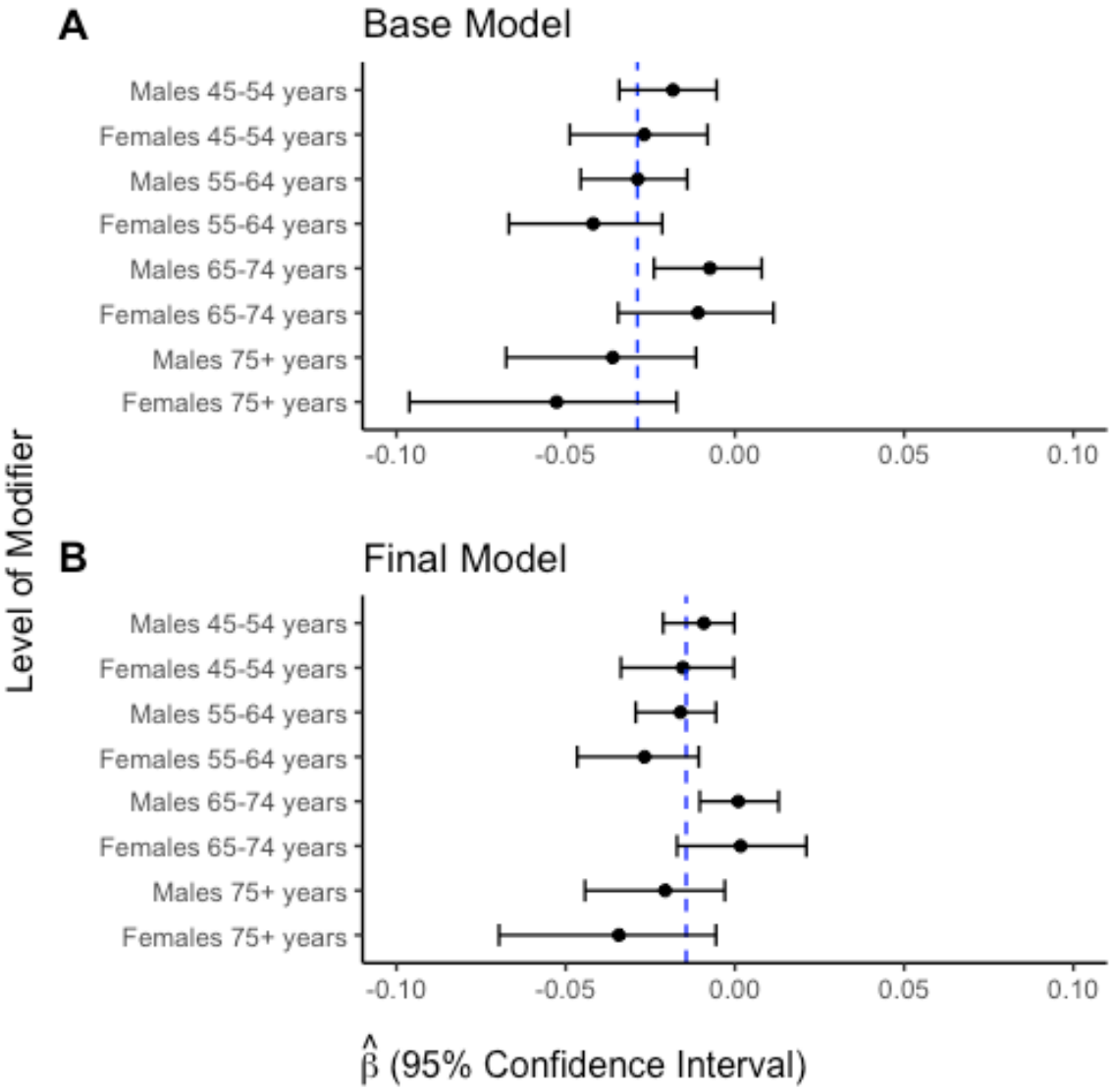

Figure 9. Forest Plot Assessing Moderation by Age Group and Sex for the Association Between Low Functional Social Support and Executive Function through Depressive Symptoms, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

Note. The base model included T0 depressive symptoms and T0 executive function. The final model included the same terms as the base model, with the addition of sociodemographic, health, and lifestyle covariates at T0.
$\hat{\beta}$ = regression coefficient.

Table 9. Proportion of the Effect of Low Functional Social Support on Executive Function through Depressive Symptoms by Age Group and Sex, Canadian Longitudinal Study on Aging Comprehensive Cohort

	Indirect Effect β (95% Bootstrap CI)	Direct Effect β (95% CI)	Total Effect β (95% CI)	Proportion Mediated (%)
	Males 45–54 (n = 2222)			
Base model[a]	-0.0155 (-0.0465, 0.0055)	-0.0179 (-0.3460, 0.3102)	-0.0334 (-0.3609, 0.2942)	46.41
Final model[b]	-0.0037 (-0.0232, 0.0080)	0.0810 (-0.2723, 0.4342)	0.0773 (-0.2759, 0.4304)	-4.79
	Males 55–64 (n = 2804)			
Base model[a]	-0.0494* (-0.0912, -0.0161)	-0.1029 (-0.3964, 0.1905)	-0.1523 (-0.4459, 0.1413)	32.44
Final model[b]	-0.0254* (-0.0598, -0.0002)	-0.0479 (-0.3556, 0.2597)	-0.0733 (-0.3812, 0.2346)	34.65
	Males 65–74 (n = 1971)			
Base model[a]	0.0175 (-0.0145, 0.0571)	-0.4890* (-0.8619, -0.1161)	-0.4715* (-0.8432, -0.0999)	-3.71
Final model[b]	0.0181 (-0.0056, 0.0545)	-0.4958* (-0.8899, -0.1018)	-0.4778* (-0.8713, -0.0842)	-3.79
	Males ≥ 75 (n = 1102)			
Base model[a]	-0.0089 (-0.0493, 0.0175)	-0.3047 (-0.8661, 0.2567)	-0.3135 (-0.8748, 0.2477)	2.84
Final model[b]	-0.0114 (-0.0602, 0.0207)	-0.0537 (-0.6409, 0.5335)	-0.0651 (-0.6523, 0.5221)	17.51
	Females 45–54 (n = 2393)			
Base model[a]	-0.0396* (-0.0882, -0.0066)	-0.0734 (-0.4488, 0.3021)	-0.1130 (-0.4879, 0.2620)	35.04
Final model[b]	-0.0244 (-0.0642, 0.0006)	-0.0255 (-0.4070, 0.3561)	-0.0499 (-0.4310, 0.3312)	48.90
	Females 55–64 (n = 2915)			
Base model[a]	-0.0391* (-0.0859, -0.0034)	-0.3861* (-0.7010, -0.0711)	-0.4251** (-0.7386, -0.1117)	9.20
Final model[b]	-0.0192 (-0.0574, 0.0097)	-0.2410 (-0.5656, 0.0835)	-0.2602 (-0.5838, 0.0633)	7.38
	Females 65–74 (n = 1899)			
Base model[a]	-0.0185 (-0.0540, 0.0076)	-0.1128 (-0.5183, 0.2927)	-0.1314 (-0.5359, 0.2732)	14.08
Final model[b]	-0.0016 (-0.0286, 0.0257)	-0.0827 (-0.4889, 0.3235)	-0.0843 (-0.4896, 0.3210)	1.90

	Indirect Effect β (95% Bootstrap CI)	Direct Effect β (95% CI)	Total Effect β (95% CI)	Proportion Mediated (%)
		Females* ≥ *75 (n = 1115)		
Base model[a]	-0.0295 (-0.0886, 0.0090)	0.3325 (-0.2503, 0.9154)	0.3030 (-0.2785, 0.8846)	-9.74
Final model[b]	-0.0351 (-0.0994, 0.0087)	0.3947 (-0.1934, 0.9827)	0.3596 (-0.2269, 0.9461)	-9.76

Note. β = regression coefficient; CI = confidence interval; FSS = functional social support; T0 = baseline; T1= follow-up.

[a]Included T0 depressive symptoms and T0 executive function.

[b]Included the same terms as the base model, with the addition of sociodemographic, health, and lifestyle covariates at T0.

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

5.2.4 Moderated Effects at Path I and Path II

When assessing mediation, it is important to not only look at the indirect effect, but to also understand the moderation that may occur on each path of the mediated effect (i.e., moderated mediation). Regarding the moderated mediation model that was estimated, Path I of the mediated effect was moderated by sex, and Path II of the mediated effect was moderated by age group.

5.2.4.1 Path I: The Effect of Low FSS on Depressive Symptoms

From the fully adjusted model in Table 10 the effect of low FSS on depressive symptoms differed significantly by sex (p-value = 0.0432, F = 4.09). While the effect was statistically significant in males and females and the direction of the effect was similar in both subgroups, the magnitude of the effect differed between the sexes. The difference in magnitude was such that the effect of low FSS on depressive symptoms was greater in females (β = 1.1845, 95% CI = 0.8456, 1.5235) than in males (β = 0.7117, 95% CI = 0.3820, 1.0414).

5.2.4.2 Path II: The Effect of Depressive Symptoms on Executive Function

On Path II, the depressive symptoms*age group interaction was statistically significant (p-value = 0.0327, F = 2.92) in fully adjusted models (Table 10). The effect of depressive symptoms on executive function was statistically significant in those aged 55–64 years (β = -0.0226, 95% CI = -0.0351, -0.0101) and ≥ 75 years (β = -0.0290, 95% CI = -0.0490, -0.0089). Conversely, the effect was not significant in individuals 45–54 years old (β = -0.0130, 95% CI = -0.0264, 0.0005) and 65–74 years old (β = 0.0015, 95% CI = -0.0141, 0.0170). Generally, with increasing age, the magnitude of the effect of depressive symptoms on executive function also increased. The exception to this was in the 65–74 age group, where the magnitude of the effect was the smallest and in the opposite direction compared to the other age groups.

Table 10. Effect of Low Functional Social Support on Depressive Symptoms (Path I) by Sex and the Effect of Depressive Symptoms on Executive Function (Path II) by Age Group, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

	Path I: Low FSS → Depressive Symptoms β (95% CI)	
	Base Model[a] **FSS*Sex** ($\Delta R^2 = 0.0001$, F = 3.64)	**Final Model**[b] **FSS*Sex** ($\Delta R^2 = 0.0002$, F = 4.09)
Sex		
Males	0.9799 (0.6521, 1.3077)***	0.7117 (0.3820, 1.0414)***
Females	1.4330 (1.0929, 1.7731)***	1.1845 (0.8456, 1.5235)***
	Path II: Depressive Symptoms → Executive Function β (95% CI)	
	Base Model[a] **Depressive Symptoms*Age Group** ($\Delta R^2 = 0.0002$, F = 2.59)	**Final Model**[b] **Depressive Symptoms*Age Group** ($\Delta R^2 = 0.0002$, F = 2.92)
Age Group		
45–54	-0.0187 (-0.0321, -0.0053)**	-0.0130 (-0.0264, 0.0005)
55–64	-0.0293 (-0.0417, -0.0168)***	-0.0226 (-0.0351, -0.0101)***
65–74	-0.0076 (-0.0231, 0.0079)	0.0015 (-0.0141, 0.0170)
≥ 75	-0.0368 (-0.0569, -0.0167)***	-0.0290 (-0.0490, -0.0089)**

Note. β = regression coefficient; CI = confidence interval; FSS = functional social support; ΔR^2 = R squared change.

[a]Included T0 depressive symptoms and T0 executive function.

[b]Included the same terms as the base model, with the addition of sociodemographic, health, and lifestyle covariates at T0.

*p < .05, **p < .01, ***p < .001

5.2.5 Covariate Effects in the Moderated Mediation Model

5.2.5.1 Covariate Effects at Path I: The Association Between Low FSS and Depressive Symptoms

The sociodemographic covariates that were significantly associated with depressive symptoms at T1 were age group, marital status, living arrangements, province, and total household income (Table 11). The health factors that were significantly associated with depressive symptoms were self-rated health, chronic conditions, and functional impairment. Smoking status was the sole lifestyle factor that was significantly associated with depressive symptoms. With regards to baseline measurements of mediator and outcome, only depressive symptoms at T0 were significantly associated with depressive symptoms at T1. Since low FSS was moderated by sex at Path I, the effect sizes are not provided in Table 11.

A notable pattern emerged when observing the covariate effects at Path I for age group. The ≥ 75 years old age group was associated with more depressive symptoms, which directly contrasts the other age groups, as they were associated with less depressive symptoms. Further, living alone versus living with others was also associated with fewer depressive symptoms.

5.2.5.2 Covariate Effects on Path II: The Association Between Depressive Symptoms and Executive Function

Marital status, province, education, and total household income were the sociodemographic factors significantly associated with executive function (Table 11). The health factors that were significantly associated with executive function were self-rated health and functional impairment. The lifestyle factor that was significantly associated with executive function was smoking status. With respect to baseline measures of the depressive symptoms and executive function, only executive function at T0 was significantly associated with executive function at T1. The effect size for depressive symptoms is not provided in Table 11, as it was moderated at Path II. A key pattern that emerged when examining covariate effects is that being female (versus male) was associated with higher levels of executive function.

Table 11. Effect of Covariates on Depressive Symptoms and Executive Function, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

Independent Variables	Path I: Low FSS → Depressive Symptoms β (95% CI) (R^2 = 0.3815)	Path II: Depressive Symptoms → Executive Function β (95% CI) R^2 = 0.5843
Exposure, Mediator, and Outcome		
Exposure (T0)		
Low FSS[a]	Low FSS*sex	-0.0770 (-0.2138, 0.0598)
Mediator (T1)		
Depressive symptoms[b]		Depressive symptoms*age group
Baseline mediator and outcome (T0)		
Depressive symptoms[b]	0.4997 (0.4867, 0.5126)***	-0.0003 (-0.0087, 0.0081)
Executive function[c]	-0.0134 (-0.0347, 0.0079)	0.7046 (0.6926, 0.7165)***
Sociodemographic factors (T0)		
Age group (vs 45–54 years)		
55–64	-0.2133 (-0.3495, -0.0771)**	Depressive symptoms*age group
65–74	-0.1823 (-0.3445, -0.0201)*	Depressive symptoms*age group
≥ 75	0.2044 (0.0025, 0.4064)*	Depressive symptoms*age group
Sex (vs male)	FSS*sex	0.0356 (-0.0262, 0.0975)
Marital status (vs married/common-law)		
Single/never married	0.3033 (0.0514, 0.5552)*	0.0710 (-0.0704, 0.2124)
Widowed	-0.0512 (-0.3134, 0.2111)	-0.1788 (-0.3259, -0.0316)*
Divorced/separated	0.2812 (0.0669, 0.4955)*	0.0330 (-0.0872, 0.1532)
Lives alone (vs lives with others)	-0.3253 (-0.5346, -0.1159)**	0.0266 (-0.0910, 0.1441)
Province (vs Ontario)		
Alberta	0.1478 (-0.0603, 0.3559)	0.0350 (-0.0817, 0.1517)
British Colombia	0.0071 (-0.1489, 0.1631)	0.0964 (0.0089, 0.1839)*
Manitoba	-0.0777 (-0.2776, 0.1223)	0.1030 (-0.0091, 0.2152)
Newfoundland and Labrador	-0.0226 (-0.2306, 0.1854)	-0.1914 (-0.3081, -0.0747)*
Nova Scotia	0.1228 (-0.0789, 0.3245)	-0.1196 (-0.2328, -0.0064)*
Quebec	-0.3440 (-0.5150, -0.1729)***	0.0591 (-0.0369, 0.1550)
Education (vs post-secondary degree/diploma)		
Less than secondary school	-0.0613 (-0.3408, 0.2181)	-0.6152 (-0.7720, -0.4585)***
Secondary school graduate	0.1247 (-0.0675, 0.3169)	-0.2511 (-0.3590, -0.1433)***

Independent Variables	Path I: Low FSS → Depressive Symptoms β (95% CI) (R^2 = 0.3815)	Path II: Depressive Symptoms → Executive Function β (95% CI) R^2 = 0.5843
Some post-secondary education	-0.0110 (-0.2151, 0.1932)	-0.1330 (-0.2475, -0.0185)*
Total household income (vs ≥ $150,000)		
< $20,000	0.9342 (0.5964, 1.2720)***	-0.5053 (-0.6950, -0.3156)***
≥ $20,000 to < $50,000	0.5503 (0.3449, 0.7556)***	-0.3774 (-0.4927, -0.2621)***
≥ $50,000 to < $100,000	0.2857 (0.1228, 0.4485)***	-0.1510 (-0.2424, -0.0595)*
≥ $100,000 to < $150,000	0.0802 (-0.0889, 0.2493)	-0.0786 (-0.1736, 0.0163)
Missing	0.5995 (0.3250, 0.8740)***	-0.3220 (-0.4761, -0.1680)***
Urban (vs rural)	0.0299 (-0.1709, 0.2308)	0.0557 (-0.0570, 0.1683)
Health factors (T0)		
Self-rated health (vs excellent)		
Poor	2.7969 (2.2319, 3.3620)***	0.0929 (-0.2252, 0.4110)
Fair	1.8604 (1.6059, 2.1148)***	-0.2823 (-0.4259, -0.1387)***
Good	0.9214 (0.7647, 1.0780)***	-0.1039 (-0.1921, -0.0157)*
Very good	0.4416 (0.3028, 0.5805)***	0.0156 (-0.0624, 0.0936)
Reported at least one chronic condition (vs reported none)	0.5195 (0.3006, 0.7384)***	0.1121 (-0.0110, 0.2351)
Functional Impairment (vs no impairment)	0.4846 (0.2734, 0.6958)***	-0.1868 (-0.3054, -0.0682)**
Lifestyle Factors (T0)		
Smoking status (vs never)		
Former	0.0128 (-0.0989, 0.1245)	-0.0942 (-0.1569, -0.0315)**
Current	0.5679 (0.3627, 0.7731)***	-0.0773 (-0.1926, 0.0380)
Alcohol use (vs no)		
Occasional	-0.0712 (-0.2996, 0.1573)	0.0671 (-0.0610, 0.1953)
Regular	-0.0433 (-0.2234, 0.1368)	0.0959 (-0.0051, 0.1970)
Missing	-0.3100 (-0.7238, 0.1039)	0.0393 (-0.1928, 0.2715)

Note. β = regression coefficient; CI = confidence interval; T0 = baseline; T1= follow-up; vs = versus.

[a]FSS was measured using the Medical Outcomes Survey-Social Support Survey. Scores range from 1–5 and low FSS = ≤ 3.

[b]Depressive symptoms were measured using the Centre for Epidemiological Studies Short Depression Scale. The possible range of scores is 0–30.

[c]An executive function score was created by standardizing and then combining the results from 5 different cognitive tests evaluating executive function.

*p < .05, **p < .01, ***p < .001

5.2.6 Sensitivity Analysis: Modelling the Association Between Depressive Symptoms and Executive Function Prospectively

In the mediation models, the association between low FSS and depressive symptoms (Path I) was modelled prospectively (i.e., T0 low FSS and T1 depressive symptoms) and the relationship between depressive symptoms and executive function (Path II) was modelled cross-sectionally (i.e., T1 depressive symptoms and T1 executive function). Path II was modelled cross-sectionally since at the time of analyses, data for executive function at T2 were not available. Thus, sensitivity analyses were conducted to see if the cross-sectional and prospective results (i.e., T0 depressive symptoms and T1 executive function) were consistent. Models were fully adjusted for covariates and included T0 depressive symptoms as the exposure and T1 executive function as the outcome.

5.2.6.1 Testing Interactions

Testing interactions for sensitivity analyses was conducted in a similar manner as what was done for the main analyses, with one key difference. In the sensitivity analyses, low FSS at T0 and executive function at T1 were included as covariates in the model. The main analyses also controlled for T0 depressive symptoms, but in sensitivity analyses, it was the exposure variable.

As with the main analyses, three-way interactions followed by two-way interactions were tested at Path II in multiple linear regression models. The depressive symptoms*age group*sex interaction was not significant (R^2 change = 0.0000, p-value = 0.5802). In a model that included both the depressive symptoms*age group and depressive symptoms*sex interaction terms, the joint test of interaction was nonsignificant (R^2 change = 0.0001, p-value = 0.2857). When only the depressive symptoms*sex interaction term was included in the model, the interaction term was not statistically significant (R^2 change = 0.0000, p-value = 0.4315). These nonsignificant interaction terms are consistent with the results from the main analyses.

The next step in testing interactions was to test the depressive symptoms*age group interaction term, which was the only significant interaction term in the main analyses. The depressive symptoms*age group interaction term was significant when modelled cross-sectionally in the main analyses, but it was not significant when it was included in the prospective sensitivity model (R^2 change = 0.0001, p-value = 0.2260). Although the depressive symptoms*age group interaction term was not significant, it was still included in the final model to allow for further comparison between

cross-sectional and prospective results. Overall, cross-sectional and prospective results were consistent, apart from the depressive symptoms*age group interaction term.

5.2.6.2 Path II: The Effect of Depressive Symptoms on Executive Function

Consistent patterns across the cross-sectional and prospective sensitivity results included that, apart from the 65–74 age group, the magnitude of the effect of depressive symptoms on executive function increased with increasing age (Table 12 for the prospective results and Table 10 for the cross-sectional results), and that the association between depressive symptoms and executive function was significant in the ≥ 75 age group. However, a difference between cross-sectional and prospective results is that the cross-sectional association was also statistically in those aged 55–64 years.

Table 12. Sensitivity Analyses: Prospective Results for the Effect of Depressive Symptoms on Executive Function (Path II) by Age Group, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

	Path II: Depressive Symptoms → Executive Function β (95% CI)	
	Base Model[a] **Depressive Symptoms*Age Group** ($\Delta R^2 = 0.0002$, F = 1.95)	**Final Model**[b] **Depressive Symptoms*Age Group** ($\Delta R^2 = 0.0001$, F = 1.45)
Age Group		
45–54	-0.0151 (-0.0274, -0.0027)*	-0.0029 (-0.0155, 0.0096)
55–64	-0.0220 (-0.0328, -0.0111)***	-0.0095 (-0.0206, 0.0016)
65–74	-0.0160 (-0.0302, -0.0017)*	-0.0026 (-0.0171, 0.0118)
≥ 75	-0.0429 (-0.0634, -0.0224)***	-0.0261 (-0.0467, -0.0055)*

[a]The model included T0 FSS and T1 executive function.
[b]Included the same terms as the base model, with the addition of sociodemographic, health, and lifestyle covariates at T0.
*p < .05, **p < .01, ***p < .001

Chapter 6
Discussion

6.1 Summary of Results

The overall goals of this study were twofold: 1) to determine if depressive symptoms mediated the association between FSS and executive function, and 2) to ascertain if the mediated association was moderated by age group and sex. These associations were examined after adjusting for T0 measurements of depressive symptoms and executive function, as well as sociodemographic, health, and lifestyle covariates. The results demonstrated that depressive symptoms were a statistically significant mediator of the association between FSS and executive function, and this significant mediation was present in most subgroups. In the subgroups where mediation was significant, low FSS was associated with higher levels of depressive symptoms and these in turn were associated with lower executive function. The exception to these findings was in participants 65–74 years old (both males and females), where the mediated effect was nonsignificant. Significant moderation by age group and sex was found only in males 65–74 years old on the direct (unmediated) path. In fully adjusted prospective models from the sensitivity analyses, age group was not a statistically significant moderator of Path II, which contrasted with the cross-sectional results from the main analyses.

6.2 Discussion of Mediation Results

The findings of the current study are consistent with studies in the literature that have examined the mediating effect of depression on the association between social factors and cognition. In a study of middle-aged and older adults from the China Health and Retirement Study, depressive symptoms were found to mediate a small proportion of the effect of social participation on global cognition (Chen et al., 2024). Another mediation study done using data from the English Longitudinal Study of Ageing and the Swedish National Study of Aging and Care found that the association of network size and positive and negative support with verbal fluency, and the relationship between positive support and immediate recall, were both mediated by depressive symptoms (Stafford et al., 2024). Depressive symptoms have also been found to be a mediator of the association between loneliness and cognitive function (Kim et al., 2020; Q. Wang et al., 2022), as well as the relationship between social engagement and cognition (Kumar et al., 2022). Psychological distress (a measure that includes depression) partially mediated the relationship between low social support (conceptualized as

subjective support, objective support, and support utilization) and cognitive frailty in Chinese older adults (Y. Wang et al., 2022). Altogether, the current study's results are consistent with findings in the literature: depressive symptoms mediate the association between social factors and cognition in middle-aged and older adults. The findings of the current study add to the current state of the literature by examining FSS, a specific category of social support, and by examining executive function, a specific domain of cognition important in aging.

The associations found at each path in this study are consistent with evidence in the literature. At Path I, low FSS at T0 was associated with higher levels of depressive symptoms at T1, and this relationship is consistent with existing evidence that greater FSS is associated with fewer depressive symptoms (Almquist et al., 2017; Chao et al., 2018; Lee & Shinkai, 2005; Mohd et al., 2019; Muramatsu et al., 2010; Rote et al., 2015). The study's findings are also consistent with the social causation theory, which states that low social support is related to an increased likelihood of depression (Kaniasty & Norris, 2008; Ren et al., 2018). Under this theory, social support and depression may be related through the influence of close relationships on emotional regulation (Marroquín, 2011). There is also a biological basis for the association between social factors and depression. The social transduction theory of depression states that parts of the immune system involved with inflammation become activated when a person experiences social threats and adversity. Pro-inflammatory cytokines are responsible for this immune response, as well as behavioural changes. Depressive symptoms, such as sad mood, fatigue, and socio-behavioural withdrawal, are some of the changes are caused by pro-inflammatory cytokines (Slavich & Irwin, 2014).

At Path II, there was a negative association between depressive symptoms and executive function, controlling for FSS. Depressive symptoms have been shown to be associated with deficits in executive function (Dotson et al., 2020; Ha, 2019; Snyder, 2013). In the current study, there is evidence to support depression as a potential prodrome of cognitive impairment. Depressive symptoms were negatively associated with executive function, and this finding extended to the prospective results from sensitivity analyses, such that the negative association was significant in both the cross-sectional and prospective results for the ≥ 75 age group. However, a limitation of the evidence in support of the prodromal hypothesis presented in this study is the duration of time between baseline and follow-up. The duration of follow-up was three years, which may not be a long enough period to understand if depression is a prodrome for cognitive impairment. Biological mechanisms that help explain the association between depression and cognitive impairment are

vascular disease, increased production of glucocorticoid steroids leading to damage of the hippocampus, accumulation of amyloid plaques, pro-inflammatory changes, and decreases in nerve growth factors (Byers & Yaffe, 2011). Impaired function in the prefrontal cortex, caused by functional and structural abnormalities, also biologically links depression with executive function impairments (Snyder, 2013). These pathophysiologic processes are potential mechanisms through which depression is related to developing cognitive impairment (Butters et al., 2008).

6.3 Discussion of Moderated Mediation Results

An overview of the moderated mediation results within the context of the evidence from the literature will be discussed in this section. Section 6.3.1 discusses the current study's results within the context of these previous findings. Section 6.3.2 discusses how the type of social support received could have led to nonsignificant results at Path I in males and females aged 65–74 years. Section 6.3.3 outlines how there is a lack of consensus regarding the effects of retirement on health outcomes in the stated subgroups at Path II. Section 6.3.4 discusses moderation of the direct effect by age and sex. Section 6.3.5 explores possible reasons as to why age was not a significant moderator at Path I and sex was not a significant moderator at Path II.

6.3.1 Discussion of Overall Moderated Mediation Results

The general pattern observed in the current study was that with increasing age, the magnitude of the mediated effect also increased, and this effect was consistently greater in females compared to males from the same age group. However, mediation by depressive symptoms in males and females aged 65–74 years old was not significant. The significant results are consistent with findings in the literature regarding age, but not sex. Chen et al. (2024) examined potential mediated effects of depressive symptoms on the association between social participation and global cognition. When the data were stratified by age group and by sex, the mediating effect of depressive symptoms was greater in participants aged 65 years or older compared to individuals younger than 65 years, although the effect was statistically significant in both subgroups. No sex differences were found, as the estimate for the mediated effect via depressive symptoms was similar and statistically significant in both males and females (Chen et al., 2024). In another study that examined the mediated effect of depressive symptoms on the relationship between various social factors and cognition by sex, certain associations were mediated by depressive symptoms in males only, and other associations were mediated by depressive symptoms in females only (Stafford et al., 2024).

Differences between the current study and findings in the literature are related to a variety of factors. Chen et al.'s (2024) study found no sex differences and reported that the mediated effect was greater in the older age group compared to the younger age group. The current study found similar results to Chen et al.'s study regarding age, as generally with increasing age, the magnitude of the mediated effect in the current study increased as well. A slight contrast between the studies is that the current study found the mediated effect was greatest in the ≥ 75 age group, while Chen et al.'s study found the effect was largest in the 65 or older age group. There is a lack of consistency between the two studies with respect to sex differences, as the current study did find differences in the mediated effect by sex. The contrasts between Chen et al.'s findings and the current study's results could be attributed to several reasons, including heterogeneity between measures, the number of age categories, and the way in which the moderated mediation was examined. For the measures, the differences included the social and cognitive factors of interest. Chen et al. measured social participation and global cognition, while the current study measures FSS and executive function. For age group, Chen et al. conceptualized age group as a dichotomous variable, while the current study had four different age groups. Regarding moderated mediation, Chen et al. examined the moderating effects of age and sex separately, while the current study looked at the moderating effect of these variables together. Another possible explanation for different results is that the ≥ 75 subgroup in the current study was more similar to Chen et al.'s ≥ 65 age group, especially as Canada has a higher life expectancy at birth compared to China (*World Bank Open Data*, n.d.).

Comparisons with the current study and Stafford et al.'s (2024) study are difficult. Unlike this study, the Stafford et al. examined a variety of different social health variables and only analysed the moderating effect of sex. While they found that some associations were significant only in males and others were significant only in females, the current study found that the association between FSS and depressive symptoms was significant in both sexes, and the magnitude of the effect differed between the sexes.

Iacono et al. (2023) also studied the relationship between FSS, depressive symptoms, and executive function by examining if FSS was a mediator of the association between depressive symptoms and executive function. They reported FSS was a statistically significant mediator of the association in females ≥ 75 years old (Iacono et al., 2023). Although the current study and Iacono et al.'s reversed the role of FSS and depressive symptoms in analyses, in both studies the mediated effect was significant in females aged ≥ 75 years old. In the current study, this was one of the many subgroups

where the mediated effect was significant, but in Iacono et al.'s study, this was the only subgroup where mediation was significant. Altogether, these comparisons are evidence that the relationship between FSS, depressive symptoms, and executive function is bidirectional.

The current study's finding that the mediated effect was greater in older age groups is consistent with the limited comparable literature on the moderating effects of age group on the mediated association. However, the sex differences found in the current study are dissimilar to existing evidence. There is also evidence that the association between FSS, depressive symptoms, and executive function is bidirectional in nature.

6.3.2 Discussion of Moderated Effect by Sex at Path I

The moderating effect of sex on the association between social support and depressive symptoms in most subgroups is consistent with findings in the literature. Studies whose samples consisted of middle-aged or older adults have found sex/gender differences in the effect of social support on depressive symptoms (Almquist et al., 2017; Gariépy et al., 2016; G. Li et al., 2023). Further, the association between social support and depression has been found to be particularly significant for women (Santini et al., 2015), who have a higher prevalence of depressive symptoms than men (Kawachi & Berkman, 2001). The differences in the association between social support and depression in men and women may be attributed to social norms (Almquist et al., 2017), as women are more involved in their social relationships than men (Kawachi & Berkman, 2001). In contrast to men, women are more likely to maintain intimate relationships, reach out for social support in stressful situations, and provide more effective social support more frequently to those in their social networks, and reciprocity of social support is an important protective factor against depression in women (Belle, 1987).

There was an absence of moderation by sex in males and females aged 65–74 years observed in this study. There is evidence that the lack of significant moderation in this subgroup is not due to small sample sizes. The sample size of the subgroups for males and females aged ≥ 75 years were smaller than those for males and females aged 65–74 years, but a statistically significant indirect effect was still found in the ≥ 75 subgroup.

Instead, the nonsignificant effect in participants 65–74 years old may be explained by changes in social support experienced in the post-retirement transition period. It is plausible that the current study did not observe a significant moderated effect by sex in males and females 65–74 due to the

way social support was conceptualized. For retirement-aged individuals, it is the sources of social support that are key factors in the relationship between social support and well-being (Y. Chen & Feeley, 2014). Measuring overall FSS instead of specific sources of social support, such as familial support, may contribute to why the current study was unable to detect a significant association in males and females aged 65–74 years. When a person retires, the composition of their social network changes, such that weak ties with friends and colleagues are replaced with stronger familial ties. Males who are retirement-aged make changes to their social networks; as the centre of their lives move away from the workplace to the community, they reduce their share of colleagues in their social network in favour of strong ties with family and build more intimate relationships with the remaining ties in their network (Comi et al., 2022; La Fleur & Salthouse, 2017; Takashima et al., 2020). A similar pattern is seen for retirement-aged females, who reduce the number of friends in their social network and create stronger ties with family (Comi et al., 2022). By making these changes, retirement-aged adults experience greater satisfaction with their relationships and higher levels of FSS, as the relationships they have maintained are more positive and yield more benefits (Comi et al., 2022; La Fleur & Salthouse, 2017). In retirement-aged individuals, regardless of sex, it is greater reciprocal support from family and spouses that is associated with fewer depressive symptoms (Cheung & Mui, 2023; Gariépy et al., 2016), and less familial support is associated with higher level of depressive symptoms (Buber & Engelhardt, 2008).

6.3.3 Discussion of Moderated Effect by Age Group at Path II

The general consensus within the literature is that age modifies the association between depressive symptoms and executive function (Dotson et al., 2020; Jung et al., 2023). Additionally, the strength of the effect of depressive symptoms on executive function is greater in older adulthood (Dotson et al., 2020; Jung et al., 2023). This is consistent with most findings from the current study, although an exception to the observed pattern was found in males and females aged 65–74 years. There is a positive and significant relationship between older age and depressive symptoms (Chui et al., 2015; Dong et al., 2014; Zenebe et al., 2021). Further, there is evidence to suggest that depressive episodes contribute to accelerated aging (Szymkowicz et al., 2023), and that accelerated aging is associated with cognitive deficits (Christman et al., 2020). Age-related changes in neurobiological mechanisms may also help provide reasoning behind why older age is related to greater depression-related cognitive impairment. It may be that the effect of age-related changes in the brain and depression-related brain alterations share similar mechanisms (Butters et al., 2008), and the effect of both these

changes coupled together creates a greater likelihood for developing cognitive dysfunction (Dotson et al., 2020). Additionally, depression as a prodromal feature of dementia is more likely at older ages (Byers & Yaffe, 2011). A nonsignificant association in the 65–74 age group is consistent with findings from a study that used CLSA data to examine the cross-sectional association between depressive symptoms and executive function (Ha, 2019).

A lack of a significant relationship between depressive symptoms and executive function in males and females 65–74 years old was found in the current study. There is heterogeneity in the evidence of the effect that retirement has on health outcomes, including mental health and cognition (van Ours, 2022). Retirement has been shown to improve mental health due to experiencing less stress and having more time to engage in leisure activities (Vo & Phu-Duyen, 2023), but stating that mental health improves in retirement is a general statement and not universally applicable (van Ours, 2022). The evidence for the effect of retirement on cognition is also mixed, as retirement has been shown to have no effect on cognition (van Ours, 2022; Xue et al., 2018), while other studies shows that retirement leads to the decline of cognitive abilities (Hamm et al., 2020; Meng et al., 2017; van Ours, 2022). Given the lack of consensus in the literature regarding the effect of retirement age on health outcomes, the current study's finding that the effect of depressive symptoms on executive function was nonsignificant in individuals 65–74 years old is not atypical.

6.3.4 Discussion of Moderation of the Association Between Functional Social Support and Executive Function

Forest plots were used to help assess in which subgroups moderation reached statistical significance. Moderation by age group and sex was significant only in males 65–74 years old, despite the indirect effect being nonsignificant in this subgroup. The direct effect and total effect were significant in this subgroup, which indicates that effect modification by age group and sex may have been on the direct path (i.e., the association between low FSS and executive function).

As discussed in Section 6.3.2, retirement-aged males reduce their share of colleagues in their social network in favour of closer familial ties. These changes generally result in greater social support and satisfaction with relationships, as these relationships are more positive and rewarding (Comi et al., 2022; La Fleur & Salthouse, 2017). There are also differences in cognition by age and by sex. With older age, individuals experience changes in their cognition, including declines in executive function (Murman, 2015). Sex differences in cognitive decline also exist: compared to males, generally

women experience faster declines in cognition and executive function (Levine et al., 2021). When examining age and sex together, there is evidence that there are sex differences in the association between social support and age-related cognitive decline, such that in males, having higher positive social support from their partner or spouse is associated with greater cognitive function and slower cognitive decline (Liao & Scholes, 2017). Thus, based on evidence from the literature, there is support for significant moderation of the association between FSS on executive function in males 65–74 years old.

6.3.5 Discussion of Nonsignificant Moderators at Path I and Path II

Age group was not a significant moderator of the association between FSS and depressive symptoms at Path I, perhaps due to this study measuring overall FSS, rather than subtypes of FSS. Across the lifespan, there may be differences in the effect of social support subtypes on depressive symptoms. In comparison to instrumental support, there is more consistent evidence that emotional support is protective against depression in middle-aged adults. In older adults, there is evidence that both emotional and instrumental support are important protective factors against depression (Gariépy et al., 2016).

The nature of the depressive symptoms variable may have led to sex not being a significant moderator of the association between depressive symptoms and executive function at Path II. There is a lack of consensus in the literature regarding sex differences in the effect of depressive symptoms on cognition. These inconsistencies may be due to variability in the measurement of depression within the literature (Sundermann et al., 2017; Underwood et al., 2019). Studies that utilize self-report measures of depression often use cut-off scores to help conceptualize the presence of depression (Gong et al., 2023; Underwood et al., 2019), and compared to clinical depression, it is mostly these latter studies that found sex differences in the relationship between depression and cognition. Thus, the way the presence of depression is defined in studies may affect whether sex differences are observed. Examining depressive symptoms using a self-reported assessment but without using a cut-off score may be the reason as to why sex was not a significant moderator of the association at Path II. However, the current study decided against using a cut-off score on the CES-D-10 due to the benefits of preserving the continuous nature of a variable (see Section 4.2.2 for additional information regarding the benefits of maintaining a variable's continuous nature).

6.4 Strengths of the Study

For the mediation results, both the joint significance test and the index test showed the presence of statistically significant mediation. There is debate regarding which test is more appropriate to use, with both having pros and cons associated with their use. Thus, given the lack of consensus within the literature on which test is most suitable when assessing the presence of mediation, it is a strength of this study that the joint significant test and the index test were both conducted and that both showed significant mediation. Agreement between both tests strengthens the evidence that statistically significant mediation by depressive symptoms was occurring.

An additional strength is that moderated mediation analyses were conducted which, compared to previous work, is a more robust analytic method since it allowed this study to examine if the mediated effect was moderated by age group and sex. Most of the previous mediation studies have not examined if the mediated effect of depression on the relationship between social factors and cognition is moderated (Gow et al., 2013; Kim et al., 2020; Kumar et al., 2022; Q. Wang et al., 2022; Y. Wang et al., 2022). Kumar et al. (2022) did explore moderation effects by gender, but this was done for the association between social engagement and cognition rather than for the mediated effect. Conditional process analysis is also a more rigorous statistical technique when compared to traditional mediation analysis methods, such as the causal steps approach that was popularized by Baron & Kenny (1986). The causal steps approach cannot directly quantify the indirect effect and is based on multiple, fallible hypothesis tests that reduce the statistical power of this method (Hayes, 2009), while conditional process analysis directly estimates indirect effects and minimizes the number of tests performed.

A substantial benefit of utilizing data from the CLSA is that participants were between the ages of 45 and 85 at baseline, meaning this study adds to the limited body of literature by analysing a study sample with a broader age range compared to current work done within the area of social support, depression, and cognition. In systematic reviews that examined the effect of social support on cognition (Costa-Cordella et al., 2021), the association between FSS and cognition (Mogic et al., 2023), and the relationship between depression and cognition (Dotson et al., 2020), the majority of articles reviewed were based on samples of older adults. A smaller number of the reviewed studies were based on samples that included both middle-aged and older adults. By recruiting a study sample with a wide age range, an insight into how the mediated effect of depressive symptoms on the relationship between FSS and executive function differs across the lifespan and in different age

groups is gained. The broader age range is also important because it adds to the small yet growing body of literature that examines social support, depression, and cognition in middle-aged and older adults.

The current state of the literature has emphasized a need for studies that employ longitudinal data when studying the relationship between social support and cognition (Pillemer & Holtzer, 2016) and how depression can mediate this association (Gow et al., 2013; Kumar et al., 2022; Q. Wang et al., 2022). The current study has helped further our understanding of this knowledge gap by using longitudinal data from the CLSA collected at two different timepoints. By using data from both timepoints in PROCESS and modelling Path II prospectively in sensitivity analyses, this study was able to assess temporality in the mediated effect of depressive symptoms on the association between FSS and executive function. Addressing the gap in our understanding of how depression mediates the association between social support and cognition is also important, as having a more robust understanding of the mediated effect has real-world implications on program and policy development.

The measures used are another strength of the current study. Numerous covariates were controlled for in multivariable analyses, and these variables spanned three distinct categories. By controlling for this breadth of covariates, confounding bias is minimized. Measuring executive function in a sample of middle-aged and older adults is also a strength of this study because executive function is important in the aging process (Diamond, 2013), and it is important to build a detailed understanding of age-related differences in executive function across the lifespan (Ferguson et al., 2021). The study used numerous tests to create a combined executive function score; compared to individual scores, composite scores help reduce measurement error (Amaefule et al., 2021).

6.5 Limitations of the Study

A limitation of the current study is that the mediator and outcome were measured at the same time point. Mediation models should ideally have the exposure, mediator, and outcome occur at separate time points, such that the mediator occurs after the exposure variable and before the outcome variable. To help mitigate this issue, sensitivity analyses were performed, which provided valuable insight into how the results were affected by modelling Path II cross-sectionally rather than prospectively (see Section 5.2.6). Consistent patterns were found across the cross-sectional and prospective analyses, such as the magnitude of the effect of depressive symptoms on executive function increasing with older age groups (apart from the 65–74-year age group) and a significant

association in participants aged ≥ 75 years old. An inconsistency between the cross-sectional results from the main analyses and the prospective results from sensitivity analyses was that age group was not a significant moderator of the prospective association. There is evidence from the literature to support this finding, as age group has been a moderator of the association between depression and cognition in cross-sectional associations (Brown et al., 2022; Dotson et al., 2020; Ha, 2019), but not in prospective associations (Chang & Wang, 2021; Gale et al., 2012), and the association between depression and cognition has been found to be significant in longitudinal studies with study samples of middle-aged and older adults (Choi et al., 2019; Huang et al., 2022). The inability to assess the mediated effect prospectively meant temporality was not fully maintained, and sensitivity analyses demonstrated that this limitation, to a certain extent, did affect the results from the main analyses. However, there were some consistencies between cross-sectional and prospective results, and similar findings to those found in the current study have been seen in the literature.

The measure of depression used in the current study was depressive symptoms as assessed by the CES-D-10 rather than alternative measures such as a clinical diagnosis of depression. In lieu of a formal diagnostic test for depression, the CLSA uses the CES-D-10, which quantifies and assesses depressive symptoms within the past week, and a question that assesses self-reported history of clinical depression. The CES-D-10 is a valid tool to screen for depression (Mohebbi et al., 2018) and depressive symptoms, while different than a diagnosis of clinical depression (Köhler et al., 2014), are important in their own right. The presence of depressive symptoms in older adults is associated with different health outcomes (Agustini et al., 2020; Formánek et al., 2020), including cognitive decline (Formánek et al., 2020). Previous work conducted in middle-aged and older adults on depression and cognition, as well as on social support and depression, has also used the CES-D-10 (Gariépy et al., 2016; Ha, 2019; D. Kim, 2022).

Although results generated using CLSA data are applicable to the Canadian population on several key demographic and social variables, the applicability of data from the CLSA's Comprehensive cohort is a limitation of this study. Although the study sample is recruited from the overall population, CLSA participants differ from the target population due to selection biases, such as volunteer bias and recruitment bias. Recruiting the Comprehensive cohort participants was also restricted by distance, as participants in this cohort needed to live within 25–50 kilometres of 1 of the 11 DCS. Compared to the overall population of Canadians, Comprehensive cohort participants are more likely to be healthy, born in Canada, have a higher level of education, and have a higher overall

household income. Weighted data for the Comprehensive cohort are available, but these data reflect the regions where Comprehensive participants were recruited rather than being national in scope (Raina et al., 2019) and weighted data cannot be used in PROCESS. Although there is evidence to suggest that applying weights does not affect analyses involving FSS and executive function (Oremus et al., 2022), there is still the issue that Comprehensive cohort participants differ from the overall Canadian population. Thus, care must be taken when interpreting the results of the current study and generalizing findings to the whole Canadian population.

A general limitation of longitudinal studies is missing data. Iacono et al. (2023) found that CLSA participants with complete data differed from people with missing data on executive function at T1 (Iacono et al., 2023). Those individuals who had missing executive function scores at T1 had an increased likelihood of higher depressive symptom scores, lower FSS scores, and lower executive function scores at T0. One strategy in the current study that helped lessen the impact of missing data and retain participants in the analytic sample was the strategy of creating a 'missing' category for covariates with >1% missing data. Additional strategies regarding how to mitigate issues related to missing data are currently being developed by the University of Waterloo CLSA Project Team.

6.6 Implications and Future Directions

To the author's knowledge, this is the first study to examine the mediating effect of depressive symptoms on the association between FSS and executive function and its moderation by age group and sex. Depressive symptoms were found to mediate a small, but statistically significant proportion of the association between FSS and executive function. In subgroups defined by age group and sex, depressive symptoms significantly mediated the association between FSS and executive function in most subgroups. These results indicate that at least some of the benefits of social support on cognition occur through mitigating depressive symptoms, and the evidence supports targeting social support interventions to middle-aged and older adults more broadly, rather than to any specific age group or sex. These FSS interventions should have components addressing depression, as these types of programs may be effective at promoting executive function in middle-aged and older adults. An example of such an intervention could be delivering both food and mental health resources through a program such as Meals on Wheels to middle-aged and older adults. By addressing social support needs and an individual's depressive symptoms, the intervention may help to promote cognitive health in these subpopulations.

When determining where moderation reached statistical significance, the results showed that the moderated effect of the association between FSS and executive function was significant only in males 65–74 years old. In this subgroup, interventions that promote social support with the purpose of promoting executive function may be particularly beneficial. Given the importance of familial support in this subgroup, interventions should focus on facilitating supportive interactions between this subgroup and their loved ones, such as spouses.

Interventions to promote social support are recognized as crucial in a post-COVID-19 pandemic world. During the pandemic, both middle-aged and older adults experienced stressors, which were associated with declines in perceived social support (Li et al., 2021) and increases in depressive symptoms (Raina et al., 2021), and there is the possibility that these declines in mental and social well-being may have long-term consequences (Krendl & Perry, 2021). Thus, there is a need for a more comprehensive understanding of the effect of FSS on cognitive outcomes through depression in a post-pandemic society.

Given the results and the limitations of the study, the findings should be interpreted with caution. The proportion of the relationship between FSS and executive function mediated by depressive symptoms varies greatly across subgroups. The indirect effect in all the subgroups was relatively small, and often the direct and total effects were not statistically significant. Altogether, these results indicate that there may be other factors at play that help to explain the relationship between FSS and executive function. The results should be also interpreted with caution because temporality was not maintained across both paths, and sensitivity analyses indicates that cross-sectional and prospective results at Path II were not fully consistent. The CLSA sample also differs from the Canadian population on key demographic and social variables, meaning that the ability of the current study to apply its results to the entire Canadian population is limited.

To build on the work of the current study, future studies could examine if the association between subtypes of FSS (e.g., emotional/informational, affectionate, tangible, positive social interactions) and executive function is mediated by depressive symptoms. By doing so, social support programs that aim to improve cognition through addressing depressive symptoms could provide individuals with the subtype(s) of social support that may be the most effective. Other future studies could examine the impact of different sources of FSS or extend assessment of mediation by depressive symptoms to examine other mental health measures, such as clinical depression, psychological distress, and generalized anxiety disorder. By examining different mediators, a more complete picture of the

association between FSS and executive function can be gained, especially as the results indicate that there are potentially other factors that may help to explain the relationship between the exposure and outcome.

Given the issues with temporality in the current study, future studies could also examine the same measures as the current study, but with three distinct timepoints instead of the two that were used in the study. Sensitivity analyses revealed some differences in cross-sectional versus prospective results and there is the potential for bidirectionality at both paths of the mediated effect, which further stresses the importance of measuring both paths prospectively. By estimating both paths of the mediated effect prospectively, a more robust understanding of the association between FSS and executive mediated by depressive symptoms can be obtained, which can then better inform social support interventions to promote cognition.

6.7 Conclusion

The worldwide population is aging, which stresses the importance of understanding how factors such as social support and depression affect cognition in aging. Programs and interventions designed to promote cognition are informed by greater understanding of the effect of depression on the association between social support and cognition. In the current study, depressive symptoms were a statistically significant mediator of the association between FSS and executive function in most subgroups. These findings add to the limited body of literature that has examined the mediating effect of depression on the relationship between social factors and cognition and add novel information to the field, as most existing studies do not examine if the mediation is moderated. Potential future research ideas include examining FSS subtypes or sources of social support as exposures and other mental health measures as mediators, as well as using longitudinal data from three distinct timepoints. By doing so, a more comprehensive understanding of the association between social support and cognition is gained, which in turn drives program development and interventions aimed at improving the cognitive health of older adults.

References

Agustini, B., Lotfaliany, M., Mohebbi, M., Woods, R. L., McNeil, J. J., Nelson, M. R., Shah, R. C., Murray, A. M., Reid, C. M., Tonkin, A., Ryan, J., Williams, L. J., Forbes, M. P., & Berk, M. (2022). Trajectories of depressive symptoms in older adults and associated health outcomes. *Nature Aging*, *2*(4). https://doi.org/10.1038/s43587-022-00203-1

Agustini, B., Lotfaliany, M., Woods, R. L., McNeil, J. J., Nelson, M. R., Shah, R. C., Murray, A. M., Ernst, M. E., Reid, C. M., Tonkin, A., Lockery, J. E., Williams, L. J., Berk, M., Mohebbi, M., & Group, A. I. (2020). Patterns of association between depressive symptoms and chronic medical morbidities in older adults. *Journal of the American Geriatrics Society*, *68*(8), 1834–1841. https://doi.org/10.1111/jgs.16468

Airaksinen, J., Hakulinen, C., Elovainio, M., Lehtimäki, T., Raitakari, O. T., Keltikangas-Järvinen, L., & Jokela, M. (2015). Neighborhood effects in depressive symptoms, social support, and mistrust: Longitudinal analysis with repeated measurements. *Social Science & Medicine*, *136–137*, 10–16. https://doi.org/10.1016/j.socscimed.2015.04.034

Alkabbani, W., Maxwell, C. J., Marrie, R. A., Tyas, S. L., Lega, I. C., & Gamble, J.-M. (2024). Insulin, hypoglycaemia and dementia: A causal mediation analysis showcasing challenges and potential opportunities. *Diabetes, Obesity and Metabolism*, *26*(3), 1120–1124. https://doi.org/10.1111/dom.15385

Almquist, Y. B., Landstedt, E., & Hammarström, A. (2017). Associations between social support and depressive symptoms: Social causation or social selection—or both? *European Journal of Public Health*, *27*(1), 84–89. https://doi.org/10.1093/eurpub/ckw120

Altman, D. G., & Royston, P. (2006). The cost of dichotomising continuous variables. *BMJ*, *332*(7549), 1080. https://doi.org/10.1136/bmj.332.7549.1080

Alzheimer Society of Canada. (2022). *Navigating the path forward for dementia in Canada* (1; The Landmark Study). https://alzheimer.ca/sites/default/files/documents/Landmark-Study-Report-1-Path_Alzheimer-Society-Canada_0.pdf

Alzheimer Society of Canada. (2024). *The many faces of dementia in Canada* (2; The Landmark Study). https://alzheimer.ca/sites/default/files/documents/ASC_The%20Many%20Faces%20of%20Dementia%20In%20Canada_Landmark%20Study_Vol2.pdf

Amaefule, C. O., Dyrba, M., Wolfsgruber, S., Polcher, A., Schneider, A., Fliessbach, K., Spottke, A., Meiberth, D., Preis, L., Peters, O., Incesoy, E. I., Spruth, E. J., Priller, J., Altenstein, S., Bartels, C., Wiltfang, J., Janowitz, D., Bürger, K., Laske, C., … Teipel, S. J. (2021). Association between composite scores of domain-specific cognitive functions and regional patterns of atrophy and functional connectivity in the Alzheimer's disease spectrum. *NeuroImage: Clinical*, *29*, 102533. https://doi.org/10.1016/j.nicl.2020.102533

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.).

Amieva, H., Stoykova, R., Matharan, F., Helmer, C., Antonucci, T. C., & Dartigues, J.-F. (2010). What aspects of social network are protective for dementia? Not the quantity but the quality of social interactions is protective up to 15 years later. *Psychosomatic Medicine*, *72*(9), 905–911. https://doi.org/10.1097/PSY.0b013e3181f5e121

Andresen, E. M., Malmgren, J. A., Carter, W. B., & Patrick, D. L. (1994). Screening for depression in well older adults: Evaluation of a short form of the CES-D. *American Journal of Preventive Medicine*, *10*(2), 77–84. https://doi.org/10.1016/S0749-3797(18)30622-6

Antonucci, T. C., & Akiyama, H. (1987). An examination of sex differences in social support among older men and women. *Sex Roles*, *17*(11), 737–749. https://doi.org/10.1007/BF00287685

Bamidis, P. D., Vivas, A. B., Styliadis, C., Frantzidis, C., Klados, M., Schlee, W., Siountas, A., & Papageorgiou, S. G. (2014). A review of physical and cognitive interventions in aging. *Neuroscience & Biobehavioral Reviews*, *44*, 206–220. https://doi.org/10.1016/j.neubiorev.2014.03.019

Barrenetxea, J., Pan, A., Feng, Q., & Koh, W.-P. (2022). Factors associated with depression across age groups of older adults: The Singapore Chinese Health Study. *International Journal of Geriatric Psychiatry*, *37*(2). https://doi.org/10.1002/gps.5666

Bassuk, S. S., Glass, T. A., & Berkman, L. F. (1999). Social disengagement and incident cognitive decline in community-dwelling elderly persons. *Annals of Internal Medicine*, *131*(3), 165–173. https://doi.org/10.7326/0003-4819-131-3-199908030-00002

Bayard, S., Erkes, J., Moroni, C., & CPCN-LR. (2009). *Test du Stroop Victoria-Adaptation francophone*. Collège des Psychologues Cliniciens spécialisés en Neuropsychologie du Languedoc Roussillon (CPCN-LR).

Bayard, S., Erkes, J., Moroni, C., & CPCN-LR. (2011). Victoria Stroop Test: Normative data in a sample group of older people and the study of their clinical applications in the assessment of inhibition in Alzheimer's disease. *Archives of Clinical Neuropsychology*, *26*(7), 653–661. https://doi.org/10.1093/arclin/acr053

Bekker, M. H. J., & van Mens-Verhulst, J. (2007). Anxiety disorders: Sex differences in prevalence, degree, and background, but gender-neutral treatment. *Gender Medicine*, *4*, S178–S193. https://doi.org/10.1016/S1550-8579(07)80057-X

Belle, D. (1987). Gender differences in the social moderators of stress. In R. Barnett, L. Biener, & G. Baruch (Eds.), *Gender and stress* (pp. 257–277). American Psychological Association.

Benito-León, J., Ghosh, R., Lapeña-Motilva, J., Martín-Arriscado, C., & Bermejo-Pareja, F. (2023). Association between cumulative smoking exposure and cognitive decline in non-demented older adults: NEDICES study. *Scientific Reports*, *13*(1). https://doi.org/10.1038/s41598-023-32663-9

Bennett, S., & Thomas, A. J. (2014). Depression and dementia: Cause, consequence or coincidence? *Maturitas*, *79*(2), 184–190. https://doi.org/10.1016/j.maturitas.2014.05.009

Best, J. R., Gan, D. R. Y., Wister, A. V., & Cosco, T. D. (2021). Age and sex trends in depressive symptoms across middle and older adulthood: Comparison of the Canadian Longitudinal Study on Aging to American and European cohorts. *Journal of Affective Disorders*, *295*, 1169–1176. https://doi.org/10.1016/j.jad.2021.08.109

Blazer, D. G. (2003). Depression in late life: Review and commentary. *The Journals of Gerontology: Series A*, *58*(3), M249–M265. https://doi.org/10.1093/gerona/58.3.M249

Bouazzaoui, B., Angel, L., Fay, S., Taconnat, L., Charlotte, F., & Isingrini, M. (2014). Does the greater involvement of executive control in memory with age act as a compensatory mechanism? *Canadian Journal of Experimental Psychology / Revue Canadienne de Psychologie Expérimentale*, *68*(1), 59–66. https://doi.org/10.1037/cep0000005

Bourassa, K. J., Memel, M., Woolverton, C., & Sbarra, D. A. (2017). Social participation predicts cognitive functioning in aging adults over time: Comparisons with physical health, depression, and physical activity. *Aging & Mental Health*, *21*(2), 133–146. https://doi.org/10.1080/13607863.2015.1081152

Braun, T., Rohr, M. K., Wagner, J., & Kunzmann, U. (2018). Perceived reciprocity and relationship satisfaction: Age and relationship category matter. *Psychology and Aging*, *33*(5), 713–727. https://doi.org/10.1037/pag0000267

Brown, M. J., Hill, N. L., & Haider, M. R. (2022). Age and gender disparities in depression and subjective cognitive decline-related outcomes. *Aging & Mental Health*, *26*(1), 48–55. https://doi.org/10.1080/13607863.2020.1861214

Buber, I., & Engelhardt, H. (2008). Children's impact on the mental health of their older mothers and fathers: Findings from the Survey of Health, Ageing and Retirement in Europe. *European Journal of Ageing*, *5*(1), 31–45. https://doi.org/10.1007/s10433-008-0074-8

Butters, M. A., Young, J. B., Lopez, O., Aizenstein, H. J., Mulsant, B. H., Reynolds III, C. F., DeKosky, S. T., & Becker, J. T. (2008). Pathways linking late-life depression to persistent cognitive impairment and dementia. *Dialogues in Clinical Neuroscience*, *10*(3), 345–357. https://doi.org/10.31887/DCNS.2008.10.3/mabutters

Byers, A. L., & Yaffe, K. (2011). Depression and risk of developing dementia. *Nature Reviews. Neurology*, *7*(6), 323–331. https://doi.org/10.1038/nrneurol.2011.60

Canadian Longitudinal Study on Aging. (n.d.). *FAQs*. CLSA-ELCV. Retrieved September 19, 2023, from https://www.clsa-elcv.ca/access-faqs

Canadian Longitudinal Study on Aging. (2018a). *Derived variable – chronic conditions (CCT/CCC)*. https://www.clsa-elcv.ca/sites/default/files/documents/dv_cct_ccc_v1.1_2018aug22_0.pdf

Canadian Longitudinal Study on Aging. (2018b). *Derived variable–depression (DEP)*. https://www.clsa-elcv.ca/doc/2528

Canadian Longitudinal Study on Aging. (2023). *CLSA technical document 2023 sampling and computation of response rates and sample weights for the Tracking (telephone interview) participants and Comprehensive participants*.

Canadian Mental Health Association. (2018, December 5). *Social support*. CMHA National. Retrieved April 25, 2024, from https://cmha.ca/brochure/social-support/

Carter, A. R., Sanderson, E., Hammerton, G., Richmond, R. C., Smith, G. D., Heron, J., Taylor, A. E., Davies, N. M., & Howe, L. D. (2019). *Mendelian randomisation for mediation analysis: Current methods and challenges for implementation* (p. 835819). bioRxiv. https://doi.org/10.1101/835819

Chand, S. P., & Arif, H. (2024). Depression. In *StatPearls*. StatPearls Publishing. http://www.ncbi.nlm.nih.gov/books/NBK430847/

Chang, S. L., & Wang, J.-Y. (2021). Age differences in the longitudinal associations of leisure-time physical activity and depressive symptoms with cognitive decline in older Taiwanese. *Aging & Mental Health*, *25*(4), 679–685. https://doi.org/10.1080/13607863.2019.1701626

Chao, Y.-Y., Katigbak, C., Zhang, N. J., & Dong, X. (2018). Association between perceived social support and depressive symptoms among community-dwelling older Chinese Americans. *Gerontology and Geriatric Medicine*, *4*, 2333721418778194. https://doi.org/10.1177/2333721418778194

Charles, S., & Carstensen, L. L. (2010). Social and emotional aging. *Annual Review of Psychology*, *61*, 383–409. https://doi.org/10.1146/annurev.psych.093008.100448

Chen, C., Tian, Y., Ni, L., Xu, Q., Hu, Y., & Peng, B. (2024). The influence of social participation and depressive symptoms on cognition among middle-aged and older adults. *Heliyon*, *10*(2), e24110. https://doi.org/10.1016/j.heliyon.2024.e24110

Chen, Y., & Feeley, T. H. (2014). Social support, social strain, loneliness, and well-being among older adults: An analysis of the Health and Retirement Study. *Journal of Social and Personal Relationships*, *31*(2), 141–161. https://doi.org/10.1177/0265407513488728

Cheung, E. S. L., & Mui, A. C. (2023). Gender variation and late-life depression: Findings from a national survey in the USA. *Ageing International*, *48*(1), 263–280. https://doi.org/10.1007/s12126-021-09471-5

Choi, D.-W., Han, K.-T., Jeon, J., Jang, S.-I., Kim, S. J., & Park, E.-C. (2019). Association between depressive-symptom trajectories and cognitive function in the late middle-aged and older

population: Results of the Korean Longitudinal Study of Ageing. *Scientific Reports*, *9*(1), 7807. https://doi.org/10.1038/s41598-019-44158-7

Christman, S., Bermudez, C., Hao, L., Landman, B. A., Boyd, B., Albert, K., Woodward, N., Shokouhi, S., Vega, J., Andrews, P., & Taylor, W. D. (2020). Accelerated brain aging predicts impaired cognitive performance and greater disability in geriatric but not midlife adult depression. *Translational Psychiatry*, *10*(1), 1–11. https://doi.org/10.1038/s41398-020-01004-z

Chui, H., Gerstorf, D., Hoppmann, C. A., & Luszcz, M. A. (2015). Trajectories of depressive symptoms in old age: Integrating age-, pathology-, and mortality-related changes. *Psychology and Aging*, *30*(4), 940–951. https://doi.org/10.1037/pag0000054

Cohrdes, C., & Bretschneider, J. (2018). Can social support and physical activity buffer cognitive impairment in individuals with depressive symptoms? Results from a representative sample of young to older adults. *Journal of Affective Disorders*, *239*, 102–106. https://doi.org/10.1016/j.jad.2018.07.003

Comi, S., Cottini, E., & Lucifora, C. (2022). The effect of retirement on social relationships. *German Economic Review*, *23*. https://doi.org/10.1515/ger-2020-0109

Conner, K. O., Copeland, V. C., Grote, N. K., Koeske, G., Rosen, D., Reynolds, C. F., & Brown, C. (2010). Mental health treatment seeking among older adults with depression: The impact of stigma and race. *The American Journal of Geriatric Psychiatry*, *18*(6), 531–543. https://doi.org/10.1097/JGP.0b013e3181cc0366

Costa-Cordella, S., Arevalo-Romero, C., Parada, F. J., & Rossi, A. (2021). Social support and cognition: A systematic review. *Frontiers in Psychology*, *12*. https://www.frontiersin.org/articles/10.3389/fpsyg.2021.637060

Dao-Tran, T.-H., Lam, L.-T., Balasooriya, N. N., & Comans, T. (2023). The Medical Outcome Study Social Support Survey (MOS-SSS): A psychometric systematic review. *Journal of Advanced Nursing*, *79*(12), 4521–4541. https://doi.org/10.1111/jan.15786

Davis, J. C., Marra, C. A., Najafzadeh, M., & Liu-Ambrose, T. (2010). The independent contribution of executive functions to health related quality of life in older women. *BMC Geriatrics*, *10*(1), 16. https://doi.org/10.1186/1471-2318-10-16

de Brito, T. R. P., Nunes, D. P., Corona, L. P., da Silva Alexandre, T., & de Oliveira Duarte, Y. A. (2017). Low supply of social support as risk factor for mortality in the older adults. *Archives of Gerontology and Geriatrics*, *73*, 77–81. https://doi.org/10.1016/j.archger.2017.07.016

DeBattista, C. (2005). Executive dysfunction in Major Depressive Disorder. *Expert Review of Neurotherapeutics*, *5*(1), 79–84. https://doi.org/10.1586/14737175.5.1.79

Dempster, F. N. (1992). The rise and fall of the inhibitory mechanism: Toward a unified theory of cognitive development and aging. *Developmental Review*, *12*(1), 45–75. https://doi.org/10.1016/0273-2297(92)90003-K

Denver, P., & McClean, P. L. (2018). Distinguishing normal brain aging from the development of Alzheimer's disease: Inflammation, insulin signaling and cognition. *Neural Regeneration Research*, *13*(10), 1719. https://doi.org/10.4103/1673-5374.238608

Desai, R., Charlesworth, G. M., Brooker, H. J., Potts, H. W. W., Corbett, A., Aarsland, D., & Ballard, C. G. (2020). Temporal relationship between depressive symptoms and cognition in mid and late life: A longitudinal cohort study. *Journal of the American Medical Directors Association*, *21*(8), 1108–1113. https://doi.org/10.1016/j.jamda.2020.01.106

Desai, R., John, A., Stott, J., & Charlesworth, G. (2020). Living alone and risk of dementia: A systematic review and meta-analysis. *Ageing Research Reviews*, *62*, 101122. https://doi.org/10.1016/j.arr.2020.101122

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*(1), 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Dickinson, W. J., Potter, G. G., Hybels, C. F., McQuoid, D. R., & Steffens, D. C. (2011). Change in stress and social support as predictors of cognitive decline in older adults with and without depression. *International Journal of Geriatric Psychiatry*, *26*(12), 1267–1274. https://doi.org/10.1002/gps.2676

Dong, X., Chen, R., Li, C., & Simon, M. A. (2014). Understanding depressive symptoms among community-dwelling Chinese older adults in the Greater Chicago Area. *Journal of Aging and Health*, *26*(7), 1155–1171. https://doi.org/10.1177/0898264314527611

Dotson, V. M., McClintock, S. M., Verhaeghen, P., Kim, J. U., Draheim, A. A., Syzmkowicz, S. M., Gradone, A. M., Bogoian, H. R., & Wit, L. D. (2020). Depression and cognitive control

across the lifespan: A systematic review and meta-analysis. *Neuropsychology Review*, *30*(4), 461–476. https://doi.org/10.1007/s11065-020-09436-6

Eagly, A. H. (1987). *Sex differences in social behavior: A social-role interpretation*. Psychology Press. https://doi.org/10.4324/9780203781906

Eisele, M., Zimmermann, T., Köhler, M., Wiese, B., Heser, K., Tebarth, F., Weeg, D., Olbrich, J., Pentzek, M., Fuchs, A., Weyerer, S., Werle, J., Leicht, H., König, H.-H., Luppa, M., Riedel-Heller, S., Maier, W., Scherer, M., & the AgeCoDe Study Group. (2012). Influence of social support on cognitive change and mortality in old age: Results from the prospective multicentre cohort study AgeCoDe. *BMC Geriatrics*, *12*(1), 9. https://doi.org/10.1186/1471-2318-12-9

Ellwardt, L., Aartsen, M., Deeg, D., & Steverink, N. (2013). Does loneliness mediate the relation between social support and cognitive functioning in later life? *Social Science & Medicine*, *98*, 116–124. https://doi.org/10.1016/j.socscimed.2013.09.002

Fässberg, M. M., Orden, K. A. van, Duberstein, P., Erlangsen, A., Lapierre, S., Bodner, E., Canetto, S. S., Leo, D. D., Szanto, K., & Waern, M. (2012). A systematic review of social factors and suicidal behavior in older adulthood. *International Journal of Environmental Research and Public Health*, *9*(3). https://doi.org/10.3390/ijerph9030722

Ferguson, H. J., Brunsdon, V. E. A., & Bradford, E. E. F. (2021). The developmental trajectories of executive function from adolescence to old age. *Scientific Reports*, *11*(1), 1382. https://doi.org/10.1038/s41598-020-80866-1

Fiori, K. L., & Denckla, C. A. (2012). Social support and mental health in middle-aged men and women: A multidimensional approach. *Journal of Aging and Health*, *24*(3), 407–438. https://doi.org/10.1177/0898264311425087

Fiske, A., Wetherell, J. L., & Gatz, M. (2009). Depression in older adults. *Annual Review of Clinical Psychology*, *5*, 363–389. https://doi.org/10.1146/annurev.clinpsy.032408.153621

Formánek, T., Csajbók, Z., Wolfová, K., Kučera, M., Tom, S., Aarsland, D., & Cermakova, P. (2020). Trajectories of depressive symptoms and associated patterns of cognitive decline. *Scientific Reports*, *10*(1). https://doi.org/10.1038/s41598-020-77866-6

Fyrand, L. (2010). Reciprocity: A predictor of mental health and continuity in elderly people's relationships? A review. *Current Gerontology and Geriatrics Research*, 340161. https://doi.org/10.1155/2010/340161

Gale, C. R., Allerhand, M., & Deary, I. J. (2012). Is there a bidirectional relationship between depressive symptoms and cognitive ability in older people? A prospective study using the English Longitudinal Study of Ageing. *Psychological Medicine*, *42*(10), 2057–2069. https://doi.org/10.1017/S0033291712000402

Gariépy, G., Honkaniemi, H., & Quesnel-Vallée, A. (2016). Social support and protection from depression: Systematic review of current findings in Western countries. *The British Journal of Psychiatry*, *209*(4), 284–293. https://doi.org/10.1192/bjp.bp.115.169094

Gong, J., Harris, K., Hackett, M., Peters, S. A. E., Brodaty, H., Cooper, M., Hamet, P., Harrap, S., Mancia, G., MacMahon, S., Chalmers, J., & Woodward, M. (2021). Sex differences in risk factors for cognitive decline and dementia, including death as a competing risk, in individuals with diabetes: Results from the ADVANCE trial. *Diabetes, Obesity and Metabolism*, *23*(8), 1775–1785. https://doi.org/10.1111/dom.14391

Gong, J., Harris, K., Lipnicki, D. M., Castro-Costa, E., Lima-Costa, M. F., Diniz, B. S., Xiao, S., Lipton, R. B., Katz, M. J., Wang, C., Preux, P.-M., Guerchet, M., Gbessemehlan, A., Ritchie, K., Ancelin, M.-L., Skoog, I., Najar, J., Sterner, T. R., Scarmeas, N., … Cohort Studies of Memory in an International Consortium (COSMIC) (2023). Sex differences in dementia risk and risk factors: Individual-participant data analysis using 21 cohorts across six continents from the COSMIC consortium. *Alzheimer's & Dementia*, *19*(8), 3365–3378. https://doi.org/10.1002/alz.12962

Government of Canada, S. C. (2020, September 29). *Demographic estimates by age and gender, provinces and territories: Interactive dashboard*. Retrieved April 4, 2024, from frhttps://www150.statcan.gc.ca/n1/pub/71-607-x/71-607-x2020018-eng.htm

Gow, A. J., Corley, J., Starr, J. M., & Deary, I. J. (2013). Which social network or support factors are associated with cognitive abilities in old age? *Gerontology*, *59*(5), 454–463. https://doi.org/10.1159/000351265

Guo, Y., Pai, M., Xue, B., & Lu, W. (2023). Bidirectional association between depressive symptoms and mild cognitive impairment over 20 years: Evidence from the Health and Retirement Study in the United States. *Journal of Affective Disorders*, *338*, 449–458. https://doi.org/10.1016/j.jad.2023.06.046

Ha, E. (2019). *The Association between depressive symptoms and executive function in the Canadian Longitudinal Study on Aging* [Master's thesis, University of Waterloo]. UWSpace. http://hdl.handle.net/10012/14996

Hakulinen, C., Pulkki-Råback, L., Jokela, M., E Ferrie, J., Aalto, A.-M., Virtanen, M., Kivimäki, M., Vahtera, J., & Elovainio, M. (2016). Structural and functional aspects of social support as predictors of mental and physical health trajectories: Whitehall II Cohort Study. *Journal of Epidemiology and Community Health*, *70*(7), 710–715. https://doi.org/10.1136/jech-2015-206165

Hamm, J. M., Heckhausen, J., Shane, J., & Lachman, M. E. (2020). Risk of cognitive declines with retirement: Who declines and why? *Psychology and Aging*, *35*(3), 449–457. https://doi.org/10.1037/pag0000453

Harada, C. N., Love, M. C. N., & Triebel, K. (2013). Normal cognitive aging. *Clinics in Geriatric Medicine*, *29*(4), 737. https://doi.org/10.1016/j.cger.2013.07.002

Harris, M. L., Bennion, E., Magnusson, K. R., Howard, V. J., Wadley, V. G., McClure, L. A., Levine, D. A., Manly, J. J., Avila, J. F., Glymour, M. M., Wisco, J. J., & Thacker, E. L. (2023). Rural versus urban residence in adulthood and incident cognitive impairment. *Neuroepidemiology*, *57*(4), 218–228. https://doi.org/10.1159/000530961

Hayes, A. F. (2009). Beyond Baron and Kenny: Statistical mediation analysis in the new millennium. *Communication Monographs*, *76*(4), 408–420. https://doi.org/10.1080/03637750903310360

Hayes, A. F. (2015). An index and test of linear moderated mediation. *Multivariate Behavioral Research*, *50*(1), 1–22. https://doi.org/10.1080/00273171.2014.962683

Hayes, A. F. (2022). *Introduction to mediation, moderation, and conditional process analysis: A regression-based approach* (3rd ed.). The Guilford Press.

Hayes, A. F., & Rockwood, N. J. (2020). Conditional process analysis: Concepts, computation, and advances in the modeling of the contingencies of mechanisms. *American Behavioral Scientist*, *64*(1), 19–54. https://doi.org/10.1177/0002764219859633

Hegeman, J. M., Kok, R. M., Mast, R. C. van der, & Giltay, E. J. (2012). Phenomenology of depression in older compared with younger adults: Meta-analysis. *The British Journal of Psychiatry*, *200*(4), 275–281. https://doi.org/10.1192/bjp.bp.111.095950

Holtzman, R. E., Rebok, G. W., Saczynski, J. S., Kouzis, A. C., Wilcox Doyle, K., & Eaton, W. W. (2004). Social network characteristics and cognition in middle-aged and older adults. *The Journals of Gerontology: Series B*, *59*(6), P278-284. https://doi.org/10.1093/geronb/59.6.p278

Hosseini, S., Chaurasia, A., & Oremus, M. (2023). The association between religious participation and executive function in middle- and older-aged adults: A cross-sectional analysis of the Canadian Longitudinal Study on Aging. *The International Journal for the Psychology of Religion*, *33*(1), 36–51. https://doi.org/10.1080/10508619.2022.2061152

Huang, W., Zhu, W., Chen, H., Li, F., Huang, J., Zhou, Y., Sun, X., & Lan, Y. (2022). Longitudinal association between depressive symptoms and cognitive decline among middle-aged and elderly population. *Journal of Affective Disorders*, *303*, 18–23. https://doi.org/10.1016/j.jad.2022.01.107

Iacono, A., Oremus, M., Maxwell, C. J., & Tyas, S. L. (2023). Functional social isolation mediates the association between depression and executive function in older women: Findings from the Canadian Longitudinal Study on Aging Comprehensive cohort. *Aging, Neuropsychology, and Cognition*, 1–21. https://doi.org/10.1080/13825585.2023.2226855

Irwin, M., Artin, K. H., & Oxman, M. N. (1999). Screening for depression in the older adult: Criterion validity of the 10-Item Center for Epidemiological Studies Depression Scale (CES-D). *Archives of Internal Medicine*, *159*(15), 1701–1704. https://doi.org/10.1001/archinte.159.15.1701

Jiang, L., Drolet, A., & Kim, H. S. (2018). Age and social support seeking: Understanding the role of perceived social costs to others. *Personality and Social Psychology Bulletin*, *44*(7), 1104–1116. https://doi.org/10.1177/0146167218760798

Jorm, A. F. (2000). Is depression a risk factor for dementia or cognitive decline? A review. *Gerontology*, *46*(4), 219–227. https://doi.org/10.1159/000022163

Jorm, A. F. (2001). History of depression as a risk factor for dementia: An updated review. *Australian & New Zealand Journal of Psychiatry*, *35*(6), 776–781. https://doi.org/10.1046/j.1440-1614.2001.00967.x

Joyce, J., Ryan, J., Owen, A., Hu, J., McHugh Power, J., Shah, R., Woods, R., Storey, E., Britt, C., Freak-Poli, R., & Group, A. I. (2022). Social isolation, social support, and loneliness and their relationship with cognitive health and dementia. *International Journal of Geriatric Psychiatry*, *37*(1). https://doi.org/10.1002/gps.5644

Jung, M., Lee, S., Kang, M., & Allen, H. K. (2023). Age-varying association between depression symptoms and executive function among older adults: Moderation by physical activity. *Journal of Psychiatric Research*, *165*, 115–122. https://doi.org/10.1016/j.jpsychires.2023.07.025

Kaniasty, K., & Norris, F. H. (2008). Longitudinal linkages between perceived social support and posttraumatic stress symptoms: Sequential roles of social causation and social selection. *Journal of Traumatic Stress*, *21*(3), 274–281. https://doi.org/10.1002/jts.20334

Kawachi, I., & Berkman, L. F. (2001). Social ties and mental health. *Journal of Urban Health*, *78*(3), 458–467. https://doi.org/10.1093/jurban/78.3.458

Kendler, K. S., Myers, J., & Prescott, C. A. (2005). Sex differences in the relationship between social support and risk for major depression: A longitudinal study of opposite-sex twin pairs. *American Journal of Psychiatry*, *162*(2), 250–256. https://doi.org/10.1176/appi.ajp.162.2.250

Kim, A. J., Beam, C. R., Greenberg, N. E., & Burke, S. L. (2020). Health factors as potential mediators of the longitudinal effect of loneliness on general cognitive ability. *The American Journal of Geriatric Psychiatry*, *28*(12), 1272–1283. https://doi.org/10.1016/j.jagp.2020.07.017

Kim, D. (2022). Effects of depression on changes in cognitive function in older adults: A fixed-effects model analysis using the Korean Longitudinal Study of Aging (KLoSA). *Alzheimer Disease & Associated Disorders*, *36*(4), 319. https://doi.org/10.1097/WAD.0000000000000531

Kim, J. H. (2019). Multicollinearity and misleading statistical results. *Korean Journal of Anesthesiology*, *72*(6), 558–569. https://doi.org/10.4097/kja.19087

Kleinbaum, D., Kupper, L., Nizam, A., & Rosenberg, E. (2013). *Applied regression analysis and other multivariable methods*.

Köhler, O., Benros, M. E., Nordentoft, M., Farkouh, M. E., Iyengar, R. L., Mors, O., & Krogh, J. (2014). Effect of anti-inflammatory treatment on depression, depressive symptoms, and adverse effects: A systematic review and meta-analysis of randomized clinical trials. *JAMA Psychiatry*, *71*(12), 1381–1391. https://doi.org/10.1001/jamapsychiatry.2014.1611

Krendl, A. C., & Perry, B. L. (2021). The impact of sheltering in place during the COVID-19 pandemic on older adults' social and mental well-being. *The Journals of Gerontology: Series B*, *76*(2), e53–e58. https://doi.org/10.1093/geronb/gbaa110

Kumar, M., Muhammad, T., & Dwivedi, L. K. (2022). Assessing the role of depressive symptoms in the association between social engagement and cognitive functioning among older adults: Analysis of cross-sectional data from the Longitudinal Aging Study in India (LASI). *BMJ Open*, *12*(10), e063336. https://doi.org/10.1136/bmjopen-2022-063336

Kupferberg, A., & Hasler, G. (2023). The social cost of depression: Investigating the impact of impaired social emotion regulation, social cognition, and interpersonal behavior on social functioning. *Journal of Affective Disorders Reports*, *14*, 100631. https://doi.org/10.1016/j.jadr.2023.100631

La Fleur, C. G., & Salthouse, T. A. (2017). Which aspects of social support are associated with which cognitive abilities for which people? *The Journals of Gerontology: Series B*, *72*(6), 1006–1016. https://doi.org/10.1093/geronb/gbv119

Labaka, A., Goñi-Balentziaga, O., Lebeña, A., & Pérez-Tejada, J. (2018). Biological sex differences in depression: A systematic review. *Biological Research For Nursing*, *20*(4), 383–392. https://doi.org/10.1177/1099800418776082

Lee, Y., & Shinkai, S. (2005). Correlates of cognitive impairment and depressive symptoms among older adults in Korea and Japan. *International Journal of Geriatric Psychiatry*, *20*(6), 576–586. https://doi.org/10.1002/gps.1313

Levine, D. A., Gross, A. L., Briceño, E. M., Tilton, N., Giordani, B. J., Sussman, J. B., Hayward, R. A., Burke, J. F., Hingtgen, S., Elkind, M. S. V., Manly, J. J., Gottesman, R. F., Gaskin, D. J., Sidney, S., Sacco, R. L., Tom, S. E., Wright, C. B., Yaffe, K., & Galecki, A. T. (2021). Sex differences in cognitive decline among US adults. *JAMA Network Open*, *4*(2), e210169. https://doi.org/10.1001/jamanetworkopen.2021.0169

Lezak, M. D., Howieson, D. B., Loring, D. W., Hannay, H. J., & Fischer, J. S. (2004). *Neuropsychological assessment* (4th ed.). Oxford University Press.

Li, F., Luo, S., Mu, W., Li, Y., Ye, L., Zheng, X., Xu, B., Ding, Y., Ling, P., Zhou, M., & Chen, X. (2021). Effects of sources of social support and resilience on the mental health of different age groups during the COVID-19 pandemic. *BMC Psychiatry*, *21*, 16. https://doi.org/10.1186/s12888-020-03012-1

Li, G., Li, Y., Lam, A. I. F., Tang, W., Seedat, S., Barbui, C., Papola, D., Panter-Brick, C., Waerden, J. van der, Bryant, R., Mittendorfer-Rutz, E., Gémes, K., Purba, F. D., Setyowibowo, H., Pinucci, I., Palantza, C., Acarturk, C., Kurt, G., Tarsitani, L., … Hall, B. J. (2023). Understanding the protective effect of social support on depression symptomatology from a longitudinal network perspective. *BMJ Mental Health*, *26*(1). https://doi.org/10.1136/bmjment-2023-300802

Liao, J., & Scholes, S. (2017). Association of social support and cognitive aging modified by sex and relationship type: A prospective investigation in the English Longitudinal Study of Ageing. *American Journal of Epidemiology*, *186*(7), 787–795. https://doi.org/10.1093/aje/kwx142

Livingston, G., Huntley, J., Sommerlad, A., Ames, D., Ballard, C., Banerjee, S., Brayne, C., Burns, A., Cohen-Mansfield, J., Cooper, C., Costafreda, S. G., Dias, A., Fox, N., Gitlin, L. N., Howard, R., Kales, H. C., Kivimäki, M., Larson, E. B., Ogunniyi, A., … Mukadam, N. (2020). Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. *The Lancet*, *396*(10248), 413–446. https://doi.org/10.1016/S0140-6736(20)30367-6

Loewenstein, D. A., & Acevedo, A. (2004). *The Prospective Memory Test: Administration and scoring manual* [Unpublished].

Lugtenburg, A., Oude Voshaar, R. C., Van Zelst, W., Schoevers, R. A., Enriquez-Geppert, S., & Zuidersma, M. (2017). The relationship between depression and executive function and the

impact of vascular disease burden in younger and older adults. *Age and Ageing*, *46*(4), 697–701. https://doi.org/10.1093/ageing/afx043

Luong, G., Charles, S. T., & Fingerman, K. L. (2011). Better with age: Social relationships across adulthood. *Journal of Social and Personal Relationships*, *28*(1), 9–23. https://doi.org/10.1177/0265407510391362

Lynch, T. R., Mendelson, T., Robins, C. J., Krishnan, K. R. R., George, L. K., Johnson, C. S., & Blazer, D. G. (1999). Perceived social support among depressed elderly, middle-aged, and young-adult samples: Cross-sectional and longitudinal analyses. *Journal of Affective Disorders*, *55*(2), 159–170. https://doi.org/10.1016/S0165-0327(99)00017-8

Mackin, R. S., Jin, C., Burns, E., Kassel, M., Rhodes, E., Nosheny, R., Ashford, M., Banh, T., Eichenbaum, J., Knight, K., Tank, R., Camacho, M. R., Fockler, J., Truran, D., Neuhaus, J., & Weiner, M. (2023). Association of Major Depressive Disorder with remotely administered measures of cognition and subjective report of cognitive difficulties across the adult age spectrum. *Journal of Affective Disorders*, *326*, 198–205. https://doi.org/10.1016/j.jad.2022.12.045

Marcoulides, K. M., & Raykov, T. (2019). Evaluation of variance inflation factors in regression models using latent variable modeling methods. *Educational and Psychological Measurement*, *79*(5), 874–882. https://doi.org/10.1177/0013164418817803

Marroquín, B. (2011). Interpersonal emotion regulation as a mechanism of social support in depression. *Clinical Psychology Review*, *31*(8), 1276–1290. https://doi.org/10.1016/j.cpr.2011.09.005

Meeks, T., Vahia, I., Lavretsky, H., Kulkarni, G., & Jeste, D. (2011). A tune in "A minor" can "B major": A review of epidemiology, illness course, and public health implications of subthreshold depression in older adults. *Journal of Affective Disorders*, *129*(1–3), 126–142. https://doi.org/10.1016/j.jad.2010.09.015

Menec, V. H., Newall, N. E., Mackenzie, C. S., Shooshtari, S., & Nowicki, S. (2019). Examining individual and geographic factors associated with social isolation and loneliness using Canadian Longitudinal Study on Aging (CLSA) data. *PLOS ONE*, *14*(2), e0211143. https://doi.org/10.1371/journal.pone.0211143

Meng, A., Nexø, M. A., & Borg, V. (2017). The impact of retirement on age related cognitive decline – a systematic review. *BMC Geriatrics*, *17*(1), 160. https://doi.org/10.1186/s12877-017-0556-7

Millán-Calenti, J. C., Sánchez, A., Lorenzo-López, L., Cao, R., & Maseda, A. (2013). Influence of social support on older adults with cognitive impairment, depressive symptoms, or both coexisting. *The International Journal of Aging and Human Development*, *76*(3), 199–214. https://doi.org/10.2190/AG.76.3.b

Miočević, M., O'Rourke, H. P., MacKinnon, D. P., & Brown, H. C. (2018). Statistical properties of four effect-size measures for mediation models. *Behavior Research Methods*, *50*(1), 285–301. https://doi.org/10.3758/s13428-017-0870-1

Mitchell, A. J., & Subramaniam, H. (2005). Prognosis of depression in old age compared to middle age: A systematic review of comparative studies. *American Journal of Psychiatry*, *162*(9), 1588–1601. https://doi.org/10.1176/appi.ajp.162.9.1588

Mo, P. K. H., Wong, E. L. Y., Yeung, N. C. Y., Wong, S. Y. S., Chung, R. Y., Tong, A. C. Y., Ko, C. C. Y., Li, J., & Yeoh, E. (2022). Differential associations among social support, health promoting behaviors, health-related quality of life and subjective well-being in older and younger persons: A structural equation modelling approach. *Health and Quality of Life Outcomes*, *20*(1), 38. https://doi.org/10.1186/s12955-022-01931-z

Moak, Z. B., & Agrawal, A. (2010). The association between perceived interpersonal social support and physical and mental health: Results from the national epidemiological survey on alcohol and related conditions. *Journal of Public Health*, *32*(2), 191–201. https://doi.org/10.1093/pubmed/fdp093

Mogic, L., Rutter, E. C., Tyas, S. L., Maxwell, C. J., O'Connell, M. E., & Oremus, M. (2023). Functional social support and cognitive function in middle- and older-aged adults: A systematic review of cross-sectional and cohort studies. *Systematic Reviews*, *12*(1), 86. https://doi.org/10.1186/s13643-023-02251-z

Mohd, T. A. M. T., Yunus, R. M., Hairi, F., Hairi, N. N., & Choo, W. Y. (2019). Social support and depression among community dwelling older adults in Asia: A systematic review. *BMJ Open*, *9*(7), e026667. https://doi.org/10.1136/bmjopen-2018-026667

Mohebbi, M., Nguyen, V., McNeil, J. J., Woods, R. L., Nelson, M. R., Shah, R. C., Storey, E., Murray, A. M., Reid, C. M., Kirpach, B., Wolfe, R., Lockery, J. E., & Berk, M. (2018). Psychometric properties of a short form of the Center for Epidemiologic Studies Depression (CES-D-10) scale for screening depressive symptoms in healthy community dwelling older adults. *General Hospital Psychiatry*, *51*, 118–125. https://doi.org/10.1016/j.genhosppsych.2017.08.002

Montoya, A. K., & Hayes, A. F. (2017). Two-condition within-participant statistical mediation analysis: A path-analytic framework. *Psychological Methods*, *22*(1), 6–27. https://doi.org/10.1037/met0000086

Moroni, C., & Bayard, S. (2009). Processus d'inhibition: Quelle est leur évolution après 50 ans? *Psychologie & NeuroPsychiatrie du vieillissement 7*(2), 121–129.

Muhammad, T., & Meher, T. (2021). Association of late-life depression with cognitive impairment: Evidence from a cross-sectional study among older adults in India. *BMC Geriatrics*, *21*(1), 364. https://doi.org/10.1186/s12877-021-02314-7

Muramatsu, N., Yin, H., & Hedeker, D. (2010). Functional declines, social support, and mental health in the elderly: Does living in a state supportive of home and community-based services make a difference? *Social Science & Medicine*, *70*(7), 1050–1058. https://doi.org/10.1016/j.socscimed.2009.12.005

Murman, D. L. (2015). The impact of age on cognition. *Seminars in Hearing*, *36*(03), 111–121. https://doi.org/10.1055/s-0035-1555115

National Institute on Ageing. (2022). *Understanding social isolation and loneliness among older Canadians and how to address it*. National Institute on Ageing, Toronto Metropolitan University.

Newall, N. E. G., & Menec, V. H. (2019). Loneliness and social isolation of older adults: Why it is important to examine these social aspects together. *Journal of Social and Personal Relationships*, *36*(3), 925–939. https://doi.org/10.1177/0265407517749045

Newall, N. E. G., & Menec, V. H. (2020). A comparison of different definitions of social isolation using Canadian Longitudinal Study on Aging (CLSA) data. *Ageing & Society*, *40*(12), 2671–2694. https://doi.org/10.1017/S0144686X19000801

Nolen-Hoeksema, S. (2001). Gender differences in depression. *Current Directions in Psychological Science*, *10*(5), 173–176.

Nolen-Hoeksema, S., Larson, J., & Grayson, C. (1999). Explaining the gender difference in depressive symptoms. *Journal of Personality and Social Psychology*, *77*(5), 1061–1072. https://doi.org/10.1037//0022-3514.77.5.1061

O'Connell, M. E., Grant, P. R., McLean, M., Griffith, L. E., Wolfson, C., Kirkland, S., & Raina, P. (2018). P1-603: Measurement invariance of the Centre for Epidemiological Studies Depression Scale 10-Item Short Form (CES-D-10) in the Canadian Longitudinal Study on Aging. *Alzheimer's & Dementia*, *14,* P570–P570. https://doi.org/10.1016/j.jalz.2018.06.616

O'Connell, M. E., Kadlec, H., Griffith, L. E., Wolfson, C., Maimon, G., Taler, V., Kirkland, S., & Raina, P. (2023). Cognitive impairment indicator for the neuropsychological test batteries in the Canadian Longitudinal Study on Aging: Definition and evidence for validity. *Alzheimer's Research & Therapy*, *15*(1), 167. https://doi.org/10.1186/s13195-023-01317-3

Ohman, A. (2020). *The association between social support availability and memory: A cross-sectional analysis of the Canadian Longitudinal Study on Aging* [Master Thesis, University of Waterloo]. https://uwspace.uwaterloo.ca/handle/10012/16002

Ohman, A., Maxwell, C. J., Tyas, S. L., & Oremus, M. (2023). Subtypes of social support availability are not differentially associated with memory: A cross-sectional analysis of the Comprehensive Cohort of the Canadian Longitudinal Study on Aging. *Aging, Neuropsychology, and Cognition*, *30*(3), 354–369. https://doi.org/10.1080/13825585.2022.2030294

Olsen, C. D. H., Möller, S., & Ahrenfeldt, L. J. (2023). Sex differences in quality of life and depressive symptoms among middle-aged and elderly Europeans: Results from the SHARE survey. *Aging & Mental Health*, *27*(1), 35–42. https://doi.org/10.1080/13607863.2021.2013434

Olsen, O., Iversen, L., & Sabroe, S. (1991). Age and the operationalization of social support. *Social Science & Medicine*, *32*(7), 767–771. https://doi.org/10.1016/0277-9536(91)90302-S

Oremus, M., Konnert, C., Law, J., Maxwell, C. J., O'Connell, M. E., & Tyas, S. L. (2019). Social support and cognitive function in middle- and older-aged adults: Descriptive analysis of

CLSA tracking data. *European Journal of Public Health*, *29*(6), 1084–1089. https://doi.org/10.1093/eurpub/ckz047

Oremus, M., Maxwell, C., Tyas, S. L., Griffith, L. E., & Heuvel, E. R. van den. (2022). *Unweighted versus weighted regression methods may be sufficient to analyze complex survey data in the Canadian Longitudinal Study on Aging* (p. 2022.08.31.22279464). medRxiv. https://doi.org/10.1101/2022.08.31.22279464

Oremus, M., Tyas, S. L., Maxwell, C. J., Konnert, C., O'Connell, M. E., & Law, J. (2020). Social support availability is positively associated with memory in persons aged 45–85 years: A cross-sectional analysis of the Canadian Longitudinal Study on Aging. *Archives of Gerontology and Geriatrics*, *86*, 103962. https://doi.org/10.1016/j.archger.2019.103962

Otte, C., Gold, S. M., Penninx, B. W., Pariante, C. M., Etkin, A., Fava, M., Mohr, D. C., & Schatzberg, A. F. (2016). Major Depressive Disorder. *Nature Reviews Disease Primers*, *2*(1), 1–20. https://doi.org/10.1038/nrdp.2016.65

Ouellet, M.-C., Sirois, M.-J., Beaulieu-Bonneau, S., Gagné, M.-È., Morin, J., Perry, J., Daoust, R., Wilding, L., Provencher, V., Camden, S., Allain-Boulé, N., & Émond, M. (2016). Correlates of cognitive functioning in independent elderly patients discharged home from the emergency department after a minor injury. *International Psychogeriatrics*, *28*(8), 1313–1322. https://doi.org/10.1017/S104161021600065X

Overdorp, E. J., Kessels, R. P. C., Claassen, J. A., & Oosterman, J. M. (2016). The combined effect of neuropsychological and neuropathological deficits on instrumental activities of daily living in older adults: A systematic review. *Neuropsychology Review*, *26*(1), 92–106. https://doi.org/10.1007/s11065-015-9312-y

Ozbay, F., Johnson, D. C., Dimoulas, E., Morgan III, C. A., Charney, D., & Southwick, S. (2007). Social support and resilience to stress: From neurobiology to clinical practice. *Psychiatry*, *4*(5), 35–40.

Peleg, S., & Nudelman, G. (2021). Associations between self-rated health and depressive symptoms among older adults: Does age matter? *Social Science & Medicine*, *280*, 114024. https://doi.org/10.1016/j.socscimed.2021.114024

Pieters, R. (2017). Meaningful mediation analysis: Plausible causal inference and informative communication. *Journal of Consumer Research*, *44*(3), 692–716. https://doi.org/10.1093/jcr/ucx081

Pillemer, S. C., & Holtzer, R. (2016). The differential relationships of dimensions of perceived social support with cognitive function among older adults. *Aging & Mental Health*, *20*(7), 727–735. https://doi.org/10.1080/13607863.2015.1033683

Public Health Agency of Canada. (2021, July 14). *Aging and chronic diseases: A profile of Canadian seniors*. https://www.canada.ca/en/public-health/services/publications/diseases-conditions/aging-chronic-diseases-profile-canadian-seniors-report.html

Quebec Network for Research on Aging. (n.d.). Retrieved June 11, 2024, from https://rqrv.com/en/init_NuAge.php

Radloff, L. S. (1977). The CES-D scale: A self-report depression scale for research in the general population. *Applied Psychological Measurement*, *1*(3), 385–401. https://doi.org/10.1177/014662167700100306

Raina, P. S., Wolfson, C., & Kirkland, S. (n.d.). *Canadian Longitudinal Study on Aging (CLSA) protocol*. CLSA-ELCV. https://clsa-elcv.ca/doc/511

Raina, P. S., Wolfson, C., Kirkland, S. A., Griffith, L. E., Oremus, M., Patterson, C., Tuokko, H., Penning, M., Balion, C. M., Hogan, D., Wister, A., Payette, H., Shannon, H., & Brazil, K. (2009). The Canadian Longitudinal Study on Aging (CLSA). *Canadian Journal on Aging / La Revue Canadienne Du Vieillissement*, *28*(3), 221–229. https://doi.org/10.1017/S0714980809990055

Raina, P., Wolfson, C., Griffith, L., Kirkland, S., McMillan, J., Basta, N., Joshi, D., Oz, U. E., Sohel, N., Maimon, G., & Thompson, M. (2021). A longitudinal analysis of the impact of the COVID-19 pandemic on the mental health of middle-aged and older adults from the Canadian Longitudinal Study on Aging. *Nature Aging*, *1*(12), 1137–1147. https://doi.org/10.1038/s43587-021-00128-1

Raina, P., Wolfson, C., Kirkland, S., Griffith, L. E., Balion, C., Cossette, B., Dionne, I., Hofer, S., Hogan, D., van den Heuvel, E. R., Liu-Ambrose, T., Menec, V., Mugford, G., Patterson, C., Payette, H., Richards, B., Shannon, H., Sheets, D., Taler, V., … Young, L. (2019). Cohort

profile: The Canadian Longitudinal Study on Aging (CLSA). *International Journal of Epidemiology*, *48*(6), 1752–1753j. https://doi.org/10.1093/ije/dyz173

Read, D. E. (1987). Neuropsychological assessment of memory in the elderly. *Canadian Journal of Psychology / Revue Canadienne de Psychologie*, *41*(2), 158–174.

Ren, L., Zheng, Y., Wu, L., Gu, Y., He, Y., Jiang, B., Zhang, J., Zhang, L., & Li, J. (2018). Investigation of the prevalence of cognitive impairment and its risk factors within the elderly population in Shanghai, China. *Scientific Reports*, *8*(1), 3575. https://doi.org/10.1038/s41598-018-21983-w

Ren, P., Qin, X., Zhang, Y., & Zhang, R. (2018). Is social support a cause or consequence of depression? A longitudinal study of adolescents. *Frontiers in Psychology*, *9*. https://doi.org/10.3389/fpsyg.2018.01634

Riddle, M., McQuoid, D. R., Potter, G. G., Steffens, D. C., & Taylor, W. D. (2015). Disability but not social support predicts cognitive deterioration in late-life depression. *International Psychogeriatrics*, *27*(5), 707–714. https://doi.org/10.1017/S1041610214002543

Rijnhart, J. J. M., Lamp, S. J., Valente, M. J., MacKinnon, D. P., Twisk, J. W. R., & Heymans, M. W. (2021). Mediation analysis methods used in observational research: A scoping review and recommendations. *BMC Medical Research Methodology*, *21*(1), 226. https://doi.org/10.1186/s12874-021-01426-3

Rippon, D., Shepherd, J., Wakefield, S., Lee, A., & Pollet, T. V. (2022). The role of self-efficacy and self-esteem in mediating positive associations between functional social support and psychological wellbeing in people with a mental health diagnosis. *Journal of Mental Health*, *0*(0), 1–10. https://doi.org/10.1080/09638237.2022.2069695

Romans, S. E., Tyas, J., Cohen, M. M., & Silverstone, T. (2007). Gender differences in the symptoms of Major Depressive Disorder. *The Journal of Nervous and Mental Disease*, *195*(11), 905–911. https://doi.org/10.1097/NMD.0b013e3181594cb7

Rote, S., Chen, N.-W., & Markides, K. (2015). Trajectories of depressive symptoms in elderly Mexican Americans. *Journal of the American Geriatrics Society*, *63*(7), 1324–1330. https://doi.org/10.1111/jgs.13480

Rutter, E. C. (2019). *The association between social support availability and executive function in the Canadian Longitudinal Study on Aging* [Master's thesis, University of Waterloo]. UWSpace. http://hdl.handle.net/10012/14772

Sachdev, P. S., Blacker, D., Blazer, D. G., Ganguli, M., Jeste, D. V., Paulsen, J. S., & Petersen, R. C. (2014). Classifying neurocognitive disorders: The DSM-5 approach. *Nature Reviews Neurology*, *10*(11), 634–642. https://doi.org/10.1038/nrneurol.2014.181

Santini, Z. I., Koyanagi, A., Tyrovolas, S., Mason, C., & Haro, J. M. (2015). The association between social relationships and depression: A systematic review. *Journal of Affective Disorders*, *175*, 53–65. https://doi.org/10.1016/j.jad.2014.12.049

Schnittker, J. (2007). Look (closely) at all the lonely people: Age and the social psychology of social support. *Journal of Aging and Health*, *19*(4), 659–682. https://doi.org/10.1177/0898264307301178

Seeman, T. E., Lusignolo, T. M., Albert, M., & Berkman, L. (2001). Social relationships, social support, and patterns of cognitive aging in healthy, high-functioning older adults: MacArthur Studies of Successful Aging. *Health Psychology*, *20*(4), 243–255. https://doi.org/10.1037//0278-6133.20.4.243

Segal, D. L., Coolidge, F. L., Mincic, M. S., & O'Riley, A. (2005). Beliefs about mental illness and willingness to seek help: A cross-sectional study. *Aging & Mental Health*, *9*(4), 363–367. https://doi.org/10.1080/13607860500131047

Semkovska, M., Quinlivan, L., O'Grady, T., Johnson, R., Collins, A., O'Connor, J., Knittle, H., Ahern, E., & Gload, T. (2019). Cognitive function following a major depressive episode: A systematic review and meta-analysis. *The Lancet Psychiatry*, *6*(10), 851–861. https://doi.org/10.1016/S2215-0366(19)30291-3

Sherbourne, C. D., & Stewart, A. L. (1991). The MOS Social Support Survey. *Social Science & Medicine*, *32*(6), 705–714. https://doi.org/10.1016/0277-9536(91)90150-B

Sims, R. C., Levy, S.-A., Mwendwa, D. T., Callender, C. O., & Campbell, A. L. (2011). The influence of functional social support on executive functioning in middle-aged African Americans. *Aging, Neuropsychology and Cognition*, *18*(4), 414–431. https://doi.org/10.1080/13825585.2011.567325

Singh-Manoux, A., Kivimaki, M., Glymour, M. M., Elbaz, A., Berr, C., Ebmeier, K. P., Ferrie, J. E., & Dugravot, A. (2012). Timing of onset of cognitive decline: Results from Whitehall II Prospective Cohort Study. *BMJ*, *344*, d7622. https://doi.org/10.1136/bmj.d7622

Slavich, G. M., & Irwin, M. R. (2014). From stress to inflammation and Major Depressive Disorder: A social signal transduction theory of depression. *Psychological Bulletin*, *140*(3), 774–815. https://doi.org/10.1037/a0035302

Snyder, H. R. (2013). Major Depressive Disorder is associated with broad impairments on neuropsychological measures of executive function: A meta-analysis and review. *Psychological Bulletin*, *139*(1), 81. https://doi.org/10.1037/a0028727

Song, Y., Qian, L., Sui, J., Greiner, R., Li, X.-M., Greenshaw, A. J., Liu, Y. S., & Cao, B. (2023). Prediction of depression onset risk among middle-aged and elderly adults using machine learning and Canadian Longitudinal Study on Aging cohort. *Journal of Affective Disorders*, *339*, 52–57. https://doi.org/10.1016/j.jad.2023.06.031

Stafford, J., Dekhtyar, S., Welmer, A.-K., Vetrano, D. L., Grande, G., Laukka, E. J., Marseglia, A., Moulton, V., Mansfield, R., Liu, Y., Ning, K., Wolf-Ostermann, K., Brodaty, H., Samtani, S., Ikram, M. A., Melis, R., Rymaszewska, J., Szcześniak, D., Gessa, G. D., … Maddock, J. (2024). Social health and subsequent cognitive functioning in people aged 50 years and older: Examining the mediating roles of depressive symptoms and inflammatory biomarkers in two European longitudinal studies. *The Lancet Healthy Longevity*, *5*(5), e356–e369. https://doi.org/10.1016/S2666-7568(24)00046-1

Stafford, M., Antonucci, T. C., & Zaninotto, P. (2019). Joint trajectories of spousal social support and depressive symptoms in older age. *Journal of Aging and Health*, *31*(5), 760–782. https://doi.org/10.1177/0898264317747077

Sundermann, E., Katz, M., & Lipton, R. (2017). Sex differences in the relationship between depressive symptoms and risk of amnestic mild cognitive impairment. *The American Journal of Geriatric Psychiatry, 25*(1), 13–22. https://doi.org/10.1016/j.jagp.2016.08.022

Szymkowicz, S. M., Gerlach, A. R., Homiack, D., & Taylor, W. D. (2023). Biological factors influencing depression in later life: Role of aging processes and treatment implications. *Translational Psychiatry*, *13*(1), 1–16. https://doi.org/10.1038/s41398-023-02464-9

Takashima, R., Onishi, R., Saeki, K., & Hirano, M. (2020). The values and meanings of social activities for older urban men after retirement. *PLoS ONE*, *15*(11), e0242859. https://doi.org/10.1371/journal.pone.0242859

Teng, E. (1995). *The Mental Alternations Test (MAT)*. *9*(3), 287. https://doi.org/10.1080/13854049508400492

Troyer, A. K., Leach, L., & Strauss, E. (2006). Aging and response inhibition: Normative data for the Victoria Stroop Test. *Aging, Neuropsychology, and Cognition*, *13*(1), 20–35. https://doi.org/10.1080/138255890968187

Tuokko, H., Griffith, L. E., Simard, M., & Taler, V. (2017). Cognitive measures in the Canadian Longitudinal Study on Aging. *The Clinical Neuropsychologist*, *31*(1), 233–250. https://doi.org/10.1080/13854046.2016.1254279

Tuokko, H., Griffith, L. E., Simard, M., Taler, V., O'Connell, M. E., Voll, S., Kadlec, H., Wolfson, C., Kirkland, S., & Raina, P. (2020). The Canadian Longitudinal Study on Aging as a platform for exploring cognition in an aging population. *The Clinical Neuropsychologist*, *34*(1), 174–203. https://doi.org/10.1080/13854046.2018.1551575

Underwood, E. A., Davidson, H. P., Azam, A. B., & Tierney, M. C. (2019). Sex differences in depression as a risk factor for Alzheimer's Disease: A systematic review. *Innovation in Aging*, *3*(2), igz015. https://doi.org/10.1093/geroni/igz015

United Nations Department of Economic and Social Affairs. (2022). *World population prospects 2022: Summary of results*. United Nations. https://www.un.org/development/desa/pd/sites/www.un.org.development.desa.pd/files/wpp2022_summary_of_results.pdf

United Nations Department of Economic and Social Affairs. (2023). *World social report 2023: Leaving no one behind in an ageing world*. United Nations. https://doi.org/10.18356/9789210019682

van Ours, J. C. (2022). How retirement affects mental health, cognitive skills and, mortality; An overview of recent empirical evidence. *De Economist*, *170*(3), 375–400. https://doi.org/10.1007/s10645-022-09410-y

VanderWeele, T. J. (2016). Explanation in causal inference: Developments in mediation and interaction. *International Journal of Epidemiology*, *45*(6), 1904–1908. https://doi.org/10.1093/ije/dyw277

Verreckt, E., Grimm, E., Agrigoroaei, S., de Saint Hubert, M., Philippot, P., Cremer, G., & Schoevaerdts, D. (2022). Investigating the relationship between specific executive functions and functional decline among community-dwelling older adults: Results from a prospective pilot study. *BMC Geriatrics*, *22*(1), 976. https://doi.org/10.1186/s12877-022-03559-6

Vetter, J. S., Spiller, T. R., Cathomas, F., Robinaugh, D., Brühl, A., Boeker, H., Seifritz, E., & Kleim, B. (2021). Sex differences in depressive symptoms and their networks in a treatment-seeking population – a cross-sectional study. *Journal of Affective Disorders*, *278*, 357–364. https://doi.org/10.1016/j.jad.2020.08.074

Vila, J. (2021). Social support and longevity: Meta-analysis-based evidence and psychobiological mechanisms. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.717164

Vo, T. T., & Phu-Duyen, T. T. (2023). Mental health around retirement: Evidence of Ashenfelter's dip. *Global Health Research and Policy*, *8*(1), 35. https://doi.org/10.1186/s41256-023-00320-3

Wang, Q., Zan, C., Jiang, F., Shimpuku, Y., & Chen, S. (2022). Association between loneliness and its components and cognitive function among older Chinese adults living in nursing homes: A mediation of depressive symptoms, anxiety symptoms, and sleep disturbances. *BMC Geriatrics*, *22*(1), 959. https://doi.org/10.1186/s12877-022-03661-9

Wang, Y., Li, J., Fu, P., Jing, Z., Zhao, D., & Zhou, C. (2022). Social support and subsequent cognitive frailty during a 1-year follow-up of older people: The mediating role of psychological distress. *BMC Geriatrics*, *22*(1), 162. https://doi.org/10.1186/s12877-022-02839-5

West, R. L. (1996). An application of prefrontal cortex function theory to cognitive aging. *Psychological Bulletin*, *120*(2), 272–292. https://doi.org/10.1037/0033-2909.120.2.272

Weyers, S., Dragano, N., Möbus, S., Beck, E.-M., Stang, A., Möhlenkamp, S., Jöckel, K. H., Erbel, R., & Siegrist, J. (2008). Low socio-economic position is associated with poor social

networks and social support: Results from the Heinz Nixdorf Recall Study. *International Journal for Equity in Health*, *7*(1), 13. https://doi.org/10.1186/1475-9276-7-13

World Bank Open Data. (n.d.). World bank open data. Retrieved May 2, 2024, from https://data.worldbank.org

World Health Organization. (2021). *Comprehensive mental health action plan 2013–2030*. https://iris.who.int/bitstream/handle/10665/345301/9789240031029-eng.pdf?sequence=1

Xue, B., Cadar, D., Fleischmann, M., Stansfeld, S., Carr, E., Kivimäki, M., McMunn, A., & Head, J. (2018). Effect of retirement on cognitive function: The Whitehall II Cohort Study. *European Journal of Epidemiology*, *33*(10), 989–1001. https://doi.org/10.1007/s10654-017-0347-7

Yang, C. C., Totzek, J. F., Lepage, M., & Lavigne, K. M. (2023). Sex differences in cognition and structural covariance-based morphometric connectivity: Evidence from 28,000+ UK Biobank participants. *Cerebral Cortex*, *33*(19), 10341–10354. https://doi.org/10.1093/cercor/bhad286

Yen, F.-S., Wang, S.-I., Lin, S.-Y., Chao, Y.-H., & Wei, J. C.-C. (2022). The impact of heavy alcohol consumption on cognitive impairment in young old and middle old persons. *Journal of Translational Medicine*, *20*(1), 155. https://doi.org/10.1186/s12967-022-03353-3

Yeretzian, S. T., Sahakyan, Y., Kozloff, N., & Abrahamyan, L. (2023). Evaluating sex-differences in the prevalence and associated factors of mood disorders in Canada. *Journal of Affective Disorders*, *333*, 72–78. https://doi.org/10.1016/j.jad.2023.04.027

Yoo, S. S., Tyas, S. L., Maxwell, C. J., & Oremus, M. (2023). The association between functional social support and memory in middle-aged and older adults: A prospective analysis of the Canadian Longitudinal Study on Aging's Comprehensive cohort. *Archives of Gerontology and Geriatrics*, *114*, 105076. https://doi.org/10.1016/j.archger.2023.105076

Yoshida, K., Glynn, R. J., Choi, H. K., Everett, B. M., Li, Y., MacFadyen, J. G., Ridker, P. M., & Solomon, D. H. (2023). Canakinumab's effect against subsequent gout flares and high-sensitivity C-Reactive protein levels: A causal mediation analysis. *Arthritis Care & Research*, *75*(4), 817–824. https://doi.org/10.1002/acr.24832

Yzerbyt, V., Muller, D., Batailler, C., & Judd, C. M. (2018). New recommendations for testing indirect effects in mediational models: The need to report and test component paths. *Journal of Personality and Social Psychology*, *115*(6), 929–943. https://doi.org/10.1037/pspa0000132

Zanto, T. P., & Gazzaley, A. (2019). Chapter 20—Aging of the frontal lobe. In M. D'Esposito & J. H. Grafman (Eds.), *Handbook of clinical neurology* (Vol. 163, pp. 369–389). Elsevier. https://doi.org/10.1016/B978-0-12-804281-6.00020-3

Zenebe, Y., Akele, B., W/Selassie, M., & Necho, M. (2021). Prevalence and determinants of depression among old age: A systematic review and meta-analysis. *Annals of General Psychiatry*, *20*, 55. https://doi.org/10.1186/s12991-021-00375-x

Zhang, R., Shen, L., Miles, T., Shen, Y., Cordero, J., Qi, Y., Liang, L., & Li, C. (2020). Association of low to moderate alcohol drinking with cognitive functions from middle to older age among US adults. *JAMA Network Open*, *3*(6), e207922. https://doi.org/10.1001/jamanetworkopen.2020.7922

Zhao, D., Hu, C., Chen, J., Dong, B., Ren, Q., Yu, D., Zhao, Y., Li, J., Huang, Y., & Sun, Y. (2018). Risk factors of geriatric depression in rural China based on a generalized estimating equation. *International Psychogeriatrics*, *30*(10), 1489–1497. https://doi.org/10.1017/S1041610218000030

Zhou, S., Gao, L., Liu, F., Tian, W., Jin, Y., & Zheng, Z.-J. (2021). Socioeconomic status and depressive symptoms in older people with the mediation role of social support: A population-based longitudinal study. *International Journal of Methods in Psychiatric Research*, *30*(4), e1894. https://doi.org/10.1002/mpr.1894

Zunzunegui, M.-V., Alvarado, B. E., Del Ser, T., & Otero, A. (2003). Social networks, social integration, and social engagement determine cognitive decline in community-dwelling Spanish older adults. *The Journals of Gerontology: Series B*, *58*(2), S93–S100.

Appendices

Appendix A Supplemental Figure

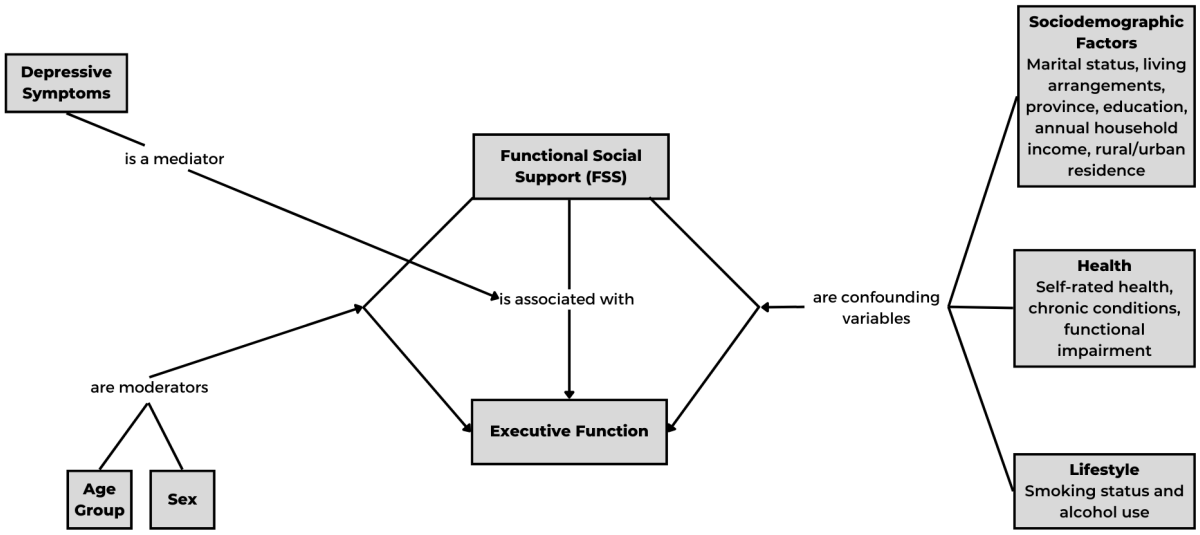

Figure A1. Conceptual Diagram of the Association Between Functional Social Support and Executive Function with Potential Mediating, Moderating and Confounding Variables

Appendix B Social Support Survey Instrument

The 19 items included in the MOS-SSS are listed below (Sherbourne & Stewart, 1991). The items are responses to the following question: "How often is each of the following kinds of support available to you if you need it?". Possible responses for each item were none of the time (1), a little of the time (2), some of the time (3), most of the time (4), and all of the time (5). The MOS-SSS measures four subtypes of FSS: emotional/informational support, affectionate support, tangible support, and positive social interactions. Emotional/informational support is measured by items 2, 3, 7, 8, 12, 15, 16, and 18 on the MOS-SSS. Tangible support is measured by items 1, 4, 11, and 14. Affectionate support is measured by items 5, 9, and 19 on the instrument. Positive social interactions is measured by items 6, 10, and 17. There is an additional item on the MOS-SSS (item 13) that is not included in any of the four subscales. Details regarding how the FSS variable was created using the MOS-SSS can be found in Appendix C.

Items:

1. Someone to help if you were confined to bed.
2. Someone you can count on to listen to you when you need to talk.
3. Someone to give you advice about a crisis.
4. Someone to take you to the doctor if needed.
5. Someone who shows you love and affection.
6. Someone to have a good time with.
7. Someone to give you information in order to help you.
8. Someone to confide in or talk to about yourself or your problems.
9. Someone who hugs you.
10. Someone to get together with for relaxation.
11. Someone to prepare your meals if you were unable to do it yourself.
12. Someone whose advice you really want.
13. Someone to do things with to help you get your mind off things.
14. Someone to help with daily chores if you were sick.
15. Someone to share your most private worries and fears with.
16. Someone to turn to for suggestions about how to deal with a personal problem.
17. Someone to do something enjoyable with.
18. Someone who understands your problems.
19. Someone to love you and make you feel wanted.

Appendix C Derivation of the Overall Functional Social Support Variable Using Mean Imputation

C.1 Creating a Variable Where Only One Item in a Subscale was Allowed to be Missing

Mean imputation was done for each subtype, as well as for the one additional item from the MOS-SSS that did not belong to any subtype (see Sections C.4 and C.5 to see how mean imputation was done for the latter variable). When performing mean imputation within each subtype, only one item from each subscale was allowed to be missing. To help explain imputing within each subtype, the positive social interactions subscale will be used as an example. The three items in this subscale include: 1) Someone to have a good time with (SSA_GOODT), 2) someone to get together with for relaxation (SSA_RELAX), and 3) someone to do something enjoyable with (SSA_ENJOY). The first step in doing mean imputation within a subtype was to create a variable where a maximum of one item was allowed to be missing. For the positive social interactions subscale, one of the three items was allowed to be missing at any one time, and the item that was allowed to be missing was specified as its own category. The variable for positive social interactions was named POS_IMP1 (refer to the code found below for how this variable was derived). This variable was created to help with the next step, which was to calculate the mean of the remaining items in the subscale.

```
DATA LAURA.CLSADATA;
SET LAURA.CLSADATA;
POS_IMP1=.;
IF SSA_RELAX NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . THEN POS_IMP1= 1;
IF SSA_RELAX EQ . AND SSA_GOODT NE . AND SSA_ENJOY NE . THEN POS_IMP1= 2;
IF SSA_GOODT EQ . AND SSA_RELAX NE . AND SSA_ENJOY NE . THEN POS_IMP1= 3;
IF SSA_ENJOY EQ . AND SSA_RELAX NE . AND SSA_GOODT NE . THEN POS_IMP1= 4;
RUN;
```

C.2 Creating a Variable that is Equal to the Mean of the Remaining Items in a Subscale

When calculating the value of the second variable, a maximum of one item was allowed to be missing from the subscale. For the positive social interactions subscale, there were four possible outcomes when calculating the mean for the second variable: no items were missing, item 2 was missing, item 1 was missing, or item 3 was missing. Each of these outcomes corresponded to a different level of POS_IMP1, and this second variable, POS_IMP2, was equal to the mean of the remaining items in the subscale (see code below). For example, if item 2 was missing, then POS_IMP2 was equal to the mean of items 1 and 3. The goal behind creating this second variable was to impute the value of the missing item from the subscale using the mean of the remaining items.

```
DATA LAURA.CLSADATA;
SET LAURA.CLSADATA;
POS_IMP2=.;
IF POS_IMP1= 1 THEN POS_IMP2=MEAN(OF SSA_RELAX SSA_GOODT SSA_ENJOY);
IF POS_IMP1= 2 THEN POS_IMP2=MEAN(OF SSA_GOODT SSA_ENJOY);
IF POS_IMP1= 3 THEN POS_IMP2=MEAN(OF SSA_RELAX SSA_ENJOY);
IF POS_IMP1= 4 THEN POS_IMP2=MEAN(OF SSA_RELAX SSA_GOODT);
RUN;
```

C.3 Calculating the Value of a Whole Subscale

A third variable was then created to calculate the value of each whole subscale. To do so, the mean of all of the items in the subscale was calculated. In the case that an item from the subscale was missing, then the second variable was used in its place. For positive social interactions, the third variable was named POS_IMPUTE (see below for the coding of this variable). To derive the value of POS_IMPUTE, a maximum of one item was allowed to be missing from the subscale. For example, if item 2 was missing from the positive social interactions subscale, then POS_IMPUTE was equal to the mean of item 1, item 3, and POS_IMP2. The entire process outlined for positive social interactions was repeated for the emotional/information subscale, tangible social support subscale, and affectionate support subscale.

```
DATA LAURA.CLSADATA;
SET LAURA.CLSADATA;
POS_IMPUTE=.;
IF POS_IMP1= 1 THEN POS_IMPUTE=MEAN(OF SSA_RELAX SSA_GOODT SSA_ENJOY);
IF POS_IMP1= 2 THEN POS_IMPUTE=MEAN(OF SSA_GOODT SSA_ENJOY POS_IMP2);
IF POS_IMP1= 3 THEN POS_IMPUTE=MEAN(OF SSA_RELAX SSA_ENJOY POS_IMP2);
IF POS_IMP1= 4 THEN POS_IMPUTE=MEAN(OF SSA_RELAX SSA_GOODT POS_IMP2);
RUN;
```

C.4 Code for Creating a Variable Where a Maximum of One Item was Allowed to be Missing from the Medical Outcomes Survey – Social Support Survey

The value for the additional MOS-SSS item "Someone to do things with to help you get your mind off things," was imputed in a similar way to imputing within each subtype. The additional item (SSA_MINDOFF) does not belong to a subscale. Thus, to impute the value of the additional item, the remaining 18 items from the MOS-SSS were used when performing mean imputation. The first step in imputing the additional item was creating a variable (FSS_MISS1) where a maximum of one item from the MOS-SSS was allowed to be missing (see the code below). More specifically, only 1 of the 19 items was allowed to be missing at any one time, and the item that was permitted to be missing had its own category in FSS_MISS1.

```
DATA LAURA.CLSADATA;
SET LAURA.CLSADATA;
FSS_MISS1 =.;
IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED
NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX
NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . ANDSSA_ADVCE NE . AND
SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND
SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF
NE . THEN FSS_MISS1 = 1;

IF SSA_TYTDR EQ . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED
NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX
NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND
SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND
SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF
NE . THEN FSS_MISS1 = 2;

IF SSA_TYTDR NE . AND SSA_MEALS EQ . AND SSA_CHORES NE . AND SSA_CONFBED
NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX
NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND
```

SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 3;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES EQ . AND SSA_CONFBED NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 4;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED EQ . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 5;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED NE . AND SSA_SHLOV EQ . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 6;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED NE . AND SSA_SHLOV NE . AND SSA_HUGS EQ . AND SSA_LOVU NE . AND SSA_RELAX NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 7;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU EQ . AND SSA_RELAX NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 8;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX EQ . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 9;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX NE . AND SSA_GOODT EQ . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 10;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX NE . AND SSA_GOODT NE . AND SSA_ENJOY EQ . AND SSA_ADVCE NE . AND SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 11;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE EQ . AND SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 12;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND SSA_NDTLK EQ . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 13;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND SSA_NDTLK NE . AND SSA_CRISIS EQ . AND SSA_SUGG NE . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 14;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG EQ . AND SSA_INFO NE . AND SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF NE . THEN FSS_MISS1 = 15;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX

```
NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND
SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO EQ . AND
SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF
NE . THEN FSS_MISS1 = 16;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED
NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX
NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND
SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND
SSA_CONFID EQ . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF
NE . THEN FSS_MISS1 = 17;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED
NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX
NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND
SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND
SSA_CONFID NE . AND SSA_PROBLM EQ . AND SSA_SHFEAR NE . AND SSA_MINDOFF
NE . THEN FSS_MISS1 = 18;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED
NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX
NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND
SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND
SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR EQ . AND SSA_MINDOFF
NE . THEN FSS_MISS1 = 19;

IF SSA_TYTDR NE . AND SSA_MEALS NE . AND SSA_CHORES NE . AND SSA_CONFBED
NE . AND SSA_SHLOV NE . AND SSA_HUGS NE . AND SSA_LOVU NE . AND SSA_RELAX
NE . AND SSA_GOODT NE . AND SSA_ENJOY NE . AND SSA_ADVCE NE . AND
SSA_NDTLK NE . AND SSA_CRISIS NE . AND SSA_SUGG NE . AND SSA_INFO NE . AND
SSA_CONFID NE . AND SSA_PROBLM NE . AND SSA_SHFEAR NE . AND SSA_MINDOFF
EQ . THEN FSS_MISS1 = 20;
RUN;
```

C.5 Code for Creating the Imputed Variable for the Additional Item on the Medical Outcomes Survey – Social Support Survey

The next step in imputing the value of the additional item involved creating a second variable named MINDOFF_IMPUTE (refer to the code below for how this variable was created). If no items were missing from the MOS-SSS, then MINDOFF_IMPUTE was equal to the mean of all 19 items. In the case that one item was missing from the scale, then MINDOFF_IMPUTE was equal to the mean of the 18 remaining items in the overall scale. An example of the calculation that was performed was if

item 2 (SSA_RELAX) from the positive social interactions subscale was missing, then MINDOFF_IMPUTE was equal to the mean of the remaining 18 items from the MOS-SSS.

```
DATA LAURA.CLSADATA;
SET LAURA.CLSADATA;
MINDOFF_IMPUTE = .;
IF FSS_MISS1 = 1 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV
SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK
SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID SSA_PROBLM SSA_SHFEAR
SSA_MINDOFF);

IF FSS_MISS1 = 2 THEN MINDOFF_IMPUTE = MEAN (OF SSA_MEALS SSA_CHORES
SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT
SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID
SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 3 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_CHORES
SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT
SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID
SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 4 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT
SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID
SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 5 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT SSA_ENJOY
SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID SSA_PROBLM
SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 6 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT
SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID
SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 7 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_LOVU SSA_RELAX SSA_GOODT
SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID
SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 8 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_RELAX SSA_GOODT
```

SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 9 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 10 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 11 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS SSA_CHORES SSA_CONFBED SSA_SHLOV
SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 12 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS SSA_CHORES SSA_CONFBED SSA_SHLOV
SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT SSA_ENJOY SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 13 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 14 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_SUGG SSA_INFO SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 15 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_INFO SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 16 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 17 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX

```
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 18 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 19 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_MINDOFF);

IF FSS_MISS1 = 20 THEN MINDOFF_IMPUTE = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR);
RUN;
```

C.6 Code for Creating the Overall Functional Social Support Variable

To create the overall FSS score, a variable named FSS_OVERALL_IMPUTE was created (refer below for the code). When creating the overall FSS variable, up to one item from the overall survey was allowed to be missing. The missing item was replaced with the imputed variable for its respective subscale. Thus, the overall FSS variable was calculated as the mean of the imputed variable and the remaining 18 items. For example, if item 2 (SSA_RELAX) from the positive social interactions subscale was missing, the positive social interactions imputed variable (POS_IMPUTE) would be used in its place.

As there was an additional item that did not belong to any subscale, the value of the additional item (SSA_MINDOFF) had to be imputed using all the items from the MOS-SSS. Thus, when the missing item was the additional item that did not belong to any subscale, the imputed variable for the additional item (MINDOFF_IMPUTE) was used in its place. The overall FSS score was then equal to the mean of the imputed variable and the 18 remaining items.

```
DATA LAURA.CLSADATA;
SET LAURA.CLSADATA;
FSS_OVERALL_IMP = .;
IF FSS_MISS1 = 1 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 2 THEN FSS_OVERALL_IMP = MEAN (OF TAN_IMPUTE SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 3 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR TAN_IMPUTE
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 4 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
TAN_IMPUTE SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 5 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES TAN_IMPUTE SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 6 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED AFF_IMPUTE SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 7 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV AFF_IMPUTE SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 8 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS AFF_IMPUTE SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 9 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU POS_IMPUTE
```

```
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 10 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
POS_IMPUTE SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 11 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT POS_IMPUTE SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 12 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY EMO_IMPUTE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 13 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV
SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT SSA_ENJOY SSA_ADVCE EMO_IMPUTE
SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID SSA_PROBLM SSA_SHFEAR
SSA_MINDOFF);

IF FSS_MISS1 = 14 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK EMO_IMPUTESSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 15 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS EMO_IMPUTE SSA_INFO
SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 16 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG
EMO_IMPUTE SSA_CONFID SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 17 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
EMO_IMPUTE SSA_PROBLM SSA_SHFEAR SSA_MINDOFF);
```

```
IF FSS_MISS1 = 18 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID EMO_IMPUTE SSA_SHFEAR SSA_MINDOFF);

IF FSS_MISS1 = 19 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV SSA_HUGS SSA_LOVU SSA_RELAX
SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK SSA_CRISIS SSA_SUGG SSA_INFO
SSA_CONFID SSA_PROBLM EMO_IMPUTE SSA_MINDOFF);

IF FSS_MISS1 = 20 THEN FSS_OVERALL_IMP = MEAN (OF SSA_TYTDR SSA_MEALS
SSA_CHORES SSA_CONFBED SSA_SHLOV
SSA_HUGS SSA_LOVU SSA_RELAX SSA_GOODT SSA_ENJOY SSA_ADVCE SSA_NDTLK
SSA_CRISIS SSA_SUGG SSA_INFO SSA_CONFID SSA_PROBLM SSA_SHFEAR
MINDOFF_IMPUTE);
RUN;
```

Appendix D Description of Weighted Data and Weighted Descriptive Analyses Results

The CLSA provides two types of sampling weights: inflation weights and analytic weights. The inflation weights were created to account for issues with the sampling design, such as sample misrepresentation resulting from unequal sampling probabilities, frame-coverage error, and nonresponse (Canadian Longitudinal Study on Aging, 2023). When summed, the inflation weights are equal to the number of Canadians who were eligible to participate in the CLSA. The analytic weights are proportional to the inflation weights and for the Comprehensive cohort specifically, are rescaled to be equal to the sample size in the DCS part of each province and have a mean value of one within this specified area.

Only the inflation weights were used for weighted descriptive analyses, as inflation weights are recommended for descriptive analysis whereas the analytic weights are recommended for multivariable analysis (Canadian Longitudinal Study on Aging, 2023). The results of weighted descriptive analyses can be found below in Table D1. Conversely, when performing multivariable analyses, the analytic weights were not used. Only unweighted data was used in multivariable analyses because weighted data cannot be used in PROCESS, the research questions aim to determine associations and not prevalence estimates, and when using CLSA data to examine the association between SSA and cognition, the use of weights does not always appear to be strictly necessary. It has been shown that when modelling the association between SSA and cognitive function with both unweighted and weighted data, the regression coefficients generated were similar for both models (Oremus et al., 2022).

Table D1. Participant Characteristics at Baseline by Depressive Symptoms and Executive Function at Follow-up, Weighted Analytic Sample in the Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 1,940,863)

Characteristics (T0)	Total	Mediator (T1)		Outcome (T1)
		Depressive symptoms[b]		Executive function[c]
	%	$\bar{x}$ *(SE)*	*MD (IQR)*	$\bar{x}$ *(SE)*
Low FSS[a]				
Low	5.33	8.95 (0.33)***	7.83 (7.98)	-0.73 (0.16)***
Other	94.67	4.90 (0.07)	3.53 (5.39)	0.45 (0.04)
Sociodemographic factors				
Age group				
45–54	43.12	5.15 (0.13)	3.63 (5.31)	1.30 (0.07)***
55–64	32.05	5.08 (0.10)	3.58 (5.52)	0.55 (0.07)
65–74	16.83	4.90 (0.15)	3.55 (5.64)	-0.95 (0.08)
≥ 75	8.01	5.51 (0.19)	3.98 (5.94)	-2.38 (0.13)
Sex				
Female	51.82	5.67 (0.10)***	3.87 (6.22)	0.26 (0.06)***
Male	48.18	4.52 (0.10)	3.38 (4.66)	0.53 (0.07)
Marital status				
Single/never married	7.87	6.87 (0.30)***	5.19 (7.36)	0.11 (0.20)***
Married/common-law	77.46	4.67 (0.07)	3.43 (4.69)	0.59 (0.05)
Widowed	4.87	6.28 (0.29)	4.78 (5.63)	-1.85 (0.19)
Divorced/separated	9.80	6.63 (0.37)	4.78 (7.12)	0.15 (0.12)
Living arrangements				
Lives alone	13.92	6.47 (0.19)***	4.81 (6.70)	-0.53 (0.10)***
Lives with others	86.08	4.90 (0.08)	3.53 (5.41)	0.53 (0.05)
Province				
Alberta	10.59	4.85 (0.19)*	3.62 (5.47)	0.43 (0.10)*
British Columbia	31.40	4.99 (0.16)	3.54 (4.83)	0.74 (0.08)
Manitoba	7.29	5.24 (0.18)	3.64 (5.74)	0.26 (0.10)
Newfoundland and Labrador	2.56	5.06 (0.22)	3.38 (5.59)	-0.49 (0.11)
Nova Scotia	3.84	5.46 (0.15)	3.93 (5.62)	-0.27 (0.10)
Ontario	19.36	5.17 (0.11)	3.63 (5.55)	0.16 (0.07)
Quebec	24.96	5.26 (0.16)	3.74 (5.54)	0.32 (0.12)
Education				
Less than secondary school	12.51	5.94 (0.38)***	4.50 (6.29)	-1.58 (0.23)***
Secondary school graduate	10.84	5.25 (0.18)	3.62 (5.54)	-0.26 (0.11)
Some post-secondary education	10.07	5.35 (0.19)	3.85 (6.08)	0.39 (0.12)
Post-secondary degree/diploma	66.57	4.90 (0.07)	3.52 (5.44)	0.86 (0.04)
Total household income				
< $20,000	4.35	9.33 (0.63)***	7.93 (8.38)	-1.49 (0.33)***
≥ $20,000 and < $50,000	17.50	6.12 (0.17)	4.78 (6.04)	-0.98 (0.10)
≥ $50,000 and < $100,000	31.61	5.05 (0.11)	3.68 (5.35)	0.31 (0.07)

Characteristics (T0)	Total	Mediator (T1) Depressive symptoms[b]		Outcome (T1) Executive function[c]
	%	$\bar{x}$ *(SE)*	*MD (IQR)*	$\bar{x}$ *(SE)*
≥ $100,000 and < $150,000	21.90	4.34 (0.12)	2.94 (4.48)	1.02 (0.08)
≥ $150,000	19.58	4.06 (0.12)	2.64 (4.84)	1.67 (0.07)
Missing	5.06	5.86 (0.36)	3.80 (5.73)	-0.51 (0.20)
Rural/urban residence				
Rural	5.11	4.86 (0.23)*	3.36 (4.74)	0.34 (0.12)
Urban	94.89	5.13 (0.07)	3.65 (5.44)	0.39 (0.05)
Health factors				
Perceived health				
Poor	1.09	11.22 (0.95)***	9.86 (9.54)	-1.19 (0.48)***
Fair	7.03	8.57 (0.30)	6.97 (7.10)	-0.86 (0.23)
Good	29.25	6.08 (0.15)	4.71 (5.57)	0.08 (0.07)
Very good	42.24	4.57 (0.09)	3.42 (4.58)	0.58 (0.06)
Excellent	20.39	3.34 (0.13)	1.91 (4.03)	0.94 (0.09)
Chronic conditions				
Reported none	7.99	3.30 (0.18)***	1.94 (3.75)	0.86 (0.14)***
Reported at least one	92.01	5.27 (0.08)	3.72 (5.40)	0.34 (0.05)
Functional Impairment				
Yes	6.17	7.83 (0.36)***	5.89 (7.51)	-0.98 (0.18)***
No	93.83	4.94 (0.07)	3.55 (5.42)	0.48 (0.04)
Lifestyle factors				
Smoking status				
Never	46.19	4.86 (0.09)***	3.46 (5.47)	0.65 (0.05)***
Former	43.51	5.07 (0.12)	3.65 (5.39)	0.20 (0.07)
Current	10.31	6.45 (0.28)	4.63 (6.79)	-0.01 (0.14)
Alcohol use				
No	12.46	6.05 (0.25)	4.17 (6.28)	-0.20 (0.12)***
Occasional	11.78	5.81 (0.19)	4.55 (6.10)	-0.34 (0.13)
Regular	73.87	4.85 (0.08)	3.50 (5.38)	0.62 (0.05)
Missing	1.89	4.94 (0.42)	2.98 (5.67)	-0.60 (0.33)

Note. T-tests and ANOVA tests were used. The median and interquartile range were calculated for depressive symptoms because the distribution of the data is skewed.
FSS = functional social support; IQR = interquartile range; MD = median; SD = standard deviation; T0 = baseline; T1 = follow-up; $\bar{x}$ = mean.
[a]Low FSS = ≤ 3 on the Medical Outcomes Survey-Social Support Survey. Scores range from 1–5.
[b]Depressive symptoms were measured using the Centre for Epidemiological Studies Short Depression Scale. Score range from 0–30.
[c]An executive function score was created by standardizing and then combining the results from five different cognitive tests evaluating executive function.
$^{*}p < .05$, $^{**}p < .01$, $^{***}p < .001$

Appendix E Additional Results from Testing Interactions

When Model 21 included sex as the moderator at Path I and age group as the moderator at Path II, both interaction terms were significant. Furthermore, this version of Model 21 was the only model where all included interaction terms were statistically significant, and thus it was chosen as the final moderated mediation model. To help confirm that Model 21 in the PROCESS macro was the most suitable to use as the final model, various fully adjusted moderated mediation models were estimated. These models included the mediation being moderated only at Path I, only at Path II, or at both paths by sex and/or age group.

When a moderated mediation model was estimated where only Path I was moderated, the only interaction term that was significant was the two-way interaction between low FSS and sex (Table E1). The low FSS*sex interaction term was significant in Model 7 and in Model 9. In Model 9, of the three interaction terms, the only interaction that was statistically significant was the low FSS*sex interaction term. These results demonstrate that at Path I, it is only the low FSS*sex interaction term that was significant.

Table E1. Fully Adjusted Moderated Mediation Models with Moderation of the Effect of Low Functional Social Support on Depressive Symptoms (Path I)

PROCESS Model[a]	Interaction Term(s)	p-value
Model 11	Low FSS*sex*age group	0.7134
Model 9	Low FSS*sex Low FSS*age group	Low FSS*sex → 0.0425* Low FSS*age group → 0.7084 Both[b] → 0.2419
Model 7	Low FSS*sex	0.0432*
Model 7	Low FSS*age group	0.7146

Note. Model 11 includes a three-way interaction term at Path I. Model 9 includes two separate two-way interaction terms at Path I. Model 7 includes a two-way interaction term at Path I. When sex or age group was not included as a moderator, it was adjusted for as a covariate in the model.
FSS = functional social support; Low FSS*age group = interaction term between low FSS and age group; low FSS*sex = interaction term between low FSS and sex; low FSS*sex*age group = interaction term between low FSS, sex, and age group.
[a]The PROCESS model numbers are from Hayes (2022).
[b]Joint test of interaction between FSS and sex and FSS and age group
*p < .05, **p < .01, ***p < .001

When estimating moderated mediation models with moderation on Path II, the interaction between depressive symptoms and age group was found to be significant in Model 14 and Model 16 (Table E2). In Model 16, of the three interaction terms included, only the depressive symptoms*age group interaction term was significant. From these results, it is evident that it is solely the depressive symptoms*age group interaction term that was significant at Path II.

Table E2. Fully Adjusted Moderated Mediation Models with Moderation of the Effect of Depressive Symptoms on Executive Function (Path II)

PROCESS Model[a]	Interaction Term(s)	p-value
Model 18	Depressive symptoms*sex*age group	0.5137
Model 16	Depressive symptoms*sex Depressive symptoms*age group	Depressive symptoms*sex → 0.8245 Depressive symptoms*age group → 0.0327* Both[b] → 0.0661
Model 14	Depressive symptoms*sex	0.8189
Model 14	Depressive symptoms*age group	0.0327*

Note. Model 18 includes a three-way interaction term at Path II. Model 16 includes two separate two-way interaction terms at Path II. Model 14 includes a two-way interaction at Path II. Baseline FSS was adjusted for as a covariate. When sex or age group was not included as a moderator, it was adjusted for as a covariate in the model.
depressive symptoms*age group = interaction term between depressive symptoms and age group; depressive symptoms*sex = interaction term between depressive symptoms and sex; depressive symptoms*sex*age group = interaction term between depressive symptoms, sex, and age group.
[a]The PROCESS model numbers are from Hayes (2022).
[b]Joint test of interaction between depressive symptoms and sex and depressive symptoms and age group.
*p < .05, **p < .01, ***p < .001

When running models with different variations of moderated mediation at both paths, the two interaction terms that were consistently significant were the low FSS*sex interaction term and the depressive symptoms*age group interaction term (Table E3). In the PROCESS macro, Model 21 allows the user to have a moderator at Path I and a second, different moderator at Path II and thus, this was the model most suitable for use in the main analyses.

Table E3. Fully Adjusted Moderated Mediation Models with Moderation of the Effect of Low Functional Social Support on Depressive Symptoms (Path I) and the Effect of Depressive Symptoms on Executive Function (Path II)

PROCESS Model	Interaction Term(s)	p-value
Model 21	Low FSS*sex and depressive symptoms*age group	Low FSS*sex →0.0432* Depressive symptoms*age group →0.0327*
Model 21	Low FSS*age group and depressive symptoms*sex	Low FSS*age group → 0.7146 Depressive symptoms*sex →0.8189
Model 58	Low FSS*sex and depressive symptoms*sex	Low FSS*sex → 0.0432* Depressive symptoms*sex → 0.8189
Model 58	Low FSS*age group and depressive symptoms*age group	Low FSS*age group → 0.7146 Depressive symptoms*age Group →0.0327*
Model 60	Low FSS*sex, Low FSS*age group, and depressive symptoms*sex	Low FSS*sex → 0.0425* Low FSS*age group → 0.7084 Both[b] → 0.2419 Depressive symptoms*sex → 0.8189
Model 60	Low FSS*sex, Low FSS*age group, and depressive symptoms*age group	Low FSS*sex → 0.0425* Low FSS*age group → 0.7084 Both[b] → 0.2419 Depressive symptoms*age group → 0.0327*
Model 64	Low FSS*sex, depressive symptoms*sex, and depressive symptoms*age group	Low FSS*sex → 0.0432* Depressive symptoms*sex → 0.8245 Depressive symptoms*age group → 0.0327* Both[c] → 0.0661
Model 64	Low FSS*age group, depressive symptoms*sex, and depressive symptoms*age group	Low FSS*age group → 0.7146 Depressive symptoms*sex → 0.8245 Depressive symptoms*age group → 0.0327* Both[c] → 0.0661
Model 68	Low FSS*sex*age group and depressive symptoms*sex	Low FSS*sex*age group →0.7134 Depressive symptoms*sex → 0.8189
Model 68	Low FSS*sex*age group and depressive symptoms*age group	Low FSS*sex*age group → 0.7134 Depressive symptoms*age group →0.0327*
Model 70	Low FSS*sex and depressive symptoms*sex*age group	Low FSS*sex → 0.0432* Depressive symptoms*sex*age group → 0.5137

PROCESS Model	Interaction Term(s)	p-value
Model 70	Low FSS*age group and depressive symptoms*sex*age group	Low FSS*age group → 0.7146 Depressive symptoms*sex*age group → 0.5137
Model 72	Low FSS*sex*age group and depressive symptoms*sex*age group	Low FSS*sex*age group →0.7134 Depressive symptoms*sex*age group → 0.5137
Model 75	Low FSS*sex, Low FSS*age group, depressive symptoms*sex, and depressive symptoms*age group	Low FSS*sex → 0.0425* Low FSS*age group → 0.7084 Both[b] → 0.2419 Depressive symptoms*sex → 0.8245 Depressive symptoms*age group → 0.0327* Both[c] → 0.0661

Note. Model 21 includes a two-way interaction term at Path I and a two-way interaction term with a different moderator at Path II. Model 58 includes two-way interaction terms at Path I and Path II with the same moderator. Model 60 includes two-way interaction terms at Path I and Path II with the same moderator and a two-way interaction term with a different moderator at Path I. Model 64 includes two-way interaction terms at Path I and Path II with the same moderator and a two-way interaction term with a different moderator at Path II. Model 68 includes a three-way interaction term at Path I and a two-way interaction at Path II. Model 70 includes a three-way interaction term at Path II and a two-way interaction at Path I. Model 72 includes three-way interaction terms at Path I and Path II. Model 75 includes two-way interaction terms by the same moderator at Path I and Path II, and additional two-way interaction terms with a different moderator at Path I and Path II. Baseline FSS was adjusted for as a covariate at Path II. When sex or age group was not included as a moderator, it was adjusted for as a covariate in the model. The models were fully adjusted for sociodemographic, health, and lifestyle factors, as well as baseline depressive symptoms and executive function. depressive symptoms*age group = interaction term between depressive symptoms and age group; depressive symptoms*sex = interaction term between depressive symptoms and sex; depressive symptoms*sex*age group = interaction term between depressive symptoms, sex, and age group; FSS = functional social support; low FSS*age group = interaction term between low FSS and age group; low FSS*sex = interaction term between low FSS and sex; low FSS*sex*age group = interaction term between low FSS, sex, and age group.

[a]The PROCESS model numbers are from Hayes (2022).

[b]Joint test of interaction between FSS and sex and FSS and age group.

[c]Joint test of interaction between depressive symptoms and sex and depressive symptoms and age group.

*p < .05, **p < .01, ***p < .001

Appendix F Post Hoc Analyses Results

In descriptive analyses, ANOVA tests with Tukey's post-hoc test were run. The results from the post-hoc analyses are contained within this appendix. Significant mean differences ($p < 0.05$) in T1 depressive symptoms and T1 executive function across categorical variables can be found in Table F1. The results in this appendix correspond to Table 3 in Section 5.1.

Table F1. Post Hoc Analyses of Significant Mean Differences in Depressive Symptoms at Follow-Up and Executive Function at Follow-Up Across Sample Characteristics at Baseline, Canadian Longitudinal Study on Aging Comprehensive Cohort (n = 16,421)

Mediator (T1): Depressive symptoms		Outcome (T1): Executive Function	
Difference between means		**Difference between means**	
Age group (years) comparison			
45–54 vs. 65–74	0.29	45–54 vs. 55–64	0.73
≥ 75 vs. 45–54	0.31	45–54 vs. 65–74	2.06
≥ 75 vs. 55–64	0.45	45–54 vs. ≥ 75	3.52
≥ 75 vs. 65–74	0.60	55–64 vs. 65–74	1.33
		55–64 vs. ≥ 75	2.79
		65–74 vs. ≥ 75	1.46
Marital status comparison			
Single/never married vs. widowed	0.46	Married/common law vs. divorced/separated	0.42
Single/never married vs. married/common law	1.57	Married/common law vs. widowed	1.98
Divorced/separated vs. married/common-law	1.36	Single/never married vs. widowed	1.78
Widowed vs. married/common-law	1.11	Divorced/separated vs. widowed	1.56
Province comparison			
Not applicable, as the bivariate association between depressive symptoms and province was not statistically significant.		British Columbia vs. Alberta	0.31
		British Columbia vs. Manitoba	0.42
		British Columbia vs. Ontario	0.43
		British Columbia vs. Quebec	0.51
		British Columbia vs. Nova Scotia	0.85
		British Columbia vs. Newfoundland and Labrador	1.03
		Alberta vs. Nova Scotia	0.54
		Alberta vs. Newfoundland and Labrador	0.72
		Manitoba vs. Nova Scotia	0.42
		Manitoba vs. Newfoundland and Labrador	0.60
		Ontario vs. Nova Scotia	0.41
		Ontario vs. Newfoundland and Labrador	0.59
		Quebec vs. Nova Scotia	0.33
		Quebec vs. Newfoundland and Labrador	0.51
Education comparison			
Less than secondary school vs. some post-secondary education	0.94	Secondary school graduate vs. less than secondary school	1.88

Mediator (T1): Depressive symptoms		Outcome (T1): Executive Function	
Difference between means		**Difference between means**	
Less than secondary school vs. secondary school graduate	0.95	Some post-secondary education vs. secondary school graduate	0.51
Less than secondary school vs. post-secondary degree/diploma	1.60	Some post-secondary education vs. less than secondary school	2.39
Some post-secondary education vs. post-secondary degree/diploma	0.67	Post-secondary degree/diploma vs. some post-secondary education	0.85
Secondary school graduate vs. post -secondary degree/diploma	0.66	Post-secondary degree/diploma vs. secondary school graduate	1.35
		Post-secondary degree/diploma vs. less than secondary school	3.23
Income comparison			
1 vs. 2	1.87	2 vs. 1	0.51
1 vs. 6	2.28	3 vs. 6	0.70
1 vs. 3	2.92	3 vs. 2	1.14
1 vs. 4	3.44	3 vs. 1	1.65
1 vs. 5	3.80	4 vs. 3	0.77
2 vs. 3	1.06	4 vs. 6	1.47
2 vs. 4	1.57	4 vs. 2	1.91
2 vs. 5	1.94	4 vs. 1	2.42
3 vs. 4	0.51	5 vs. 4	0.57
3 vs. 5	0.88	5 vs. 3	1.34
4 vs. 5	0.37	5 vs. 6	2.04
6 vs. 3	0.64	5 vs. 2	2.48
6 vs. 4	1.16	5 vs. 1	2.99
6 vs. 5	1.53	6 vs. 2	0.44
		6 vs. 1	0.95
Self-rated health comparison			
Poor vs. fair	2.53	Good vs. fair	0.69
Poor vs. good	5.04	Good vs. poor	0.71
Poor vs. very good	6.41	Very good vs. good	0.58
Poor vs. excellent	7.52	Very good vs. fair	1.27
Fair vs. good	2.51	Very good vs. poor	1.29
Fair vs. very good	3.88	Excellent vs. very good	0.28
Fair vs. excellent	5.00	Excellent vs. good	0.87
Good vs. very good	1.37	Excellent vs. fair	1.56
Good vs. excellent	2.48	Excellent vs. poor	1.57
Very good vs. excellent	1.11		

Mediator (T1): Depressive symptoms		Outcome (T1): Executive Function	
Difference between means		**Difference between means**	
Smoking status comparison			
Current vs. former	1.25	Never vs. current	0.42
Current vs. never	1.51	Never vs. former	0.47
Former vs. never	0.26		
Alcohol use comparison			
No vs. missing	0.74	Regular vs. occasional	0.83
No vs. regular	1.05	Regular vs. no	0.88
Occasional vs. missing	0.76	Regular vs. missing	1.03
Occasional vs. regular	1.07		

Note. T1 = follow-up.

Income levels: 1 = < $20,000; 2 = ≥ $20,000 and < $50,000; 3 = ≥ $50,000 and < $100,000; 4 = ≥ $100,000 and < $150,000; 5 = ≥ $150,000; 6 = missing.

Appendix G Model Diagnostics

The figures contained in this appendix (Figures G1 and G2) are standard model diagnostic plots. From these plots, there is evidence that the assumptions of linear regression have not been violated at either path of the mediated effect. Refer to Section 5.2.7 for a summary of the findings from the model diagnostic plots.

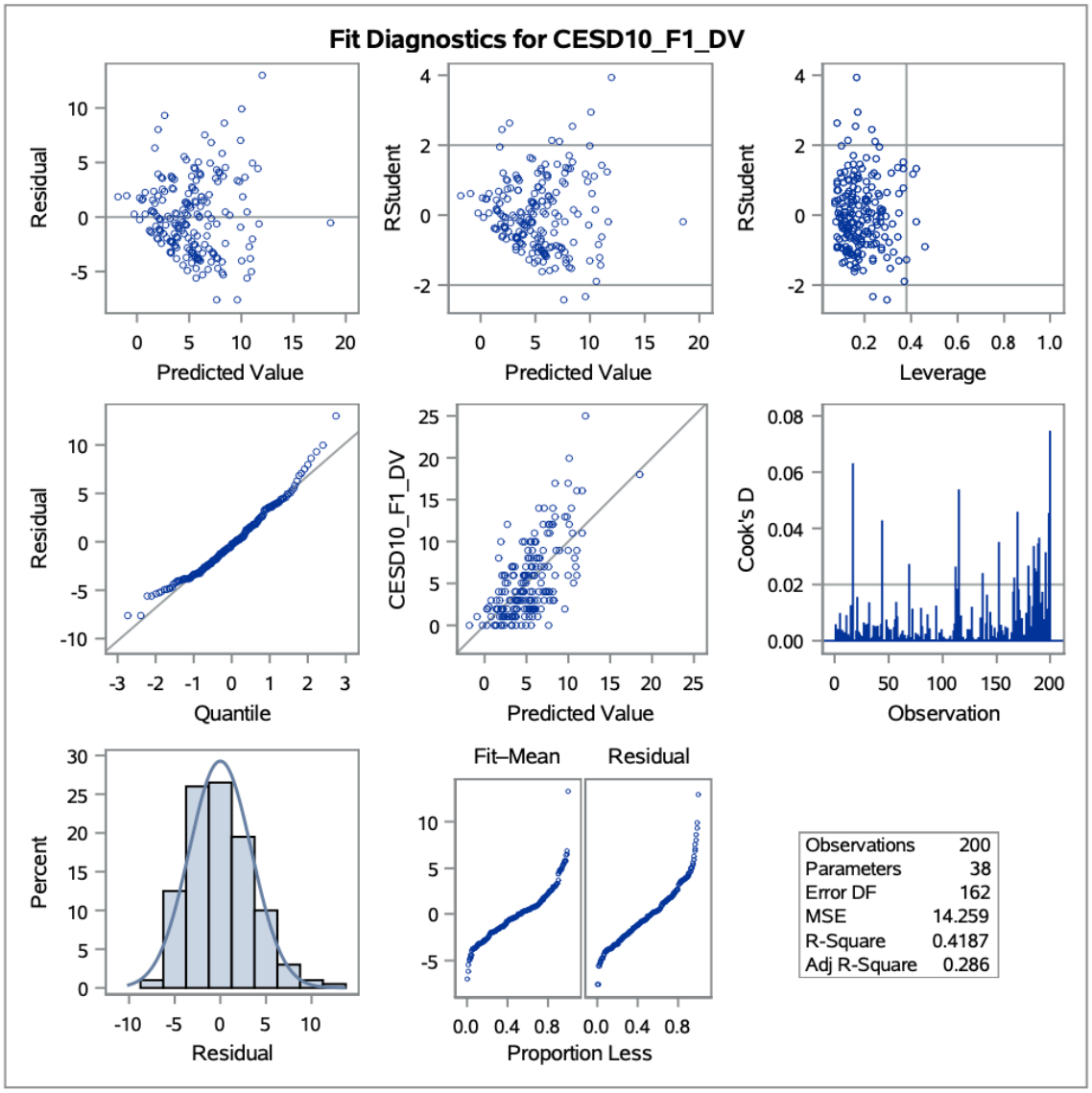

Figure G1. Fit Diagnostics for Fully Adjusted Association Between Low Functional Social Support at Baseline and Depressive Symptoms at Follow-Up on a Random Sample of 200 Participants

Note. Low functional social support = ≤ 3 on the Medical Outcomes Survey-Social Support Survey. Scores range from 1–5. The frequency of self-reported depressive symptoms within the past week were measured using the Centre for Epidemiological Studies Short Depression Scale.

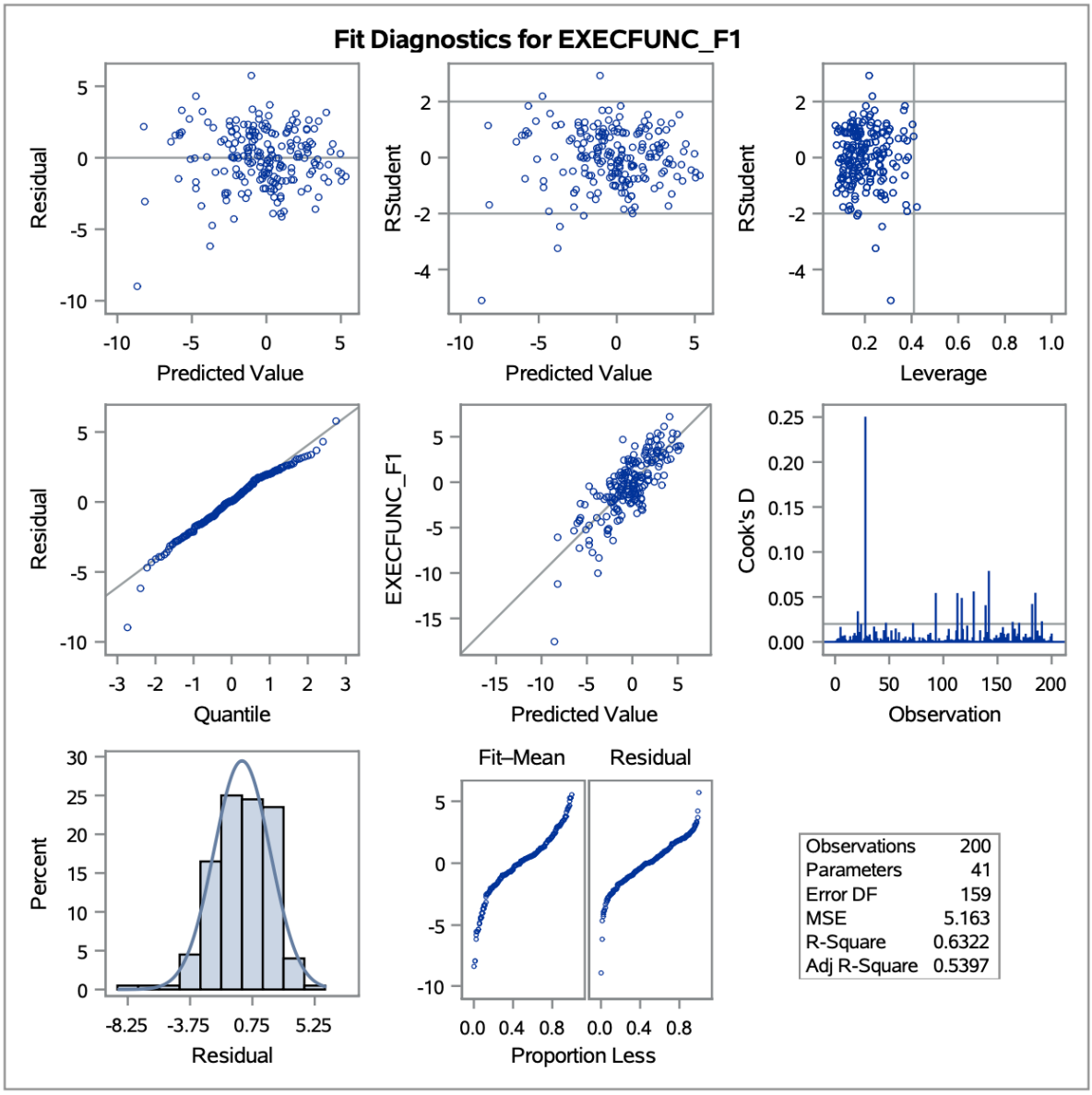

Figure G2. Fit Diagnostics for Fully Adjusted Association Between Depressive Symptoms at Follow-Up and Executive Function at Follow-Up on a Random Sample of 200 Participants

Note. The frequency of self-reported depressive symptoms within the past week were measured using the Centre for Epidemiological Studies Short Depression Scale. An executive function score was created by standardizing and then combining the results from five different cognitive tests evaluating executive function.