A Longitudinal Analysis of the Relationship between Neighbourhood Income Inequality and Maternal Mental Health in Calgary, Alberta

by

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– THESIS ABSTRACT –

Background – Emerging evidence has identified income inequality as a potential risk factor for adverse mental health outcomes. Previous research into the relationship between income inequality and mental health has been largely cross-sectional, with mixed results. Very few of these studies have focused on mothers or Canadian populations. This study addresses these gaps in current knowledge by analyzing longitudinal relationships between neighbourhood-level income inequality and anxiety and depressive symptoms among a cohort of pregnant and new mothers from Calgary, Alberta.

Study Design – This study involved secondary data analysis of an ongoing cohort of mothers and utilized a retrospective cohort study approach.

Methods – This thesis utilized longitudinal data collected from the All Our Families cohort study based in the city of Calgary, Alberta (Canada). From 2008 to 2014, respondents were asked to complete questionnaires at six time points, corresponding to <25 weeks of pregnancy to 3 years postpartum. Depressive symptoms were measured using the Edinburg Postnatal Depression Scale and the Centre for Epidemiological Studies-Depression Scale. Anxiety symptoms were measured using the Spielberger State Anxiety Inventory. Multilevel growth curve modeling was used to quantify the associations between neighbourhood-level income inequality (expressed as Gini coefficients) and anxiety and depressive symptoms over time, adjusting for individual and neighbourhood-level covariates. Outcomes were treated as both continuous and dichotomous in order to assess any subtle changes in anxiety and depressive symptoms (continuous) as well as the odds of experiencing elevated symptoms (dichotomous). Two sets of analyses were conducted: (1) with our full sample of mothers (n=2,461); and (2)

excluding mothers who had elevated depressive symptoms (n=2,047) or elevated anxiety symptoms (n=2,047) at baseline to adjust for prior experience of elevated symptoms.

Results – The full sample of AOF mothers (n=2,461) had a high proportion of mothers who were white (78.9%) and married or common-law (94.6%), who had high household income (70.1%), and at least some post-secondary education (90.5%), and they tended to be older (mean age=30.7 years, SD=4.5 years). Over the course of follow-up, mean anxiety symptom scores ranged from 17.4-20.6 and peaked at 34-36 weeks of pregnancy, whereas mean depressive symptom scores ranged from 12.8-17.7 and peaked at baseline (<25 weeks of pregnancy). The prevalence of elevated anxiety symptoms and elevated depressive symptoms ranged from 15.0%-20.3% and 12.3%-16.8%, respectively, with a cumulative incidence of 267 cases/1,000 mothers for the first occurrence of elevated anxiety symptoms and 210 cases/1,000 mothers for the first occurrence of elevated depressive symptoms. For continuous anxiety, the models yielded a significant interaction term between neighbourhood Gini and time (β=0.0012, 95%CI=0.00020, 0.0023; p=0.020), indicating an excess rate of change over time. Specifically, a standardized deviation increase in Gini (z-score) was associated with an average monthly excess 1.0012% increase in mean anxiety symptom scores. This significant excess rate of change over time was also observed among mothers who did not report elevated anxiety symptoms at baseline (β=0.0017, 95%CI=0.00049, 0.0028; p=0.005), with a standardized deviation increase in Gini (z-score) associated with an average monthly excess 1.0017% increase in mean anxiety symptom scores. In spite of these excess rates of increase, linear combination estimates indicated that higher levels of income inequality were not associated with significantly higher anxiety symptom scores during the study period. While depressive symptom scores followed similar longitudinal trajectories across levels of income inequality, these analyses did not yield significant evidence

for associations between inequality and depressive symptoms. There were also no significant associations between income inequality and dichotomous mental health outcomes, and no evidence of cross-level interactions between income inequality and household income for any study outcome.

Conclusion

This study provides evidence linking neighbourhood-level income inequality to changes in maternal mental health trajectories over time in an urban Canadian context. Further research should aim to uncover the specific mechanisms linking income inequality and mental health, and to understand how interventions intended to address income inequality might also promote better mental health and well-being.

– PREFACE –

This thesis is an original work by Samuel A.J. Lowe under the supervision of Dr. Roman Pabayo and thesis committee members Dr. Ambikaipakan Senthilselvan and Dr. Candace Nykiforuk. The conceptualization and design of this thesis, including developing the research question and methodological approach, was conducted under the guidance of Dr. R Pabayo and the supervisory committee. The analytical chapter of this thesis (chapter 4) was adapted into a manuscript and has been submitted for peer-review publication in collaboration with Dr. Sheila McDonald, Dr. Ambikaipakan Senthilselvan, Dr. Candace Nykiforuk, Dr. Radha Chari, and Dr. Roman Pabayo. This thesis is based on data collected as part of the All of Families Cohort Study based in Calgary, Alberta, and is part of a larger study being conducted by the EMERGE Research Lab under University of Alberta Ethics project ID: RES0040064RA. This research has been funded by the generosity of the Stollery Children's Hospital Foundation and supporters of the Lois Hole Hospital for Women through the Women and Children's Health Research Institute, as well as by the M.S.I. Foundation – Grant no. 896.

S. Lowe contributed to the conception of design of this study, and was responsible for developing all research protocols and methodologies; acquiring project funding; cleaning, analysing, and interpreting the data; and, drafting and revising the thesis and related manuscript. Dr. Roman Pabayo made substantial contribution to the conception and design of this project; the acquisition of funding; the acquisition and interpretation of data; and, critical review of the thesis and manuscript. Dr. Ambikaipakan Senthilselvan made substantial contributions to the design of this project; the analytical plan of the project; and critical review of the thesis and manuscript. Dr. Candace Nykiforuk made substantial contributions to the design of this project and critical review of the thesis and manuscript. Dr. Sheila McDonald and Dr. Radha Chari provided critical review of this project and the manuscript adapted from chapter 4 of this thesis.

No part of this thesis has been previously published, although chapter 4 has been refined into a manuscript and submitted to BMJ open for publication.

– DEDICATION –

“What good does it do to treat people’s illnesses, to then send them back to the conditions that made them sick?”

-The Hon. Monique Bégin

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In memory of Ellyn Otterson. Teacher. Mother. Dear, dear friend.

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– CHAPTER 1: INTRODUCTION –

1.1 Identifying the Public Health Issue – Maternal Mental Illness and Income Inequality

Mental illness presents a substantial global public health concern, affecting over one billion individuals in 2016 and costing the global economy over one trillion dollars per year (1,2). This burden is similarly high in Canada, with an estimated 8.4% to 19.8% of the Canadian population experiencing a mental illness each year (3–7), resulting in upwards of $51 billion dollars (CAD) in direct and indirect health care costs (6,8–10). While sparse, Canadian mental illness incidence estimates suggest an overall annual incidence proportion of 2.9% (95%CI=2.3%, 3.4%) (11), with models predicting that the burden of mental illness in Canada will increase from 6.8 million individuals in 2011 to 8.9 million individuals by 2041 (6). The symptoms of mental illness can manifest in many ways and vary considerably in terms of severity, ranging from increased fatigue, difficulty concentrating, and mild insomnia to extreme and persistent psychological stress and suicidal ideation (6,12–14). In addition to adverse symptoms, those experiencing poor mental health are at increased risk of developing mental and physical comorbidities, such as alcohol dependence and heart disease, and have shorter life expectancy compared to the general population (6,12).

Data on various mental disorders have highlighted a striking gender disparity, with women consistently suffering from a larger burden of mental illness compared to men (1,7,10,15). This burden is especially high among mothers, with prevalence reports of maternal depression as high as 60% in some countries (16) and studies indicating a high prevalence of maternal depression during both pregnancy (18.5%-22.0%) (17) and the early postpartum period (10%-42%) (18,19). Multiple studies have also reported high rates of anxiety among mothers ranging from 12.3%-18.2% during pregnancy and 8.1%-9.1% during the early postpartum period (17,20). In Canada, a recent national survey by Statistics Canada found that 23% of mothers who had recently given birth reported symptoms consistent with either anxiety or depression (21). Mothers could be especially susceptible to these adverse mental health conditions due to the unique stressors that they experience, such as considerable physiological changes during pregnancy (17,22) and heightened stress and financial strain associated with child-rearing (23). The high burden of and susceptibility to mental illness among mothers is concerning, as it has been linked to various adverse outcomes including substance misuse, poor utilisation of health

services, and recurrent mental illness over time (20,22,24,25). Maternal mental illness can also have negative impacts on the children of these mothers, increasing the risk of preterm delivery (24,25) and developmental delays (26).

Existing research has identified a variety of individual-level risk factors for adverse maternal mental health, including age, education, income, and personal history of mental illness (18,20,21,23,25,27–29). However, the social determinants of health framework highlights that the conditions in which individuals are born, live, work, and grow are also highly influential in shaping health and well-being (30–32). A report prepared by the Senate Subcommittee on Population Health estimated that 50% of the Canadian population's health is attributable to characteristics of the social and economic environment (33). Among these socio-economic characteristics, income inequality, which refers to the unequal distribution of incomes within a given area, has been identified as one such influential determinant (30,34,35).

There is a growing body of evidence linking income inequality with a variety of adverse health outcomes (15,34–40). Recent systematic reviews and meta-analyses have found evidence linking income inequality to mental health outcomes specifically, with many of the studies captured in these reviews reporting associations between higher levels of inequality and any mental disorder (36) and depression (15). Despite this mounting evidence, many of the studies examining income inequality and mental health are cross-sectional (15,41), thus limiting current findings. Furthermore, very little of this work has focused on the mental health of women and mothers in particular (15,42,43), which presents a large gap within the literature. Considering the high burden of mental illness among women and mothers, as well as recent increase in income inequality at various geographic scales (44,45), further investigation of the relationship between income inequality and maternal mental health is timely.

1.2 Study Aim and Objectives

This study aimed to address the gaps and limitations of previous inequality research by employing a longitudinal analysis of income inequality and the mental health of mothers from the All Our Families (AOF) cohort in Calgary, Alberta. This cohort is part of an ongoing study that incorporates a life-course perspective, following mothers and their young children from pregnancy to several years postpartum. By analysing mental health data collected between 2008 and 2014, this study sought to quantify the associations between neighbourhood-level income

inequality and changes in maternal anxiety and depressive symptoms over time. The results of this study provide a foundation for further research into the specific mechanisms linking neighbourhood inequality to mental health, and how interventions aimed at reducing inequality could have beneficial implications for mental health and well-being. The specific objectives of this study included:

- Conducting a narrative review of association studies linking income inequality to mental health outcomes, with a specific focus on studies that include mothers and women, employ a longitudinal approach, and consider anxiety and depression as distinct health outcomes, to identify limitations and gaps in current knowledge;
- Analysing the relationships between neighbourhood income inequality and maternal anxiety and depressive symptoms in a Canadian context using a multilevel modelling approach; and
- Determining whether the impacts of inequality are felt differently across levels of household income (i.e., poorer versus richer mothers).

– CHAPTER 2: BACKGROUND –

Chapter 2 presents a general review of the literature on mental health and income inequality to provide context for this thesis. The following sections include background information on the epidemiology and common risk factors of mental illness among both general and maternal populations, a description of the SDOH framework, and elaborate on the concept of income inequality. Specifically, the sections on income inequality encompasses the income inequality hypothesis, common measures of income inequality, temporal trends in income inequality, and potential mechanisms linking income inequality to health outcomes.

2.1 Burden of Mental Illness

Mental illness, while encompassing a broad range of conditions and symptoms, is generally defined as a psychological or behavioural syndrome that impacts thoughts and perceptions, behaviours, emotions, and social functioning and relationships (6,46). The impacts of these disorders can range considerably in terms of severity depending on the specific disorder, with more severe forms of mental illness contributing to disability and requiring health care interventions (6). Those experiencing mental illness are at higher risk of developing other mental and physical conditions, such as bipolar disorder, type II diabetes, and heart disease (6), typically have shorter life expectancy, and are more likely to commit suicide compared to the general population (12). In addition to poorer health, mental illness can also have adverse implications for school and job performance, interpersonal and familial relationships, and community involvement (2,6). Common categories of mental disorders include mood (e.g., depression), anxiety, psychotic (e.g., schizophrenia), cognitive impairment (e.g., dementia), and substance use (e.g., alcoholism) disorders (1,6,46). Known risk factors for these mental disorders are vast, ranging from individual biological (e.g., genetics, age, family history of mental illness) and socioeconomic (e.g., income, gender, education, ethnicity) factors to broader environmental and sociopolitical characteristics (e.g., environmental hazards, poor working conditions, lack of community support, underinvestment in social safety nets) (6,8,10,30,46)

Recent estimates from 2016 suggest that mental and addictive disorders affect over one billion people; approximately 13% of the current global population (1). These disorders constitute 7% of the total burden of disease worldwide, as measured in disability adjusted life

years (DALYs), and 19% of the total number of years lived with a disability. Anxiety and Depressive disorders account for a large fraction of the global mental health burden, with prevalence estimates of 3,715 cases/100,000 individuals and 3,627cases/100,000 individuals, respectively (1). These disorders also generate extensive economic strain, costing the global economy an estimated 1 trillion dollars (USD) per year (2). Global trends highlight that while the rates of DALYs and deaths from all diseases have been decreasing from 1990 to 2016, that these rates from mental and addictive disorders have increased (4.3% increase for DALYs, 12.0% increase for deaths). Despite this trend of increased burden and the associated costs, the global median of government spending allocated to addressing mental health is below 2% (2), with 76%-85% of individuals in low- and middle-income countries receiving no mental health treatment (46,47).

Mental illness poses a similarly large burden for public health in Canada, with an estimated 1 in 5 to 1 in 3 Canadians experiencing at least one mental disorder during their lifetime (3,6,7,10). A report from Public Health Ontario found the total health burden of mental illness to be as high as 1.5 times greater than that of all cancers and over 7 times that of infectious diseases (10,48). Within a given year, approximately 8.4%-19.8% of the Canadian population experiences a mental illness (3–7). Anxiety and mood disorders are the most common of these illnesses among Canadians, with an estimated combined annual prevalence of 11.7% of the total population (6), or 2.6%-5.8% and 4.0%-5.9% for anxiety and depression, respectively (3,5,7). Anxiety and mood disorders also represent the most common mental health comorbidity (6,7), with past 12-month estimates indicating that 52.6% of Canadians with generalized anxiety disorder also met the diagnostic criteria for depression (7).

Unfortunately, there is a dearth of consistent and contemporary data on incidence estimates of mental illness in Canada, although studies using data from the Canadian National Population Health Survey have reported an overall annual incidence proportion of 2.9% (95%CI=2.3%, 3.4%) (11) and a range from 1.3% (95%CI=0.6%, 2.1%) to 7.1% (95%CI=5.1%, 7.1%) across categories of age and sex (49). As these results are based on data collected approximately two decades ago, these estimates are likely out of date as current and future incidence could differ substantially. Additionally, models constructed by Smetanin et al. (6) predict that the burden of mental illness is likely to increase from 6.8 million individuals in 2011

(19.8% of the total population) to 8.9 million in 2041 (20.5% of the total population), suggesting that mental illness will continue to pose a public health issue in Canada over the coming decades.

Beyond its impacts on public health burden, mental illness places great strain on the Canadian economy, with an estimated annual cost of $49-$51 billion in direct health care costs, out of pocket expenses, lost productivity, declines in overall quality of life, and premature mortality (6,8–10). These costs likely underestimate the full economic burden of mental illness, as some estimates do not factor in the costs associated with impacts to the justice, social services, education, and child and youth services systems, informal costs incurred by caregivers, and deterioration of health-related quality of life (6). The economic impacts of mental illness are also expected to grow over the coming decades as the Canadian population continues to grow and age, with annual direct costs rising to an estimated $185.4 billion by 2041, corresponding to over $2.5 trillion in cumulative costs between 2011 and 2041 (6). Currently, total spending within Canada on non-dementia-related mental health care accounts for approximately 7.2% of total health care spending (9), with over 40% of Canadians who needed mental health-related support in 2018 indicating that their care needs were not fully met (50).

It should be noted that mental health disparities exist across various racial, cultural, and socioeconomic strata. The distributions of mental illness within populations vary considerably depending on factors such as gender, income, ethnicity, immigration status, education, and homelessness/houselessness (4–6,30). Women consistently experience higher burdens of mental illness compared to men globally, demonstrating higher rates for all internalizing disorders, including anxiety (4,648 cases/100,000 women versus 2,797 cases/100,000 men) and depression (4,428 cases/100,000 women versus 2,839 cases/100,000 men) (1). This gender imbalance appears to be worsening for women, as age-standardized rates of DALYs for mental and addictive disorders have been steadily increasing for women from 1990 to 2016, while leveling-off and decreasing for men from 2005 onward (1). A higher burden of mental illness among women is also evident within Canada, with annual estimates for anxiety and depression indicating higher prevalence among women (3.2% and 5.0-11.4%) compared to men (2.0% and 2.9-6.8%) (4,5,7). Large mental health disparities also exist between those with different levels of income, with those in the highest income quintile demonstrating a lower prevalence (2.9%) and 70% lower odds of reporting depression (OR=0.3, 95%CI=0.3, 0.4) to the prevalence (5.2%) and odds (OR=1, reference group) of those in the lowest quintile (5).

While some evidence for a healthy immigrant effect suggests that the occurrence of depression is lower among new immigrants (3.1-7.0%) compared to those who are native to Canada (4.2-9.5%) (4,5), more contemporary evidence indicates that recent immigrants of colour are at greater risk of experiencing adverse mental health compared to native Canadians of European descent (30). A study by Smith et al. (4) using data from the Canadian Community Health Survey demonstrated interactions between some of these stratifying factors, with the lowest rates of depression found among low income recent immigrant males (2.2%) and the highest among low income non-recent immigrant females (11.1%). It is crucial to identify and further understand these disparities in mental health, so that resources and interventions can be allocated according to the specific mental health needs and challenges of various populations. Further discussion of the sociopolitical and systemic factors driving mental health disparities is presented in section 2.2.

2.1.1 Maternal Mental Health - Epidemiology and Risk Factors

Mothers experience an especially sizeable burden of mental illness, demonstrating high prevalence of adverse psychological symptoms and disorders both during and following pregnancy (16,17,20,25,27,50,51). Much of these maternal health data are focused on depression during the prenatal, perinatal, and postnatal periods (16,20,25,28,51), with 'perinatal' referring to the period encompassing pregnancy up to the first 12 months postpartum (51,52). Estimates of maternal depression vary considerably across countries, with Halbreich and Karkun (16) reporting a range of postpartum depression from near 0% in some countries to over 60% in others. They suggest that this vast range could be due to differences in cross-cultural factors, screening methods, attitudes and perceptions surrounding mental illness, and socioeconomic conditions between countries (16). A systematic review of high-income countries by Gavin et al. (51) provided point estimates for the prevalence of maternal depression (major and minor), ranging from 11.0% (95%CI=7.6%, 15.8%) in the first trimester to 8.5% (95%CI=6.5%, 11.0%) in the third trimester of pregnancy, and from 12.9% (95%CI=10.6%, 15.8%) at three months postpartum to 6.5% (95%CI=2.7%, 12.9%) at the end of the first year postpartum (51). They also reported a cumulative or period prevalence of up to 18.4% (95%CI=14.3%, 23.3%) during pregnancy, with as high as 53.7% (95%CI=39.6%, 67.4%) of mothers having experienced depression by one year postpartum. A more recent review of perinatal depression including both

high and low/moderate income countries calculated a pooled prevalence estimate of 11.9% (95%CI=11.4%, 12.5%), which once stratified demonstrated a significantly higher prevalence among low/moderate income (13.1%, 95%CI=12.2%, 14.1%) compared to high income (11.4%, 95%CI=10.8%, 12.1%) countries (25). The average prevalence of postpartum depression in Canada is estimated to be as high as 17.6-29.5% (16,23).

While the majority of existing maternal mental health data are based on depressive disorders, more studies are recognizing the importance of considering maternal anxiety in addition to depression. This shift is due in part to the high rates of maternal anxiety and comorbidity with depression (6,7,17), and a recognition that these two disorders involve potentially different physiological and psychological pathways (17,20). A study of perinatal anxiety of mothers in England by Heron et al. (20) reported a prevalence of maternal anxiety of 14.6% at 18 weeks and 15.6% at 32 weeks of pregnancy, and 8.1% at eight weeks and 9.1% at eight months postpartum. These results align with findings from a sample of pregnant mothers in Portugal, reporting anxiety estimates of 15.0%, 12.3%, and 18.2% for mothers in their first, second, and third trimester, respectively (17). A 2018/2019 national survey by Statistics Canada considering both anxiety and depression found that 23% of mothers who had given birth in the last 5 to 13 months reported symptoms consistent with either type of disorder (21).

There are very few incidence estimates for maternal mental health, leading to a dearth of information on the trends of emergent cases of mental illnesses over time. Heron et al. (20) found that among mothers who were not depressed at 18 weeks gestation (baseline), the proportion of mothers who developed an incident case of depression was 7.3%, 3.5%, and 2.3% at 32 weeks gestation, eight weeks postpartum, and eight months postpartum, respectively. Similar trends were observed for incident cases of anxiety, with proportions of 7.3%, 2.4%, and 2.4% of mothers experiencing incident anxiety at 32 weeks gestation, eight weeks, and eight months postpartum, respectively (20). Two studies of mothers with young children (aged 11 to 42 months at baseline) reported that 11.7%-12.8% of mothers without elevated symptoms at baseline experienced incident elevated depressive symptoms after one year of follow-up (18,27). Results from Gavin et al. (51) indicated that up to 14.5 % (95%CI=8.1%, 24.4%) of mothers develop new cases of depression during pregnancy, with as high as 49.0% (95%CI=34.4%, 63.7%) of mothers developing depression during the first year following birth. More

contemporary maternal incidence estimates of various mental disorders could provide greater insights into the trends of emergent maternal psychopathologies over time.

Mothers experience a variety of unique changes and stressors that could make them especially susceptible to adverse mental health and contribute to their relatively high burden of mental illness. As mothers transition from pregnancy to early parenthood, they experience considerable physiological (e.g., heightened prenatal cortisol levels), psychological (e.g., worry of having a healthy baby), and social (e.g., more time devoted to child care; taking maternity leave) changes, potentially predisposing them to anxiety and depressive symptoms and disorders (17,20,22,53). Anxiety in particular could spike during the first trimester due to the stress of adapting to pregnancy, and during the third trimester as mothers psychologically and physically prepare to give birth (17). Material and financial factors could also play a role, with heightened stress resulting from the financial needs associated with raising a child (23). Some common predictors and correlates of maternal mental illness are identified and described in Table 1.1.

Table 2.1. Summary table of major predictors and correlates of adverse mental health among pregnant and postpartum mothers, alphabetized

Predictor	Description	Examples of Associations
Age (21,27)	Younger mothers are more likely to report depressive symptoms than older mothers	30% of Canadian mothers under the age of 25 reported symptoms consistent with depression or anxiety disorder, compared to 23% of mothers over 25 (21)
Economic Stress (54)	Mothers who experience greater economic stress (e.g., difficulty securing material necessities such as food and housing) are at increased risk of experiencing depression	Higher economic stress associated with worsening depressive symptoms (β=0.39, z=8.34, p<0.01) of mothers with a child aged 4 to 17 years (54)
Education (18,27,28)	Mothers with lower levels of education are at greater risk of developing elevated depressive symptoms compared to those with higher levels of education	Having less than high school-level education associated with a 108% greater odds (OR=2.08, 95%CI=1.00, 4.32, p=0.0026) of experiencing elevated depressive symptoms at least once during assessment compared to more highly-educated mothers (18)
Ethnicity/Race (27)	The burden of depression is higher among non-white/Caucasian mothers compared to white/Caucasian mothers.	Mothers who were non-Caucasian had a 100% greater odds (OR=2.00. 95%CI=1.26, 2.11) of experiencing incident elevated depression compared to Caucasian mothers (27)
History of Mental Illness (18,20,23,28)	Mothers with a history of depression or anxiety disorders are more likely to experience recurrent and persistent episodes of depression	Previous diagnosis of depression/prescription of antidepressants associated with a 70% greater odds (OR=1.70, 95%CI=1.32, 2.19) of minor/major postpartum depression (23)
Immigration (23)	Mothers who have newly immigrated to Canada could be at higher risk for mental illness (e.g., increased stress of living in an area with an unfamiliar culture or language)	Immigrant mothers had an 84% greater odds (OR=1.84, 95%CI=1.41, 2.40) of experiencing minor/major postpartum depression compared to non-immigrant mothers (23)
Income (23,25,28,29)	Mothers with lower household income, or who are living in lower income countries, are at greatest risk of adverse mental health outcomes	Mothers with low or moderate household income had a 111% greater odds (OR=2.11, 95%CI=1.39, 3.20) of minor/major postpartum depression compared to mothers with high levels of household income (23)
Marital Status and Quality (27,28)	Higher depressive symptoms are associated with a variety of relationship factors, including being a single parent, poorer marital quality, lower levels of paternal education, and a partner with less direct involvement in childcare.	Mothers with the poorest marriage quality had a 126% greater odds (OR=2.26, 95%CI=1.28, 4.00) of elevated depressive symptoms than mothers with normal or high marriage quality (27)

Table 2.1. Summary table of major predictors and correlates of adverse mental health among pregnant and postpartum mothers, alphabetized (cont.)

Predictor	Description	Examples of Associations
Negative Life Events (27,28)	Those who have experienced frequent stressful life events (e.g., traumatic childbirth, parenting a child with behavioral issues) are more likely to present with one or more mental health conditions than those with fewer stressful experiences	Mothers who experienced 5 or more stressful parenting-associated life events had a 111% greater odds (OR=2.11. 95%CI=1.25, 3.57) of elevated depressive symptoms compared to mothers with less than five stressful life events (27)
Physical Health (18,27,29)	Those reporting poor physical health are at greater risk of depression compared to those in relatively good health, with physical and mental health comorbidity being relatively common	Having a medical condition that involves activity limitations associated with increasing depressive symptoms (β=0.166, $p<0.005$) among inner-city mothers of young children (29)
Pregnancy Intent (28,55)	Having an unplanned pregnancy could lead to feelings of ambivalence, entrapment, and depressions	Having an unplanned pregnancy associated with a 44% greater odds (OR=1.44, 95%CI=1.10, 1.89) of major depression among new mothers 6 to 8 weeks postpartum (55)
Social Support (18,23,27,28,54)	Those lacking social supposed, such as reporting having no friends, are more susceptible to experiencing depression, potentially due to lacking emotional and tangible assistance (e.g., childcare, borrowing money)	Higher social support associated as a protective factor against worsening depressive symptoms (β=-0.18, z =-3.43, $p<0.01$) (54)

The high burden of and susceptibility to mental illness among mothers is concerning, as many mothers are not identified and treated for their mental health conditions (20,25,29). Experiencing severe depression during pregnancy has been associated with various adverse maternal health outcomes, including poor utilisation of health services, substance misuse, medical and obstetric complications, and preterm delivery (22,24,25). Adverse mental health conditions during early pregnancy and postpartum can also lead to recurrent and persistent mental illness over time. Heron et al. (20) reported that 56.3% of the mothers who experienced depression during pregnancy within their sample also experienced postnatal depression. This persistence was higher for anxiety, with 64.3% of mothers who had prenatal anxiety also experiencing postnatal anxiety (20). Further, evidence from a sample of mothers with young children found that 35.6%-46.3% of mothers with elevated depressive symptoms at baseline also had elevated symptoms at one year follow-up (18,27). Beyond these impacts on the mothers

themselves, maternal mental illness can also have considerable impacts on the health and developmental trajectories of their children (17,18,26,27). Among a sample of mother-child dyads from Calgary, Alberta, the estimated odds of delayed child development at one year of age was 78% greater (OR=1.78; 95%CI=1.01, 3.13) if the mother had experienced major depression during pregnancy (26). Thus, studying and addressing maternal mental illness has implications for both mothers and their children.

With these impacts in mind, the perinatal period could be an optimal time for mental health research and intervention targeting, considering that this is a period where mothers and their children are frequently interacting with health providers and services (52). Much of the work identifying estimates and risk factors for maternal mental health focuses on either the prenatal or postnatal periods, with studies of the perinatal period typically only extending to one or two years postpartum (25,51,52). Tracking the mental health of mothers from pregnancy through to several years postpartum could provide a clearer indication of how early experiences of mental illness translate to recurrence and incidence over time. This type of longitudinal approach would also generate additional incidence estimates for maternal mental illness, addressing a gap in the literature especially within a Canadian context (11,25,49,51). As mentioned previously, a large majority of the work on maternal mental health focuses on pre- and postnatal depressive disorders and symptomatology, with few studies including anxiety as a distinct mental health outcome (17,20,25,28,51,52). Future studies should include anxiety in addition to depressive outcomes, considering the high persistence of anxiety from pregnancy to postpartum, high comorbidity of anxiety and depressive disorders, and increased risk of adverse mental health associated with

prior experience of anxiety and depression (17,20,21,28). Finally, while much of the research on maternal mental health focuses on individual-level risk factors, factors related to the broader social, economic, cultural, and political contexts in which individuals live could also influence the distributions of and susceptibility to mental illness (30–32,56). Therefore, studies looking beyond individual drivers of adverse maternal mental health to consider if and how these contextual factors also play a role are warranted.

2.2 The Social Determinants of Health Framework

Of the various determinants of health that include individual, social, and environmental factors, research suggests that 50% of Canada's population health is explained by social and economic factors (e.g., income, education, gender, race), with 25% attributed to the health care system factors (e.g., wait times, quality of care), 15% to biological factors (e.g., genetics, physiology), and 10% to characteristics of the physical environment (e.g., air quality, built environment and infrastructure) (33). Although such a large portion of Canadian health is explained by social and economic factors, these factors are largely beyond the control of individuals. Instead, they are shaped by characteristics of the communities, services, and institutions that they belong to and interact with (30). Ergo, these social determinants of health are understood as relating to the conditions in which people are born, live, work, age, and grow (31,32).

Seventeen social determinants have been identified as being especially influential in Canada, including: disability; early child development; education; employment and working conditions; food insecurity; gender; geography; globalization; health services; housing; immigration; income and income distribution; Indigenous ancestry; race; social exclusion; social safety net; and, unemployment and job security (30,32). These social determinants of health have been linked to a variety of health outcomes, such as life expectancy, cardiovascular disease, adult-onset diabetes, respiratory diseases, and others. Additionally, the impacts of these determinants are potentially greater than behavioural factors such as diet, physical activity, and excessive alcohol and tobacco use (30). The quality and distribution of social determinants across populations is largely influenced by laws and services, social norms, and the structural distributions of power and resources at local, national, and international levels (30,32,57).

The World Health Organization's Commission on the Social Determinants of Health (CSDH) developed a conceptual framework to better understand the complex relationships between the social determinants of health, and their interactions with downstream health determinants, outcomes, and broader social, political, and cultural contexts (32,58). This framework, shown in Fig 1.1., posits that health disparities can arise from the unequal distribution of social determinants of health within a population (31,58). It depicts how broad contextual social and political mechanisms (e.g., policies, government structure, social norms) shape and are shaped by structural determinants of health inequities (e.g., socioeconomic

positioning and stratification according to income, gender, race, education, etc.), which in turn influence intermediate determinants of health (e.g., material circumstance, behaviour and psychosocial factors) and the distribution of health outcomes (31,58). There is also potential for feedback, in which poor health conditions could affect an individual's social position (e.g., through loss of employment and reduced income), or in the case of larger-scale health issues (e.g., COVID-19 pandemic) (56), influence contextual factors such as institutional social supports and governmental policies (58). Through the CSDH framework, health conditions and distributions are understood as being impacted by the complex interplay between factors that extend beyond the level of individual risk factors, and are intertwined with unequal distributions of the social determinants of health (31,32,58).

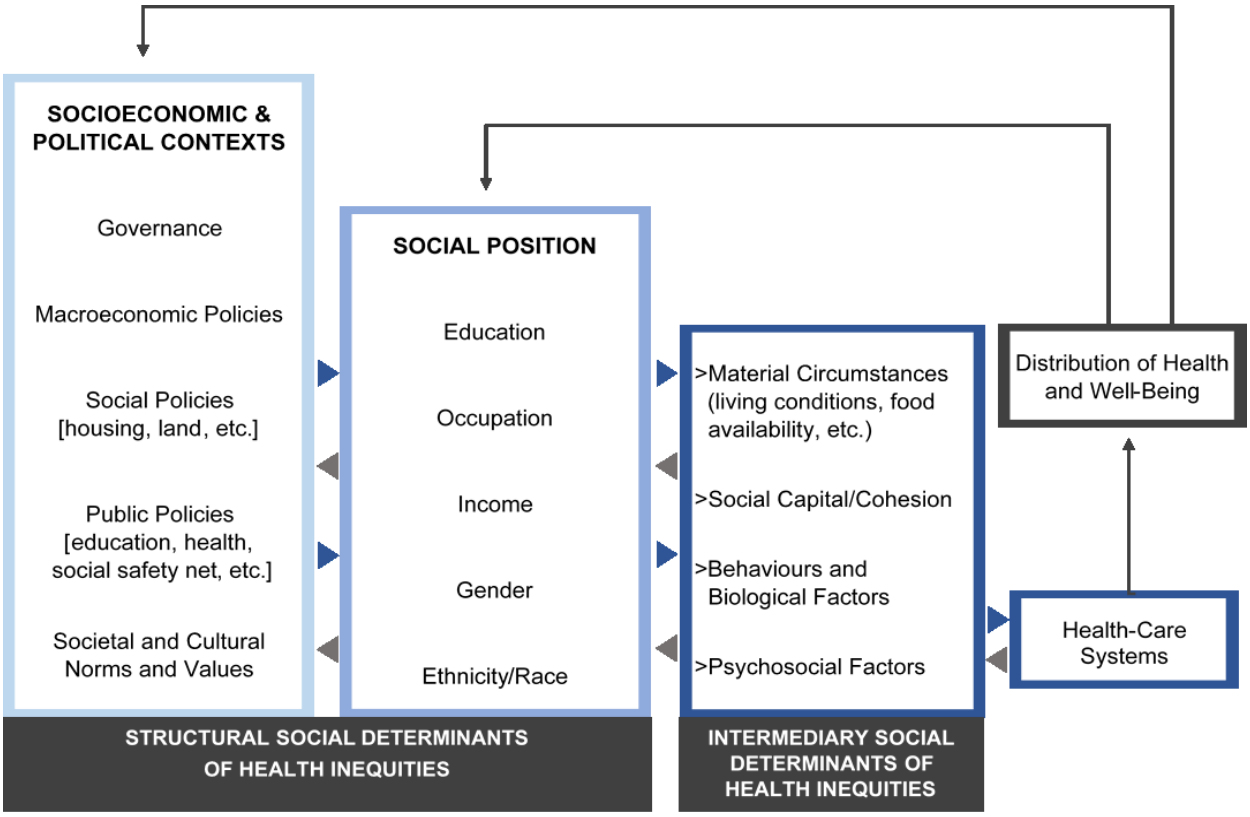

Figure 2.1. The CSDH Social Determinants of Health Framework, adapted from Solar and Irwin (2010)

The social determinants of health framework provides an important context for approaching the issue of maternal mental health, as it highlights that women consistently and disproportionately experience more adverse social determinants compared to men. As such, this framework incorporates the concept of intersectionality, which describes how discrimination and inequities arise from the interactions and interdependencies of various social strata (e.g., gender, race, social class) and structures of power (e.g., laws and policies, political bodies, religious institutions) (35,59). For example, women are less likely to have full-time employment and be eligible for unemployment benefits, and more likely to experience workplace harassment and pay inequity, compared to men (30). Single mothers are particularly at risk for experiencing adverse determinants, due in large part to their care-giving responsibilities, generally lower wages, and the lack of affordable childcare options. Other factors including race and immigration status could exacerbate these adverse determinants and resultant poor health (30,59), as racialized Canadians and non-European immigrants experience greater unemployment, food and housing insecurity, and lower incomes than white Canadians and immigrants (30). Newborn children are often subjected to many of these same social conditions as their mothers. This similarity in conditions is quite meaningful, as early life course exposures and contexts can have lifelong impacts on health outcomes as the children grow (30,35,60). For example, Lillard et al. (60) found that exposure to higher country-income inequality in the United States during the first five years of life was significantly associated with reporting worse health among adult men (β=-0.0265, SE=0.0063, $p \leq 0.01$) and women (β=-0.0304, SE=0.0067, $p \leq 0.01$). Understanding these conditions and social determinants in relation to the health outcomes of mothers will likely have implications for the health and well-being of their child(ren) as they are born, grow, and age.

2.2.1 *The Income Inequality Hypothesis*

Income, Income Inequality, and Health

Income is considered to be one of the most influential social determinants of health, having long been associated with a variety of health outcomes (e.g., life-expectancy; heart disease, mental health, child asthma, low birth weights) and health-related behaviours (e.g., diet, level of exercise and physical activity, substance use) (30,35,39,61). Those with less income, including individuals living in poverty, likely experience relatively poor health outcomes for a multitude of reasons, including difficulty securing basic human needs (e.g., food, shelter,

clothing), adequate nutrition for themselves and their children, and access to health care and social support services, and cannot overcome barriers to participate fully in some aspects of society (e.g., unable to afford an internet plan or access reliable broadband for work and communication, or a vehicle or pass for public transit) (30,35,62). Evidence has demonstrated a clear socioeconomic gradient between income and health, with wealthy individuals experiencing better overall health than those in the middle-class, who are in turn healthier than those of low socioeconomic status (31,61).

Additionally, income intersects with and shapes many social determinants of health, as alluded to in the previous section. For example, an individual's level of income could determine the quality of and access to housing, food, health care, and education that they can secure, and those who are racialized (i.e. non-white), female, Indigenous, socially excluded, and/or who have a disability tend to have relatively low incomes (30,31,35). As such, income is an especially important health determinant in countries with fewer publicly-accessible services. Although Canada supports K-12 education, emergency medical procedures, and free libraries through public funding, other services such as childcare, post-secondary education, certain prescription drugs, dental care, and retirement must be financed by the individual (30).

While this link has been well-documented and described in the literature, there is also evidence that the association between income and health outcomes (such as life expectancy) is concave and asymptotic. That is to say, increasing income will yield increasingly incremental improvements to health, with the poor benefiting the most from gaining more income, eventually reaching a plateau where more income does not yield any additional health improvements (35,62). This relationship has implications for health beyond the direct influence of absolute income, as it highlights that narrowing the income gap between the rich and poor could improve health even in situations where mean income remains the same (as health benefits gained by those on the lower end outweigh any reductions in health experienced by those on the higher end) (35,62). In fact, this observation made by Rodgers (62) and further investigated by others (34,35,40,57,63,64) formed the foundation of the income inequality hypothesis; a theory which posits that health is not only influenced by income directly, but also by the distributions of income among individuals, groups, cities, states and provinces, and countries.

Specifically, income inequality refers to the unequal—and often, inequitable—distribution of incomes within a given area (34,40,57). More simply, it refers to the widening gap

between the rich and the poor (65). Income inequality can be broken down into the two distinct concepts of absolute income inequality and relative income inequality, which are occasionally (and, incorrectly) used interchangeably in the literature (66). Relative income inequality refers to the disproportionality of income distributions, whereas absolute income inequality describes income differences in absolute money terms. This distinction can be clarified by adapting an example from Goda (66), wherein individual A (or city, province, country, etc.) has an income of $1,000 and individual B has an income of $10,000. It is evident that individual B has greater income in both absolute ($9,000 more) and relative (10 times higher) terms. If the income of both individuals increases by 20%, the absolute income difference between the two increases (from $9,000 to $10,800), whereas the relative income difference remains constant (the income of individual B remains 10 times higher than A). Alternatively, if the income of both individuals increases by $5,000, the absolute income difference remains constant ($9,000), but the relative income difference declines considerably (B now has approximately 2.5 times higher income than A). As the focus of this thesis is to ascertain if adverse mental health outcomes arise from the relative unequal distribution of income between neighbourhoods, as opposed to the absolute amounts of neighbourhood income, I have utilized the concept and measures of relative income inequality (see chapters 3 and 4).

As with many of the other determinants captured within the social determinants of health framework, income inequality can be understood as existing and acting at different scales (30,31,40,44,64,67). Within-country income inequality refers to the differences in incomes between individuals (or states and provinces, municipalities, communities, neighbourhoods, etc.) within a given country, and is often captured through household surveys and tax data (44,66,67). This form of income inequality can be measured as market inequality (unadjusted) or net inequality (accounting for direct tax payments and income transfers), with market inequality estimates tending to be higher due to the often progressive nature of direct tax payments and income transfers (66). Between-country income inequality refers to differences in incomes between countries, which is typically measured using mean GDP per capita and does not account for the inequalities between their inhabitants (66). Finally, global-income inequality encompasses population-adjusted inequalities occurring both within and between countries (e.g., rich individuals living in poor countries are compared to poor individuals living in high income

countries, etc.) (66). Due to the high variability in data collections methods, quality, and sources, estimates and trends of global income inequality are difficult to ascertain.

There is growing evidence in the literature that income inequality at various geographic scales is associated with a variety of health outcomes, with the majority of studies suggesting that greater inequality relates to poorer health (35,40,63). The early work of Rodgers (62) using cross-sectional mortality and income distribution data from 56 countries found that greater country-level income inequality was consistently associated with various measures of mortality, and that life expectancy in relatively unequal countries could be up to 5 to 10 years less than in relatively equal countries. Other studies have provided additional support for this link between inequality and mortality, as well as for the notion that greater equality relates to better health (37,68). When combining income inequality data from Canadian and US metropolitan areas, Ross (68) estimated that a 1% increase in the proportion of income earned by the poorest half of working age populations would translate to a decline in mortality by approximately 22 deaths per 10,000 individuals per year. A meta-analysis including data at country, state/province, and municipality/community levels reported that increases in inequality were associated with a higher cohort relative risk of mortality (RR=1.08; 95%CI=1.06, 1.10) and a higher cross-sectional odds ratio for poor self-rated health (OR=1.04; 95%CI= 1.01, 1.06) (37). More recent meta-analyses have also found evidence supporting associations between income inequality and mental health outcomes (15,36). Pooled estimates among nine studies yielded a significant association between increasing income inequality and any mental disorder/problem (Pooled Cohen's d effect size=0.059; 95%CI=0.015, 0.103; p=0.009) (36), and estimates from 12 studies revealed a significant trend between increasing inequality and risk of depression (pooled risk ratio=1.19; 95%CI=1.07-1.31) (15). A more thorough description, review, and discussion of the literature linking income inequality to mental health outcomes is presented in chapter 3.

2.2.2 *Measures of Income Inequality*

Among the many fields that study income inequality, including epidemiology, sociology, and economics, there are various measures used to quantify and describe income inequality. Despite the growing number of health-related studies testing the income inequality hypothesis, however, there remains no consensus as to which measures should be used (69,70). The

following section describes some of the most common means of operationalizing income inequality, as well as their main strengths and limitations.

A set of criteria from the econometrics and sociometrics literature outlines key features that all inequality measures should possess in order to appropriately capture inequality (70,71). If a measure satisfies these criteria it can be used to compare various income distributions over time and across different areas (70). The criteria include (70,71):

Anonymity principle - the identity of an individual or groups should not impact the measure of inequality (i.e., does not matter 'who' earns 'what').

Population principle - the measure of inequality should be independent of the size of the economy, which allows for comparison of different sized regions and economies regardless of their population sizes or total aggregate incomes.

Continuity - the measure should be sensitive to both large and small changes within the income distribution, and reflect those changes appropriately.

Relative Income principle - the measure of inequality should only be influenced by relative income, and not absolute income levels (e.g., if all individuals within an area experience an increase in income by the same proportion, the level of inequality should remain the same).

Transfer/Pigou-Dalton principle - a transfer of income from an individual above the median to an individual below the median that does not make the recipient richer than the donor should reduce the overall income inequality.

Scalar independence and **normalization** - the measure should not be affected by the units of the income and population(s) in question, and ideally range from 0 to 1 (perfect equality to perfect inequality) to allow for comparability.

These criteria provide guidelines for assessing the relative strengths and weaknesses of income inequality measures, and can help in selecting appropriate measures for a given context.

Gini Index

The Gini index is among the most widely-used measures of income inequality, including within the field of public health and epidemiology (69–71). Gini coefficients are derived from the Lorentz curve, which demonstrates the cumulative percentage of the total income earned within a population against the cumulative proportion of the population. Specifically, Gini is calculated by dividing the area between the Lorentz curve and the 45° line of equality (A) by the

total area under the 45° line of equality (A+B) (69; Appendix A.1). This approach generates a measure that ranges from 0 (perfect equality, where all the individuals possess the same level of income) to 1 (perfect inequality, where one individual possesses the entirety of the income). Generally, a Gini of 0.5 or greater indicates that an area is highly unequal, whereas a Gini below 0.3 is considered relatively equal (70).

Gini coefficients possess multiple characteristics that make them an appealing choice when studying income inequality. Considering their widespread use in studies of different populations and locations, they allow for comparability of income inequalities between different areas at local, regional, and international levels (69). Gini is most sensitive to inequality in the middle of the income distribution, and is generated based on information from the entire distribution, suggesting that it is an appropriate metric for many studies that are not concerned with focusing specifically on inequality at the top or bottom ends of the income distribution (69,70). In terms of the previously mentioned criteria for inequality measures, Gini coefficients are independent of the population and economy size in question, align with the transfer principle, and are normalized to a range of 0 to 1, thus aiding in interpretation and comparability (70).

The Gini index also possesses some limitations that should be considered. It lacks sensitivity to inequalities at the extreme ends of the income distribution, which could be an issue in areas with considerable inequality only among the very rich or very poor (69). Similarly, it cannot distinguish between different types of inequality, as different economies with vastly different income distribution could have similar Gini coefficients. For example, in a theoretical situation comparing one area where half the population earned 0% of the total income and the other half received 100% of the total income with another area where three-quarters of the population earned 25% of the total income while the remaining quarter received 75%, both areas would register a Gini of 0.5 (70). Finally, the value and range of Ginis for a given area could vary depending on the type of income it is derived from (e.g., before- versus after-tax income), with Gini calculated from after-tax income accounting for some of the redistributive properties of taxation (66,70).

Percentile/Share Ratios

Percentile and share ratios are other widely-used measures of income inequality that consider more specific regions of the income distribution (70). These ratios can be calculated

relatively simply by dividing the income earned by the top X% of individuals or households by the income earned by the poorest X%. Some common percentile ratios include the interdecile or 90/10 ratio comparing the incomes of those at the top 10% of the income distribution relative to those at the bottom 10%, and the Palma or 90/40 ratio comparing the top 10% with the bottom 40% (69,70). The 90/10 ratio based on disposable household income data in the United States was 6.3 in 2016, suggesting that the top 10% of households were earning over six times as much income as the bottom 10%. A ratio at or below 1.0 is considered relatively equal.

A main benefit of using this measure is that it allows for relatively straightforward sensitivity analyses (69). One could assess the robustness of an association between health outcomes and the 90/10 ratio, for example, by comparing the results with findings using 80/20, 70/30, and 60/40 ratios. As such, this method of operationalizing income inequality is explicit in regards to which region of the income distribution is being considered, and can be used to gauge which regions of the income spectrum contain the greatest inequality (69,70). However, percentile and share ratios fail to account for income differences within percentiles, as well as how income is concentrated below the lowest percentile and above the greatest percentile. Further, it does not fully satisfy the transfer principal, as it is not fully sensitive to income transfers that occur within the percentiles being considered (70).

Robin Hood Index

As with the Gini index, the Robin Hood index is derived from the Lorenz curve (69,72; Appendix A.1). It is defined as the maximum vertical distance between the Lorenz curve and the 45° line of equality, and can be understood more broadly as the proportion of income that must be transferred from those above the mean to those below the mean in order to achieve an equitable income distribution (72). Thus, a higher Robin Hood value signifies a more unequal area, with values ranging from 0 (complete equality) to 100 (complete inequality).

The Robin Hood index is relatively simple to calculate, and as with the Gini index, it demonstrates scalar independence and normalization, and is thus a good measure for comparability. However, Robin Hood values are also not able to highlight specific regions of inequality along the income distribution, and fail to capture transfer from richer to poorer individuals who are on the same side of the mean income (69,72). Thus, this measure could fail

to capture the impacts of redistributive policies affecting those above or below the mean level of income (72).

Coefficient of Variation (CV)

The coefficient of variation is perhaps one of the simplest measures of income inequality, and is calculated by dividing the standard deviation of the income distribution by the mean(69,70). The CV does not have an upper bound, with higher scores (i.e., greater standard deviations) indicating greater inequality. This method has numerous advantages, including simplicity (i.e., it can be generated with relatively little information), scale-invariance (as it is based on variability relative to a mean), and agreement with the Gini coefficient when comparing income distributions that do not have intersecting Lorenz curves (70). As the CV is fairly sensitive to the right tail (i.e., richest) of the income distribution, this measure can be quite useful when the inequalities at the top of the income distribution are of particular interest (70).

However, due to the lack of an upper bound and its limited use within the income inequality and health literature, studies using the CV face limitations in terms of comparability with other studies (69). Additionally, the mean and standard deviation of an income distribution could be highly influenced by extreme outliers and a non-normal income distributions, meaning that the CV could fail to capture an accurate measure of inequality (69,70).

Proportion of Total Income Earned

This measure can be understood simply as the amount of income shared by the bottom X% of the population in a given area (69). Typically, proportions of the bottom 50%, 60%, and 70% are used (69,72). The proportion of total income earned presents a highly intuitive measure of inequality that can be easily calculated with minimal information and basic data analysis software (69). However, this measure provides very little insight into the nature of the income distribution itself, as the proportion of income earned by bottom X% of individuals or households does not indicate how income is shared within that group or among those at the top of the income distribution (69).

Atkinson Index

Unlike other common measures such as the Gini and Robin Hood index, the Atkinson index explicitly accounts for varying inequalities along the income distribution spectrum (69,72,73). The calculation of the index includes a sensitivity parameter (ϵ), which ranges from 0 to infinity with higher values indicating an increasing aversion to income inequality (ergo, a greater desire to prioritize equality over higher individual incomes) (69,73). Higher values of ϵ also increase the sensitivity of the index to inequalities at the bottom end of the income distribution (69). Typically, the values of the sensitivity parameter are set at 0.5, 1.0, or 1.5. The index itself ranges from 0 (equal distribution of incomes) to 1 (highly unequal distributions of incomes). The Atkinson index can be interpreted as describing the level of income required to achieve the current level of social welfare if incomes were equally distributed (69,72). To clarify, De Maoi (69) presents the example that an Atkinson value of 0.20 would indicate that the current level of social welfare within an area could be achieved with 80% (1.00 - 0.20) of the current income if this income was distributed equally.

A key strength of this measure is that it is decomposable, meaning that it can quantify inequality in terms of both between- and within group inequality (73). This distinction is quite useful in terms of determining what aspects of inequality are driving income inequality trends overall. Beyond its adherence to the criteria listed above, the Atkinson index can also highlight the welfare implications of inequality and adjust for the varying attitudes of different societies towards income inequality (73). However, calculating an accurate Atkinson index could be difficult if little is known about the level of inequality aversion of the group(s) being studied.

Summary

Despite the relative strengths and weaknesses of these various measures of income inequality, there remains a lack of consensus as to which measures should be used in different contexts when studying population health (69). An early study by Kawachi and Kennedy (72) investigated whether observed associations between age-standardized mortality rates and income inequality in the United States differed based on the measure of inequality used. The authors reported that all their measures of inequality, including the Gini, Robin Hood, and Atkinson indices, decile ratios, and Theil's entropy measure, were highly correlated both with one another (Pearson $r \geq 0.86$) and with mortality rate (Pearson r ranging from 0.50-0.66). These results

suggest that the choice of measure does not influence the observed associations between income inequality and health. Consequently, this paper has been cited by many subsequent studies to justify their choice of inequality indicator (69). However, other studies have demonstrated that associations between inequality and health could in fact be influenced by the measure used. Weich et al. (74) reported a significant association between regional income inequality and poorer self-rated health when using the Gini index (OR=1.21, 95%CI=1.06, 1.39), but found that this association was not significant when using the generalised entropy index. These discrepancies highlight the need to consider how the characteristics of the various inequality measures could relate to the robustness of evidence supporting the income inequality hypothesis in different contexts. Therefore, when investigating the income inequality hypothesis, it is important to be purposeful when selecting a measure of inequality to best capture the degree and characteristics of income inequality for the population(s) and geographic area(s) of interest.

As mentioned previously, the Gini index is among most commonly used measures of income inequality in public health and economics research (69,70; see section 3.3), due in large part to its many strengths. Gini coefficients provide single summary measures of inequality that encompass more information on the entire income distribution that simpler measures (e.g., coefficient of variation, percentile ratios, proportion of income earned), meet the key criteria of a valid and effective measure of inequality, and allow for the study and comparisons of inequality within and between populations at smaller (e.g., neighbourhood, cities) and larger (e.g., within and between countries) geographic scales (69–71). This study utilizes the Gini index to operationalize income inequality in order to draw on these strengths, as well as to allow for comparability with the many existing studies linking inequality to mental health that utilize this measure. Further discussion of the Gini index, including further rationale for its inclusion as the measure of income inequality in this thesis, is provided in section 4.2.6.

2.2.3 *Trends in Income Inequality*

Further work investigating the relationship between income inequality and health is timely, considering the substantive historic and contemporary changes in income distributions at international, national, and local scales. Overall, the global distributions of income both between and within individual countries have and are continuing to becoming more unequal (30,35,40,44,61,66,67), with incomes and wealth becoming more concentrated among those at

the upper end of the income spectrum (45,57,65). A 1996 report from the United Nations found that the richest 358 individuals in the world possess more economic wealth than the collective annual incomes of the poorest countries that are home to 45% of the world's population (35,57), with more recent data of OECD countries indicating that the top 10% control half of all household wealth and have incomes approximately 10 times higher than those of the poorest 10% (65). This disproportionate concentration of incomes is also reflected within developed countries, such as the United States and Canada. Between 2002 and 2012, Americans in the top 0.01% experienced an increase in incomes of 76.2%, whereas Americans in the bottom 90% experienced a decline of 10.7% (75). In Canada, the total income shares of those in the top 1% increased from approximately 7.5% in 1982 to just over 10% in 2014, with the richest 20% of Canadian households possessing 67% of the country's net worth in 2012 (44). It is possible that these increases in incomes for those at the top end of the income distribution come at the expense of the 'disappearing middle class', as more of the population is funneled into the low (i.e., poor) and high (i.e., very rich) tails of the income distribution (30,44,45).

When considering how income inequality has changed over time, available data suggest that between-country inequality has increased considerably between 1820 and 2000. During this period, income inequality (Gini coefficient) increased from 0.20 to 0.54, with the mean GDP of the richest country (United States) growing from six times to 134 times higher than that of the poorest country (Congo) (66). This dramatic increase has been linked to much higher economic growth rates in developed countries compared to other areas in the world, as well as recent events such as the poor economic growth in Latin America, decreasing incomes within Eastern European (former Soviet Union) countries, and considerable economic issues in various African countries (66,76). Interestingly, between-country income inequality has been decreasing and stabilizing since the early 2000s, likely due to increases in commodity prices that have prompted economic growth in many commodity-producing developing countries, as well as relatively slower growth among developed countries (66,76). In terms of within-country income inequality, available estimates suggest that this form of inequality remained fairly constant between 1820 and 1960 and increased sharply in the mid-1970s, especially in highly populated countries like China and the US (66). In particular, both market and net inequality have been increasing considerably in North American and Western European countries, due in large part to productivity outpacing wages and redistributive transfers, increases in top management and

'superstar' wages, and a rising concentration of capital-related income (66). Although trends in global income inequality are difficult to quantify due to limitations in data availability, quality, and collection methods, there is a general consensus that current global inequality has increased markedly since 1820 and is overall higher than both within- and between-country inequality (66).

Canada has experienced changing trends in income inequality that have, interestingly, diverged at different geographic scales. National income inequality rose fairly steadily from the late 1970s to the early 2000s, with sharp spikes in the 1980s and 1990s, and has since reached a plateau (44). These historical increases are likely attributable to the technology-driven polarization of the labour market (i.e., many middle-skill and middle income jobs have been automated) and poor job growth during the recovery period following the 1990s recession, with the recent stabilization possibly due to greater growth in jobs across the income spectrum (44). Changing inequality trends have been fairly similar at the province level, however there are some notable exceptions. While income inequality in most provinces stabilized during the 2000s following increases during the two decades prior, it has continued to rise in Alberta (Gini from 0.294 in the early 1980s to 0.319 in 2014) while declining in Quebec (Gini 0.284 to 0.281) and New Brunswick (Gini 0.281 to 0.277) (44). Further, moving to a lower geographic scale reveals that the majority of increases in inequality have been concentrated in Canada's four largest census metropolitan areas (CMAs): Toronto, Montreal, Vancouver, and Calgary, which are home to 40% of Canada's population (44,67). Calgary in particular has experienced considerable increases in inequality, where from 1980 to 2005 the income of the riches 10% of neighbourhoods increased by 74.0% (67). Calgary has experienced an increase in after-tax Gini coefficient almost four times higher than the national average increase in Gini between 1982 and 2014 (44). This trend of increase focused mainly in the top CMAs is especially concerning, as they are home to such a large portion of the Canadian population (44). Thus, conducting a study of income inequality and health at the level of Calgary neighbourhoods, an area that has seen marked widening of inequality, is apt within a Canadian context.

2.2.4 *Proposed Mechanisms Linking Income Inequality to Health*

While the current literature linking income inequality to mental health outcomes is mixed, as described further in chapter 3, a growing majority of studies suggest that greater income inequality is associated with poorer mental health outcomes (15,35,36,40). As evidence

in support of this relationship grows, further investigation into the potential causal nature of the income inequality-health relationship has generated hypotheses of potential mediating mechanisms (40). Currently, there remains speculation and debate as to the specific mediators that underpin, shape, and link income inequality to adverse mental health outcomes, the specific geographic location and scale(s) at which the income inequality hypothesis applies, and what health indicators should be measured to capture this link (62–64). However, there are multiple pathways and associated mechanisms through which relative income inequality is suspected to influence mental health, independent of absolute income, that have been proposed (15,34,35,57,63,64).

One theory, commonly referred to as the psychosocial or status anxiety hypothesis, posits that increasing relative income inequality can lead to invidious social comparisons and a growing sense of relative deprivation (57). While these comparisons are thought of as occurring primarily in an upward direction, meaning that those at the lower end of the income distribution compare themselves unfavorably to those who are better-off, individuals in moderate and higher income ranges also experience invidious comparisons. Subsequently, stressful comparisons and social divisions could lead to feelings of shame, hostility, and social isolation, resulting in adverse mental health outcomes including psychological distress, anxiety, and depression (34,35,40,57,77). This psychological mechanism of inequality impacting health aligns well with the causal criterion on biological plausibility, specifically the biology of chronic stress and social sensitivity, the ‘fight-or flight response to stressful environments, and the importance of positive social connection for well-being and survival highlighted by evolutionary biology (40,64). Adverse social comparisons could arise both from an individual’s sense of being relatively deprived compared to the individuals around them (despite being able to satisfy their basic needs), as well as being unable to attain the norms of income and material consumption within a given area (e.g., everyone else in the neighbourhood owns at least two vehicles, a smartphone, and designer clothing) (35). As such, these comparisons could be compounded by other exogenous social and systemic factors, such as racial disparities arising from institutionalized, personally-mediated, and internalized racism and discrimination, as well as various individual level factors such as SES, level of education, and relative deprivation (30,35,57,63,78,79).

Previous literature has reported no marked differences in the level of social comparisons across genders, suggesting that men and women are equally likely to engage in social

comparisons (80,81). A study of 18 countries found that the intensity of income comparisons ("How important is it to you to compare your income with other people's incomes?") did not differ when comparing men to women (β=-0.020, SE=0.038, $p>0.10$) (80). However, the types of comparisons differed ("Whose income would you be most likely to compare your own with?"), with men less likely to compare themselves to family members (β=-0.452, SE=0.098, $p<0.05$) and more likely to compare themselves to others (i.e., not family members or friends; β=0.157, SE=0.094, $p<0.05$), relative to women. Similar evidence suggests that specific life domains play an important role in social comparisons, with women indicating a greater sensitivity to comparisons and inequities related to housework, and men indicating greater sensitivity to comparisons and inequities relating to paid work (79). These distinctions suggest that differences exist in terms of the reference points (i.e. who individuals are comparing themselves to) and types of social comparisons taking place across genders. Differences in gendered life experiences could contribute to disparities in how males and females compare themselves to others and subsequently manifest distress, with females tending to exhibit a greater emphasis on the collective (i.e., others) over the self (79). So, while women and mothers might not experience more social comparisons than their male counterparts, they could be more susceptible to the adverse effects of social comparisons in highly unequal areas during their transition from pregnancy to parenthood; a period involving considerable psychological, emotional, and social changes, as well as heightened worry and pressure of being perceived as a "perfect parent" (17,53). It is worth noting that the bulk of this social comparison literature appears to consider gender in a strictly binary manner (i.e., women and men), with little information on how transgender and non-binary individuals engage in and react to social comparisons (82).

Another proposed mechanism, the social capital hypothesis, suggests that high levels of income inequality can erode social capital and social cohesion between individuals and groups (15,34,57,64,77). Although the definition of social capital remains highly variable between disciplines, it is generally understood as resources that emerge through social connections (e.g., social support, civic participation, trust, norms of reciprocity, cooperation for mutual benefit) that can be accessed via membership within a certain social network or group (35,64). In addition to providing these beneficial resources, social cohesion at the neighbourhood level has been identified as a protective factor against the adverse impacts of deprivation on mental health (83). As increasing income inequality creates wider gaps and more distinct social strata between

those with more or less income, social capital and social cohesion could begin to break down, thus resulting in feelings of mistrust, isolation, and stress, ultimately leading to poor mental health (34,35,40,77). Considering that levels of social connectedness, access to social capital, and mistrust can be felt by all individuals within an area, this mechanism suggests that the impacts of increasing income inequality would be felt not only by those at the bottom of the income distribution, but by the rich as well (34,35). Both the social capital and the social comparison pathways are suspected as being more relevant for more local scales of inequality, such as neighbourhoods and communities (15).

Various gender disparities in social capital, supports, and networks are highlighted within the literature. While women have demonstrated a greater responsiveness to social support (84,85), and a tendency to report receiving higher levels of social support compared to men (79), men tend to have larger social networks that are typically more resource rich (i.e., provide access to more varied and influential social resources) (86). The composition of these networks also vary, with women's social networks typically comprised of more intimate connections with close family, friends, and neighbours, and men's networks typically comprised of more diffuse relationships involving coworkers, advisors, and friends (85–89). Erosion of social connectedness at a more local scale (e.g., neighbourhoods) could have a greater impact on women, then, as their more proximal sources of support and social capital break down. Strange et al. (90) found that mothers who engaged in civic participation and connectedness within their local area of residence experienced strong benefits to their social capital and mental well-being, whereas those who engaged outside their local area did not. These findings suggest that a more local context of social connectedness is especially salient for mothers (90). Furthermore, a study by Brown et al. (91) of inner city mothers indicated that those who reported adequate social support at baseline and then subsequently lost that support over time (i.e., support was not available when they needed it) were at high risk of developing depression (89,91). Therefore, as social cohesion and social capital within a smaller area erode over time, pregnant and new mothers could experience greater difficulties in maintaining their social networks and accessing social support and community resources, such as informal playgroups and parent networks, and suffer greater isolation and poorer mental health as a result (89–91).

A third potential mechanism, the neo-materialist hypothesis, presents an argument for a contextual effect of income inequality whereby highly unequal areas experience various forms of

material deprivation (15,34,35,57,64,77). This hypothesis suggests that increasing inequality within an area results in underinvestment in social infrastructure and safety nets, such as health services, education, and transportation (64). Thus, those living in the area are prevented from accessing these important health-promoting resources, which could be especially detrimental for those with low income by compounding the barriers that they face. Underinvestment in public resources could be attributed to the 'pulling-away' of the richest individuals from the rest of society (e.g., accessing private health care and schools, living in gated communities), and their subsequent reluctance to subsidize public services that they do not use and their requests for tax relief (35). This underinvestment also relates to the social capital pathway, as individuals are less inclined to support social programs and supports as inequality increases and social capital and cohesion break down (35).

Additionally, the neo-materialist pathway suggests that even the health of those who are not as sensitive to invidious social comparisons and relative deprivation would suffer in high inequality through degradation of public services, and that all but potentially the top 1% would suffer as a result of widening inequality. However, some authors have argued that the contextual effects of income inequality impact even the richest members of a society, as they are still exposed to the 'pathologies of poverty' (e.g., heightened exposure to crime, violence, certain infectious diseases), as well as feelings of fear and resentment that emerge in highly unequal areas (15,35,40). As opposed to the previous two mechanisms, the neo-materialist hypothesis is likely more relevant at regional, national, and international levels, as resource spending and allocation are not typically decided at the neighbourhood level (15,92). When taken together, these three potential mechanisms suggest that income inequality could be acting on health through different pathways depending on the geographic level in question.

While there remains speculation and debate within the literature as to the specific pathways and their relative importance linking income inequality to health, some evidence has provided support for these three proposed mechanisms within general populations. A study of individuals from over 30 countries found that the influence of national income inequality (Gini) on individual mental wellbeing was attenuated by 30% and become non-significant when introducing variables related to status anxiety (perceived social position, anti-social behaviour, homicide rates) into multi-level models, thus supporting the status anxiety hypothesis (77). Layte (77) also reported a similar trend when testing the social capital pathway, with the inequality-

mental wellbeing association becoming attenuated by 45% and non-significant after adding social capital variables (trust in others, trust in institutions, affective social support, and civic participation). Further support for this pathway was provided by Oishi et al. (93), who found through multilevel mediation analysis that the negative link between country-level income inequality in the United States and happiness was explained by variables measuring general trust and perceived fairness. Although Layte (77) did not find evidence of significant mediation for neo-materialist variables (proportion of spending on social infrastructure, services, and benefits across countries), he suggests that other variables could be more appropriate for capturing the neo-materialist hypothesis of income inequality. When considering existing literature, it appears that no such studies have tested the specific mediators of income inequality on mental health among women and mothers. Further research in this vein is required to clarify the mechanisms through which inequality influences maternal health. However, to fully understand the nature and actions of these proposed pathways, as well as identify the specific mechanisms that are most relevant for different populations and at different geographical scales, we must first consider if and how income inequality is associated with adverse mental health outcomes.

– CHAPTER 3: NARRATIVE REVIEW OF ASSOCIATION STUDIES –

3.1 Overview

The following chapter presents a narrative review of association studies that explore the quantitative relationship between income inequality and mental health outcomes. The goal of this review was to describe the current evidence on the existence, nature, direction, and magnitude of these associations, especially in terms of mental health outcomes among women and mothers. By compiling this evidence, limitations and gaps in the current literature were identified to provide context for this thesis and future work in this area. The following sections include a description of the methods used to conduct this review, outline the characteristics of the captured studies, and describe and discuss their key findings, limitations, and gaps.

3.2 Methods

This thesis employed a narrative literature review to answer the research question "Are higher levels of income inequality associated with poorer mental outcomes?". A narrative review provides a useful approach to determine what is known about a particular field or subject of research. Although not as rigorous or exhaustive as a systematic review, it enables the collection and synthesis of published information in a way that highlights both existing evidence as well as current contradictions, limitations, and gaps within the literature (94).

3.2.1 *Search Strategy*

This review was conducted by one reviewer (S. Lowe) using four databases (PubMed, PsycINFO, CINAHL, and Google Scholar) with a variety of search terms focused on income inequality (e.g., "income inequality*", "income inequit*, "Gini index") and mental health outcomes (e.g., "mental illness", "depress*", "anxiety", "distress"). Priority was given to studies that included women and mothers in their study samples, and had anxiety and depression as distinct outcomes. However, due to the limited number of studies meeting these criteria, the ultimate scope of the search was broadened to include various populations, mental health outcomes, and geographical contexts. Searches were conducted between October 2018 and May 2019, with an additional round of searches completed in January and August of 2020 to capture new and updates publications.

3.2.2 *Inclusion Criteria and Study Selection*

Criteria were established a priori to determine which of the captured studies to include in the review, and are as follows:

- Includes quantitative measure of income inequality (e.g., Gini Index, Robin Hood Index, Coefficient of Variation) and mental health outcome(s) (e.g., CES-D, Kessler Psychological Distress Scale, Composite International Diagnostic Interview)
- Includes quantitative analysis of the association between income inequality and mental health outcome(s)
- Peer-reviewed (i.e. academic) literature
- Human Subjects
- English language

The reviewer completed a two-stage screening process to identify relevant articles based on the above inclusion criteria. Primary screening involved a review of the titles and abstracts of studies captured in the searches. Secondary screening involved full-text reviews of the studies that met the criteria during primary screening.

3.2.3 *Data Extraction*

Using structured data summary tables, the following information was extracted from each of the captured articles:

- Identifying information (author, year, title)
- Study location, population, and objectives
- Study design, methods, and statistical analysis approach
- Main exposure (i.e., how income inequality was measured)
- Individual- and area-level covariates included in the analysis
- Outcomes variables and measures
- Key results and limitations

3.3 Study Characteristics, Measures, and Outcomes

Following both rounds of screening, 38 studies were included for data extraction and narrative review. Table 2 provides a summary of various characteristics of the 38 included studies, including location and study populations, study designs, measures of income inequality, and measures of mental health outcomes.

Table 3.1. Summary of study characteristics of papers included in the narrative literature review

Study	Location	Sample	Study Design	Inequality Measure	Mental Health Measure
International/Country Level Studies					
Cifuentes et al. (2008) (95)	International (65 Countries)	251,158 individuals from 65 countries captured by 2002 World Health Survey conducted by the WHO	Cross-Sectional	Country-level Gini coefficients • Calculated from 2002 data, or closest available year • Coefficients multiplied by 100 for modeling and interpretation	Algorithm derived from DSM-IV and Diagnosis Item Properties Study (major depressive episode) • Cases of MDE defined by two sets of questions (must have answered "yes" on at least four questions in first set, and at least two questions in second set)
Detollenaere et al. (2018) (96)	Europe (24 Countries)	45,007 respondents with data in the European Social Survey (ESS) and the Primary Health Care Activity Monitor Europe databases within 24 countries	Cross-Sectional	Country-level Gini coefficients • Estimated using 2011 household disposable income data	ESS question "how happy are you" (mental well-being/happiness) • Scores ranging from 0 ("extremely unhappy") to 10 ("extremely happy")
Kim and Haquist (2018) (97)	Sweden (14 municipalities within an unspecified county)	14,809 grade 9 students (aged 15-16 years) capture by the Young in Värmland study (collected six times between 1995-2011)	Repeated Cross-Sectional	Country-level Gini index • Generated using equalised household disposable income data from Statistics Sweden for the study years • Adjusted for household size and composition	Psychosomatic Problems Scale (mental problems) • Scales comprised of eight items related to mental health issues measured in 5-point Likert scale • Scores summed/transformed to linear scale using Rasch model
Oishi et al. (2011) (93)	United States	43,318 adults (aged 18 to 89 years) from the General Social Survey	Repeated cross-sectional	Country-level Gini index • Data (1972 to 2008) from US Census Bureau	Question from the General Social Survey (happiness) • "Taken all together, how would you say things are these days—would you say that you are very happy, pretty happy, or not too happy"

Table 3.1. Summary of study characteristics of papers included in the narrative literature review (cont.)

Study	Location	Sample	Study Design	Inequality Measure	Mental Health Measure
Rai et al. (2013) (98)	International (53 Countries)	187,496 adults (aged 18 years and over), including institutionalized individuals, from the WHO World Health Survey (2002-03)	Cross-sectional	Country-level Gini index • From the World Bank using values closest to 2002 for each country • Ginis expressed on percentile scale (0-100)	Composite International Diagnostic Interview (depressive episode) • Episode of depression based on presence of at least four symptoms, including three core symptoms, over a period of two weeks
Sommet et al. (2018) (99)	International (40 countries; Part I)	146,034 adults captured in four waves of Word Values Survey (1994-2014; Part I)	Repeated Cross-Sectional (Part I)	Country-level Gini coefficients (Part I) • Based on World Bank national estimates	One-item scale (feelings of unhappiness – Part I) • Scale ranged from 1 "very happy" to 4 "not happy at all"
Steptoe et al. (2007) (100)	International (23 Countries)	17,348 university students (aged 17-30 years) from the International Health and Behaviour Study	Cross-Sectional	Country-level Gini coefficients • Data from the World Resources Institute (1996) • Expressed on percentile scale (0-100)	Beck Depression Inventory (depressive symptoms) • Scores dichotomized (≥8 defined as elevated levels of depressive symptoms)
Yu (2018) (101)	International (122 Countries)	122 Countries from the Global Burden of Disease datasets (2016)	Ecological	Country-level Gini Index • Data from the World Bank and World Economic Forum	Recorded clinical case definitions consistent with International Classifications of Disease (major depressive disorders and dysthymia) • Depressive disorders were considered as both rate ratios (Females to Males per 100,000 individuals) and rates (DALYs for Depressive Disorder Rates per 100,000)

Table 3.1. Summary of study characteristics of papers included in the narrative literature review (cont.)

Study	Location	Sample	Study Design	Inequality Measure	Mental Health Measure
Weich et al. (2001) (102)	England (16 regions), Wales (1 region) and Scotland (1 region)	8,371 individuals (aged 16-75 years) from the first wave of the British Household Panel Survey (1991)	Cross-Sectional	Gini coefficients from each region • Separate coefficients calculated using net income and gross income from entire survey first wave sample • Regions characterized into four Gini categories (low to high)	General Health Questionnaire – 12 item version (common mental disorders) • Each item scored as "present" or "absent", with a score ≥3 being classified as a case (dichotomous)
State/Province Level Studies					
Du et al. (2019) (41)	China (20 Provinces)	29,331 adult respondents from waves I (2010) and III (2014) of the China Family Panel Studies Survey	Cohort Study (Longitudinal)	Province-level Gini index • Based on household income from Chinese statistical yearbooks	Six-item survey scale of symptoms of psychological distress in the past month (psychological distress) • Scores averaged, with higher scores = more severe distress • Composite score of one item for life satisfaction and one item for happiness (subjective well-being) • Higher composite score = better subjective well-being
Fan et al. (2011) (103)	United States (38 states and Washington, D.C.)	293,405 non-institutionalized adults (aged 18 years and older) captured in the Behavioural Risk Factor Surveillance System	Cross-Sectional	State-level Gini index • Based on self-reported gross income • Coefficients multiplied by factor of 10 for use in models	Patient Health Questionnaire-2 (depressive symptoms) • Based on cardinal DSM-IV symptoms • Score of two items ranged from 0-6, with depression= score ≥3

Table 3.1. Summary of study characteristic of papers included in the narrative literature review (cont.)

Study	Location	Sample	Study Design	Inequality Measure	Mental Health Measure
Fernandez-Nino et al. (2014) (104)	Mexico	8,874 older adults (aged 60 years and older) captured in the National Health and Nutrition Survey (2012)	Cross-Sectional	State-level and municipal-level Gini coefficients • Gini coefficients quantified using data from the Population and Housing Census 2010 (based on total household income in previous month, in pesos)	Centre for Epidemiological Studies Depression Scale – seven item version (depression) • Scores dichotomized, with ≥5 indicating depression
Henderson et al. (2004) (105)	United States (48 states excluding North Dakota and Nebraska)	42,862 non-institutionalized adults (aged 18 years and older) sampled from the National Longitudinal Alcohol Epidemiologic Survey	Cross-Sectional	State-level Gini coefficients • Both raw and adjusted (for taxes, case transfers, and household composition) calculated and divided into quintiles	Alcohol Use Disorder and Associated Disabilities Interview Schedule (depressive symptoms and Alcohol Dependence) • Dichotomized depression (one or more of nine depressive symptoms)
Kahn et al. (2000) (42)	United States (50 states)	8,060 women with children aged 26-48 months captured in the 1988 National Maternal Infant Health Survey	Cross-Sectional	State-level Gini coefficients • Calculated from 1990 US census data • States categorized into “low”, “medium”, or “high” inequality states	Centre for Epidemiologic Depression scale (depressive symptoms) • Scores dichotomized (≥16=correlated with presence of clinical depression)
Messias et al. (2011) (106)	United States (45 States)	235,067 non-institutionalized adults from the CDC’s Behavioral Risk Factor Surveillance System (2006 and 2008 waves)	Ecological	State-level Gini coefficients • Data from 2006 American Community Survey	Patient Health Questionnaire depression scale – 8 item version (depressive symptoms) • 8 criteria for depressive symptoms over past two weeks • Characterized as “major depression” if score ≥5, and “Other Depression” if score =2-4 (including at least one of two key criteria)

Table 3.1. Summary of study characteristics of papers included in the narrative literature review (cont.)

Study	Location	Sample	Study Design	Inequality Measure	Mental Health Measure
Pabayo et al. (2014) (107)	United States (50 States and District of Columbia)	34,653 non-institutionalized adults (aged 18 years and over) from the Epidemiologic Survey on Alcohol and Related Conditions	Cohort Study (Longitudinal)	State-level Gini coefficients • Calculated from US Census data • States categorized into Gini quintiles from low to high	Alcohol Use Disorder and Associated Disabilities Interview Schedule-IV (episodes of depression) • Outcome is dichotomous (episode vs. no episode)
Quon and McGrath (2015) (108)	Canada (10 Provinces)	11,899 adolescents (aged 12-17 years) captured by the Longitudinal Survey of Children and Youth (2001, 2006-07)	Cross-Sectional	Province-level Gini index • Calculated from 2000 and 2006 Statistics Canada data	Aggregated indices developed from Behaviour Checklist questionnaires (emotional disoders) • 7-items used to develop indicator for emotional disorders (α=0.76-0.79)
Municipality/County/District Level Studies					
Adjaye-Gbewonyo et al. (2016) (109)	South Africa	9,664 individuals (aged 15 years and older) from the National Income Dynamics Survey (2008 to 2012)	Cohort Study (Longitudinal)	District-level Gini coefficients • Based on self-reported gross income • Coefficients multiplied by factor of 10 for use in models	Centre for Epidemiological Studies Depression Scale Short form (depressive symptoms) • Scores ranging from 0-30 were dichotomized (≥10=high depressive symptoms)
Burns et al. (2017) (110)	South Africa	25,936 individuals (aged 15 years and older) from three waves (2008, 2010, 2012) of the National Income Dynamics Survey	Cohort Study (Longitudinal)	District municipality P90/P10 income inequality ratio • Ratio=mean income of 90^{th} income %ile divided by mean income of 10^{th} income %ile • Based on per capita household income data from 2005/2006	• Centre for Epidemiological Studies Depression Scale Short form (depressive symptoms) • Scores ranging from 0-30 were dichotomized (≥10=high depressive symptoms)

Table 3.1. Summary of study characteristics of papers included in the narrative literature review (cont.)

Study	Location	Sample	Study Design	Inequality Measure	Mental Health Measure
Chiavegatto Filho et al. (2013) (111)	Sao Paulo (Brazil)	3,542 adults (aged 18 years and older) from the Sao Paula Megacity Mental Health Survey	Cross-Sectional	Municipality and administrative region Gini coefficients • Based on self-reported gross income • Coefficients multiplied by factor of 10 for models	Composite International Diagnostic Interview (depression, anxiety, and any mental disorder) • Presence of depression, anxiety, and any mental disorder assessed according to DSM-IV criteria
Fujita et al. (2019) (112)	Chiba City (Japan)	116,658 beneficiaries of Japan's National Health Insurance (aged 20-69) who were enrolled for 3 years (2013-2016)	Cohort-Study (Longitudinal)	Gini-coefficients calculated for areas with 30-minutes walking distance of the participants' houses • Coefficients divided into quartiles	Insurance claim "0504" during study period (various mood disorders) • Code corresponds to F30-F39 conditions in the International Statistical Classification of Diseases – 10 • Dichotomous outcome modelled as incident cases over the study
Lin et al. (2017) (113)	China (8 Cities)	15,999 individuals captured in the Internal Migrant Dynamic Monitoring Survey (2014)	Cross-Sectional	City-level Gini coefficients • Calculated using monthly income of the internal migrants and set as low (0.2 Gini≤ 0.3), medium (0.3<Gini≤0.4), high (0.4 <Gini≤0.5), and very high (Gini>0.5) inequality	K6 Scale of Psychological Well-being (mental health) • Higher scores=better mental health
Quon and McGrath (2015) (114)	Canada (109 schools)	2,199 adolescents (aged 13-16) from the Quebec Child and Adolescent Health and Social Survey	Cross-Sectional	District-level coefficient of variation • Squared coefficient of variation $(SD/N)^2$, reverse-coded	Multi-item scales with Likert responses (anxiety, depression, anger) and Rosenberg self-esteem scale (self-esteem) • 3 items for anxiety, 4 items for depression, 4 items for anger • Higher scores=higher self-esteem

Table 3.1. Summary of study characteristics of papers included in the narrative literature review (cont.)

Study	Location	Sample	Study Design	Inequality Measure	Mental Health Measure
San Sebastian et al. (2018) (115)	Sweden (4 Municipalities)	21,004 adults (aged 24-84) captured in the Health on equal terms survey	Cross-Sectional	Municipal-level Gini coefficients • Calculated by aggregating individual-level income data from Statistics Sweden and divided into quintiles	General Health Questionnaire – 12 item version (common mental disorders/psychological distress) • Respondents classified as a case if score≥3
Sommet et al. (2018) (99)	Switzerland (1,745 municipalities; Part II)	14,790 participants from the first 15 years (1999-2013) of the Swiss Household Panel (Part II)	Cohort Study (Longitudinal)	Municipal-level Gini coefficients (Part II) • Calculated using data from the Swiss Federal Statistical Office	One-item scale (psychological health problems – Part II) • Scale ranged from 0 "never to 10 "always" in which participants "have negative feelings such as having the blues, being desperate, suffering from anxiety or depression)
Sturm and Gresenz (2002) (116)	United States (60 Metropolitan Areas)	8,235 adults captured in Health for Communities survey (1997-98)	Cross-Sectional	Metropolitan-area Gini coefficients • Ginis generated from community tracking study	Composite International Diagnostic Interview (depressive and anxiety disorders) • Dichotomised outcomes
Zimmerman and Bell (2006) (117)	United States (855 counties)	4,817 individuals (aged 40-45) captured in the 2000 wave of the National Longitudinal Survey of Youth	Cross-Sectional	County-level inequality measured as "percent rich" • Calculated as the percentage of households with annual income over $150,000	• Centre for Epidemiologic Studies Depression Scale (depressive symptoms) • Scores dichotomised (score ≥16 indicates depression)
Community/Neighbourhood Level Studies					
Ahern and Galea (2006) (118)	New York City (NY)	1,355 adults (aged 18 years and older) residents of NYC metropolitan areas	Cross-Sectional	Neighbourhood-level Gini coefficients • Calculated using 2000 USA census data on 59 community districts in NYC	National Women's Study Depression Module (depression) • Depression=five or more predefined symptoms over past six months

Table 3.1. Summary of study characteristics of papers included in the narrative literature review (cont.)

Study	Location	Sample	Study Design	Inequality Measure	Mental Health Measure
Bisung et al. (2018) (43)	Accra (Capital city of Ghana)	2,814 adult women (aged 18 and over) within 195 enumeration areas from wave II of the Women's Health Survey Accra (2009)	Cross-Sectional	Gini coefficients at the sub-metro-level (6 sub-metros in study) • From Ghana Statistical Services • Ginis dichotomized into low inequality (<0.35) and high inequality (≥0.35)	Survey question "In the last month (4 weeks), about how often did you feel so depressed that nothing could cheer you up?" (depressive symptoms, dichotomized) • Survey question "How much of the time during the past 4 weeks have you felt downhearted and letdown?" (feeling downhearted, dichotomized)
Erdem et al. (2019) (119)	The Netherlands	343,327 citizens (aged 19 years and older) captured by a national public health survey (Gezondheidsmonitor Volwassenen GGD-en, CBS en RIVM)	Cross-Sectional	Neighbourhood-level (n=7,803) and municipality-level (n=406) Gini coefficients • Based on 2012 Statistics Netherland's standardized disposable household income data • Quintiles made at neighbourhood and municipality-level	Kessler Psychological Distress Scale (psychological distress) • Distinguishes DSM-IV "cases" from "non-cases" • 10-item scale to assess levels of anxiety and depressive symptoms in past four weeks • Continuous (higher scores= greater distress)
Fiscella and Franks (2000) (120)	United States	6,913 non-institutionalized adults (aged 25-74 years) from the National Health and Nutrition Examination Survey (1971-1975) and Epidemiologic Follow-up Survey (1982-84, 1986-87)	Cohort Study (Longitudinal)	Community-level index of proportions • Aggregate income of the poorest 50% of the population divided by the aggregate total income of the community	General Well-Being Schedule (depressive symptoms) • Depression subscale based on symptoms of depression experienced in the last week • Scores ranging from 0-25, with lower scores indicating more depressive symptoms

Table 3.1. Summary of study characteristics of papers included in the narrative literature review (cont.)

Study	Location	Sample	Study Design	Inequality Measure	Mental Health Measure
Fone et al. (2013) (92)	Wales	88,958 individuals (aged 18-74 years) from the Welsh Health Survey)	Cross-Sectional	Neighbourhood-level (n=1,887) and unitary authority (n=22) Gini coefficients • Ginis calculated using 2001 gross household income estimates from lower super output areas (neighbourhoods) and unitary authorities (regions) • For regions, dichotomized into high and low inequality • Relative deprivation Calculated based on % of households in each LSOA with gross income <10,000 British pounds	Mental Health Inventory – 5-item subscale of Short Form Health Survey (mental well-being) • Considers symptoms of mood and anxiety disorders over past four weeks • Scores ranging from 5-25 were transformed into 0-100 scale (100=best possible mental health) and dichotomized (≤60=common mental disorders)
Gresenz et al. (2001) (121)	United States (60 communities across the country)	6,925 individuals (under 65 years) captured by the Healthcare for Communities study (1997-98)	Cross-Sectional	Community-level Gini coefficients • Derived from 1996-97 Community Tracking Survey Data • Also utilized community-level Robin Hood index and share of total income of lowest 50% of families	Mental Inventory-5 (general mood, including anxiety and depression) • Scale from 0-100; lower scores indicating worse mental health • Composite International Diagnostic Interview (various mental disorders) • Dichotomized (at least one mental disorder)
Marshall et al. (2014) (122)	England	10,644 adults (aged 50 years and over) in private households from the English Longitudinal Study of Aging (2002-2003)	Cross-sectional	Neighbourhood-level Gini (Middle Super Output Areas) • Calculated using data on the 2^{nd}, 25^{th}, 50^{th}, 75^{th}, and 98^{th} percentiles of house prices (Office for National Statistics)	Centre for Epidemiological Studies Depression Scale – 8 item version (depressive symptoms) • Scores dichotomized (≥4 indicating depression)

Table 3.1. Summary of study characteristics of papers included in the narrative literature review (cont.)

Study	Location	Sample	Study Design	Inequality Measure	Mental Health Measure
McLaughlin et al. (2012) (78)	United States	6,483 adolescents (aged 13-17 years) from the National Comorbidity Survey Adolescent Supplement (2001-2004)	Cross-sectional	Community-level Gini coefficients • Estimated using data from the adolescents' census tracts	Composite International Diagnostic Interview (mental disorders) • Assessed symptoms of mood, anxiety, disruptive behaviour, and substance disorders in past 12 months
Pabayo et al. (2016) (123)	Boston, MA (38 neighbourhoods)	1,614 students (aged 14-19 years) in grades 9-12 in Boston Public Schools from the Boston Youth Survey (2008)	Cross-sectional	Census-tract (neighbourhood) level Gini coefficients • Calculated by Boston Indicators Project • Coefficients standardized using z-transformation	Adapted version of the Modified Depression Scale (depressive symptoms) • Scales measured frequency of five symptoms in past month on Likert scale • Total score=sum of all five items, with higher scores indicating more severe depression symptoms
Vilhjalmsdottir et al. (2016) (124)	Iceland	5,958 adolescents (aged 15-16 years) from 102 schools captured in Youth in Iceland survey (2006)	Cross-Sectional	Neighbourhood-level ratio of mean disposable income of top 20% highest income households and 20% lowest income households • Higher values indicate greater inequality	Symptoms Checklist 90 – 12 item scale (emotional distress) • Likert scale responses from experiencing symptoms (1"near to never" to 4"often"), with mean score as overall measure of emotional distress

Table 3.1. Summary of study characteristics of papers included in the narrative literature review (cont.)

Study	Location	Sample	Study Design	Inequality Measure	Mental Health Measure
Vilhjamsdottir et al. (2018) (125)	Iceland	10,223 grade 9 and 10 students (aged 15-16 years) from 82 schools captured in Youth in Iceland Survey (2006 and 2014)	Repeated Cross-Sectional	Neighbourhood-level Gini coefficients • Based on equivalized disposable household income of households with children (aged 0-18)	Hopkins Symptoms Checklist 90 (anxiety and depression) • Anxiety symptoms measured with a mean scale of three items (higher scores=worse symptoms) • Depressive symptoms measured with a mean scale of nine items (higher scores=worse symptoms) • Scales gauge symptoms experienced in last week
Vilhjalmsdottir et al. (2019) (126)	Iceland (76 Neighbourhoods)	24,107 grade 9 and 10 students (aged 15-16 years) from 76 neighbourhood communities captured in Youth in Iceland Survey (2006, 2009, 2012, 2014, and 2016)	Repeated Cross-Sectional	Neighbourhood-level equality index (20/80 ratio) • Ratio=mean disposable equivalized income of those in the lowest 20% of household incomes divided by the mean income of those in the highest 20% of household incomes • Higher values indicate greater equality • 1-year lag (e.g., 2005 income data used for 2006 wave of Iceland survey)	Anxiety and depressive symptoms measured using items from the Hopkins Symptom Checklist-90 • Anxiety symptoms assessed using a mean scale of three items (alpha=0.75-0.82) • Depressive symptoms assessed using a mean scale of nine items (alpha=0.89-0.92) • Both scales were log transformed

Locations and Populations of Interest

In total, 38 studies were captured in this review, spanning a variety of areas, measures, and geographical scales. The largest proportion of these studies (37%, n=14) were set in the United States, with three studies from Iceland (124–126), two studies each from Canada (108,114), Sweden (97,115), China (41,113), and South Africa (109,110), and one study each from Brazil (111), Mexico (104), Ghana (43), The Netherlands (119), Japan (112), Wales (92), and England (122). Additionally, two studies had respondents from multiple European countries (96,102), and five studies compared samples at the international scale (capturing between 23 and 122 countries). Of the captured studies, 61% (n=23) were comprised of individuals from general populations, typically defined as non-institutionalized adults over the age of 18 or 19 , with two of these studies (109,110) setting their minimum age at 15. However, a number of studies were conducted with specific populations, including: school-aged adolescents (n=8); older adults (aged 40-60+; n=3); internal migrants in China (113); university students aged 17-30 (100); adult women (43); and mothers of children aged 26-48 months (42). All of the 38 studies had large sample sizes over 1,000 individuals, ranging widely from 1,355 (118) to 343,327 (119) individuals.

Study Designs and Measures

A large majority (79%, n=30) of the 38 studies utilized a cross-sectional study design, while others included cohort (18%, n=7) and ecological (5%, n=2) study designs. One study by Sommet et al. (99) conducted a two part study that involved both a cross-sectional (part I) and longitudinal cohort (part II) approach. Of the cohort studies, two were conducted in the United States (107,120), two in South Africa (109,110), and one in Japan (112), Switzerland (99), and China (41). One of the ecological studies was based in the United States (106), and the other involved various (n=122) United Nations member state countries (101).

The vast majority of the studies (84%, n=32) measured and reported income inequality in terms of the Gini coefficient. The other studies utilized ratio measures such as P80/P20 (124) and P90/P10 ratios (110), measures of variance including the squared coefficient of variation (114), or proportion measures such as the income of the poorest 50% of a community divided by the total income in that community (120). One study created an equality index based on a 20/80 ratio where the mean disposable equivalized income of 20% of lowest income households was divided

by that of 20% highest income households, with increasing scores indicating greater equality/lower inequality (126).

There is considerable heterogeneity in terms of both the targeted mental health outcomes and the associated measures reported in the literature. The most common mental health outcomes were depression (53%, n=20) and overall mental well-being/adverse mental health/psychological distress (45%, n=17) often defined as experiencing symptoms of one of more common mental illnesses (e.g., mood, anxiety, behaviour, or substance disorders). Only five (13%) of the studies considered anxiety as a distinct mental health outcome separate from depression (78,111,114,125,126). Bisung et al. (43) reported "feeling downhearted" as a mental health outcome separate from depressive symptoms. Many studies also considered other non-mental health outcomes, such as general physical health (42,114,116,117,120), alcohol dependence (114,124), and subjective well-being (41,114).

Although most of the mental health outcome data from these studies were collected by standardized interviews (in-person or via telephone) and questionnaires, the specific tools and measures used varied considerably. The most commonly used tools for assessing mental health included the Centre for Epidemiologic Studies-Depression Scale (16%, n=6) and variations of the Composite International Diagnostic Interview (13%, n=5), with other specific tools including the National Women's Study Depression Module (118), the Kessler Psychological Distress Scale (119), the K7 Scales of Psychological Well Being (113), the Health Quebec's Index of Psychological Distress (114); and the Psychosomatic Problem Scale (97). While some studies developed their own mental health assessment scales to collect data, most of these measures were based on symptomatology and diagnostic criteria outlined by the Diagnostic and Statistical Manual of Mental Disorders (DSM).

3.4 Study Results and Discussion

Table 3 provides a summary of the key findings of the 38 reviewed studies as they pertain to mental health outcomes. The findings of captured studies investigating the relationship between income inequality and mental health were mixed, with 61% (n=23) of the 38 studies reporting unambiguous, statistically significant associations after adjusting for confounding variables. Of these 23 studies, 91% (n=21) indicated inverse relationships, signifying that increasing income inequality resulted in worse mental health. The remaining studies reported

that increasing income inequality was associated with better mental health (115,122). Of all the studies, 13% (n=5) reported mixed or ambiguous results, such as the direction of association changing depending on the level of individual income (102) or only finding a significant relationship in bivariate analysis among men (127). Of all studies, 26% (n=10) reported no significant associations between income inequality and mental health.

Table 3.2. Summary of key findings from papers included in the narrative literature review

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Inverse Associations (greater inequality associated with more adverse mental health outcomes)						
Ahern and Galea (2006) (118)	United States (Neighbourhoods) Cross-Sectional	Depression (dichotomous)	Gini coefficient range: 0.37-0.51	**Individual-level:** age, race/ethnicity, gender, income **Area-level:** median household income	• Among low income adults (< $20,000), strong association between increasing income inequality and depression (β=35.02, SE=9.66, p<0.01) • Among low income adults, those living in high inequality neighbourhood had higher odds of depression (OR=3.76, p<0.01) and those living in low inequality neighbourhood had lower odds (OR=0.27; p<0.01) compared to those living in neighbourhoods with average inequality	• Associations only in low-income adults (income* inequality)
Burns et al. (2017) (110)	South Africa (Municipalities) Cohort (Longitudinal)	Depression (dichotomous)	P90/P10 ratio range: 0.46-0.68	**Individual-level:** age, gender, education, employment status, ethnicity, marital status, household income, assessment year	• Increasing income inequality associated with greater risk of depression (β=0.04, 95% CI=0.01, 0.07) • Decreasing household income and increasing income inequality associated with increased risk of depression (β=0.01, 95% CI=<0.01, 0.01) • No significant interaction between gender and income inequality	• Significant increase in estimated depression risk for lowest and second lowest income groups living in higher versus lower inequality areas (income* inequality)

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Chiavegatto Filho et al. (2013) (111)	Brazil (Municipalities) Cross-Sectional	Depression (dichotomous) Anxiety (dichotomous) Any Mental Disorder (dichotomous)	Gini coefficient range: 0.18 (mean of first tertile) to 0.34 (mean of third tertile)	**Individual-level:** sex, age, education, income, marital status	• Living in areas with medium inequality associated with higher odds of depression (OR=1.7, 95% CI=1.21, 2.55) and any mental disorder (OR=1.32, 95% CI=1.03, 1.68), compared to living in low inequality areas • Living in areas with high inequality associated with higher odds of depression (OR=1.53, 95% CI=1.07-2.19) compared to living in low inequality areas	• N/A
Cifuentes et al. (2008) (95)	International (Countries) Cross-Sectional	Major Depressive Episode (continuous; prevalence)	Gini coefficient range: 0.25-0.74	**Individual-level:** age, gender, marital status, education, location (urban vs. rural) **Area-level:** Human Development Index (HDI)	• For 22 highest developed countries, MDE prevalence of MDE increased by 0.28% for each 100th increase in gini • When analyses restricted to highest third of developed countries, MDE prevalence increase by 4% for every 100th increase in gini (PR=1.04, 95% CI=1.00-1.08	• Associations only in high HDI index (development) countries (development *inequality

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Detollenaere et al. (2018) (96)	Europe (Countries) Cross-sectional	Mental Well-Being (continuous; log transformed)	Gini coefficient range: not specified	**Area-level:** strength of primary care system, divided into structure, access, continuity, coordination, and comprehensiveness dimensions	• Higher income inequality associated with worse mental well-being (β=-8.160, SE=0.193, p<0.001) • Adverse effects of inequality buffered by increasing structure, access, continuity, and coordination dimensions of the primary care systems • Adverse effects of inequality aggravated by increasing comprehensiveness dimension of the primary care systems	• Buffering and aggravating effects depending on health care dimension (primary care system dimensions* inequality)
Du et al. (2019) (41)	China (Provinces) Cohort (Longitudinal)	Psychological Distress (continuous) Subjective Well-Being (continuous)	Gini coefficient range: 0.28-0.48	**Individual-level:** age, gender, education, ethnicity, marital status, personal income, residence (urban vs. rural), psychological distress and subjective well-being at baseline	• Increasing inequality was associated with greater psychological distress (β=0.292, 95% CI= 0.268, 1.805) and poorer subjective well-being (β= -1.857, 95% CI=-2.773, -0.941) • When stratified by income group, Gini associated with poorer well-being among lowest 20% and 20-40% income groups, as well as with higher distress among 20-40% income group and 80%-100% income groups	• Once stratified, impacts of inequality varied by income group (income* inequality)

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Erdem et al. (2019) (119)	The Netherlands (Neighbourhoods, Municipalities) Cross Sectional	Psychological Distress (continuous)	Gini coefficient range: Neighbourhoods mean=0.26, SD=0.03 Municipalities mean=0.26, SD=0.03	**Individual-level:** gender, age, ethnic background, marital status, education, household income **Area-level:** disposable household income, % of residents with non-western ethnic backgrounds, degree of urbanicity	• No direct association between neighbourhood inequality and distress after adjusting for covariates • For those in highest income neighbourhoods, those in high inequality neighbourhoods had 2% higher distress compared to those in lowest inequality neighbourhoods • After adjusting for covariates, those living in the highest inequality municipalities had worse distress (β=0.34, 95% CI= 0.13, 0.56) compared to those in the lowest inequality municipalities • No significant interaction between municipality income and inequality	• Associations at neighbourhood level only for those living in neighbourhood with highest mean income (neighbourhood income *inequality)
Fan et al. (2011) (103)	United States (States) Cross-Sectional	Depression (dichotomous)	Gini coefficient range: 0.40-0.54	**Individual-level:** sex, age, ethnicity, year, education, household income, chronic conditions **Area-level:** household income, % in poverty, % employed	• Individuals living in states with gini in the fourth (OR=1.20, 95% CI=1.18, 1.22) and fifth (OR=1.27, 95% CI=1.24, 1.31) quintiles had higher odds of being depressed compared to those in first quintile (most equal states)	• N/A

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Fiscella and Franks (2000) (120)	United States (Communities) Cohort (Longitudinal)	Depressive Symptoms (Continuous)	Proportion of total income earned by poorest 50% range: 0.18-0.37	**Individual-level:** age, sex, individual income	• Higher levels of inequality associated with lower General Well Being Schedule scores (β= -0.21, 95% CI= -0.13, -0.28)	• N/A
Kahn et al. (2000) (42)	United States (States) Cross-Sectional	Depression (dichotomous)	Gini coefficient range: ≤0.415 (first tertile cut-off) to >0.430 (third tertile cut-off)	**Individual-level:** maternal age, marital status, education, ethnicity, household income, number of people living in the household	• Mothers living in medium level inequality states had a higher odds of depression (OR=1.4, 95% CI=1.1, 1.8) compared to mothers from low inequality states • Mothers in the lowest fifth of the income distribution in high inequality states had a higher odds of depression (OR=3.6, 95% CI:1.8, 7.3) compared to mothers from the highest fifth of the income distribution in low inequality states	• Adverse impacts of inequality more pronounced among poorer mothers (income* inequality)
Kim and Haquist (2018) (97)	Sweden (Country) Repeated Cross-Sectional	Mental Health Problems (continuous)	Gini coefficient range: 0.22-0.30	**Individual-level:** sex, economic disadvantage (defined as experiencing unaffordability of daily leisure activities: concerts, movies, sports, and dance) **Area-level:** real country GDP per capita	• Girls experiencing unaffordability of all activities except sports had worse mental health when country-level inequality was higher (e.g., for concerts*gini, β=8.35, SE=1.8, p<0.001) • Boys frequently experiencing unaffordability of sports had worse mental health when country-level inequality was higher (β=7.28, SE=2.8, p<0.001)	• Associations for girls and boys only when experiencing unaffordability of activities (sex*economic disadvantage*in equality)

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Lin et al. (2017) (113)	China (Cities) Cross-Sectional	Mental Well-Being (continuous)	Gini coefficient range: 0.278-0.447	**Individual-level:** gender, education, category of Hukou (residence certificate, agriculture or non-agriculture), marital status, years of residence, social integration (13 total indicators, such as familiarity with local dialects and having medical insurance)	• Significant Spearman rank correlation (RS=-0.04, $p<0.001$) between Gini and mental health • Negative impact of Gini and social communication on mental health (β=-0.794, SE 0.179, $p<0.001$) • Negative impact of Gini and SES on mental health (β=-0.406, SE 0.184, $p<0.005$)	• Adverse impacts of income inequality when interacting with social communication and SES of internal migrants (social communication *inequality; SES*inequality)
Messias et al. (2011) (106)	United States (States) Ecological	Any Depression (dichotomous) Major Depression (dichotomous)	Gini coefficient range: 0.410-0.495	**Area-level:** per-capita income, % of population with college degrees, % of population above 65 years of age	• Increasing state prevalence of any depression significantly correlated with increasing income inequality (correlation coefficient=43.5, $p<0.01$ • Inequality also correlated with increasing state prevalence of major depression (correlation coefficient=10.9, $p=0.03$)	• N/A

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Oishi et al. (2011) (93)	United States (Country) Repeated Cross-Sectional	Happiness (continuous)	Gini index range: ~0.35-0.45	**Individual-level:** household-income, and sex, race, marital status, and age (specifically in mediation analyses for low-income individuals) **Potential mediators:** perceived levels of fairness, general trust, household income	• Significant direct association between increasing inequality and decreasing happiness (β=-0.385, 95%CI=-0.730, -0.041) • Once stratified by income, increasing inequality was only associated with decreasing happiness for those in the lowest 20% and 20-40% income groups • Evidence of mediation, except for those in the 60-80% and top 20% income groups	• Adverse impacts of income inequality for those in poorer household income groups (income* inequality)
Pabayo et al. (2014) (107)	United States (States) Cohort (Longitudinal)	Depression (dichotomous)	Gini coefficients range: ≤0.421(first quintile cut-off) to >0.454 (fifth quintile cut-off)	**Individual-level:** age, sex, household income, race, education, marital status, history of depression, stressful life events, self-perceived health **Area-level:** Median income, % poverty, % African American, population size, urban/suburban/ rural	• Compared to women living in lowest Gini quintile states, the odds for experiencing depression during follow-up was greater for those living in the fourth (OR=1.37, 95%CI=1.03, 1.82) and fifth (OR=1.50, 95%CI=1.14, 1.96) quintile states	• Associations found only for women (sex* inequality)

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Pabayo et al. (2016) (123)	United States (Neighbourhoods) Cross-Sectional	Depressive Symptoms (continuous)	Gini coefficients range: 0.33-0.65	**Individual-level:** age, nativity, race, perceived social cohesion **Area-level:** economic deprivation, disorder scores (social and physical disorders), social cohesion, neighbourhood danger	• Girls living in higher Gini neighbourhoods had higher depressive scores compared to girls from lower Gini neighbourhoods (β=0.11, 95% CI=0.02, 0.20) • No evidence that social cohesion acting as a mediator	• Associations found only for girls (sex* inequality)
Quon and McGrath (2015) (114)	Canada (School Districts) Cross-Sectional	Anxiety (continuous) Depression (continuous) Anger (continuous) Self-Esteem (continuous)	Squared coefficient of variation $(SD/N)^2$; reverse-coded range: does not specify	**Individual-level:** age, sex, subjective SES, household income **Area-level:** School district income	• Adolescents living in higher inequality communities has worse self-esteem (β=-0.04, $p<0.01$) and anger (β=-0.06, $p<0.05$), compared to those living in more equal communities	• N/A

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Sommet et al. (2018) (99)	**Part I:** International (Countries) Repeated Cross-Sectional **Part II:** Switzerland (Municipalities) Cohort (Longitudinal)	**Part I:** Feelings of Unhappiness (continuous) **Part II:** Psychological Health Problems (continuous	**Part I:** Gini coefficient range: mean=0.40, SD=0.10 **Part II:** Gini coefficient range: mean=0.42, SD=0.07	**Individual-level:** sex, age, education, employment status, income, wave/ number **Area-level:** population of area, poverty head-count ratio, unemployment rate, GDP	**Part I:** • No direct association between increasing inequality and feelings of unhappiness • Higher inequality associated with increasing feelings of unhappiness among those experiencing financial scarcity (β=1.71, 95% CI=0.43, 2.99), but not for those experiencing equilibrium or abundance **Part II:** • Higher income inequality associated with frequency of psychological health problems (β=0.88, 95% CI=0.08, 1.71) • Association stronger among those experiencing financial scarcity (β=2.82, 95% CI=1.06, 4.60)	• In both sets of analyses, the adverse effects of inequality on mental health experienced only (Part I) or more strongly (Part II) for those experiencing financial scarcity (economic vulnerability *inequality)
Steptoe et al. (2007) (100)	International (Countries) Cross-Sectional	Depression (dichotomous)	Gini coefficient range: 0.20-0.59	**Individual-level:** age, gender, family wealth, parental education, SES, perception of control **Area-level:** per capita GDP, tertiary education	• Greater odds of depression for countries with higher gini coefficients (OR=1.09, 95% CI=1.05, 1.15) • Higher proportion of women with depression compared to men (22% vs. 19%)	• N/A

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Vilhjalmsdottir et al. (2016) (124)	Iceland (Neighbourhoods) Cross-Sectional	Emotional Distress (continuous)	Top 20%: Bottom 20% ratio range: 4.47-39.90	**Individual-level:** gender, economic deprivation, recent move, parental support, parent conflict, family disruption, immigrant status **Area-level:** neighbourhood affluence, residential mobility, disrupted families prevalence, immigrant concentration, capital area (y/n)	• After controlling for social capital indicators, increasing inequality was associated with worsening emotional distress (β=0.0034, SE=0.05, p<0.001)	• N/A
Vilhjalmsdottir et al. (2019) (126)	Iceland (Neighbourhoods) Repeated Cross-Sectional	Anxiety Symptoms (continuous; log transformed) Depressive symptoms (continuous; log transformed)	Bottom 20% / Top 20% equality ratio range: 0.22-0.28	**Individual-level:** family deprivation, gender, age, family disruption, immigrant status **Area-level:** neighbourhood mobility rate, concentrated disadvantage index, capital area (y/n), survey cycle and survey cycle squared	• Increasing equality significantly associated with decreasing anxiety symptoms (β=-0.367, SE=0.127, p≤0.05), but not with depressive symptoms	• N/A

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
No Associations						
Adjaye-Gbewonyo et al. (2016) (109)	South Africa (Districts) Cohort (Longitudinal)	Depressive Symptoms (dichotomous)	Gini coefficient range: 0.46-0.68	**Individual-level:** age, sex, parental education, household income **Area-level:** mean household income	• No associations between district income inequality and depressive scores in cross-sectional and longitudinal fixed-effect models • No significant associations between inequality and depressive scores for either sex	• N/A
Bisung et al. (2018) (43)	Ghana (Sub Metro Areas) Cross-Sectional	Depressive Symptoms (dichotomous) Feeling Downhearted (dichotomous)	Gini coefficient range: <0.35 (cut-off for low inequality) to >0.35 (cut-off for high inequality)	**Individual-level:** age, alcohol consumption, smoking status, employment status, education, marital status, length of stay (in the community), income, number of children, health insurance status, social capital **Area-level:** sub-metro SES, sub-metro diversity (dichotomous; diverse if no single ethnic group makes up 40% or more of sub-metro population)	• No significant associations between living in high inequality areas and depressive symptoms or feeling downhearted	• N/A

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Fernandez-Nino et al. (2014) (104)	Mexico (Municipalities and States) Cross-Sectional	Depressive Symptoms (dichotomous)	Gini coefficient range: does not specify	**Individual-level:** Age, sex, civil status, paid employment status, education, difficulties with at least one activity (Katz and Lawton scales), # of chronic illnesses, participation in household decision making, history of inflicted physical violence, self-reported damage from accidents, living arrangements, household assets index **Area-level:** Municipality and state deprivation index	• No significant associations between inequality and depressive symptoms at either aggregation level	• N/A

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Fujita et al. (2019) (112)	Japan (Neighbourhoods) Cohort (Longitudinal)	Mood Disorder (dichotomous)	Gini coefficient range: 0.368 (median) and 0.352, 0.367 (25^{th},75^{th} percentiles)	**Individual-level:** sex, age, household type (e.g., single, one adult and children), individual income **Area-level:** mean household income, # of medical institutions, population size	• No association between incidence of mood disorder and inequality • No interaction between income inequality and individual income	• No effect
Gresenz et al. (2001) (121)	United States (Metropolitan Areas) Cross-Sectional	General Mood (continuous) Mental Disorder (dichotomous)	Gini coefficient range: 0.38-0.54 Robin Hood index range: does not specify	**Individual-level:** age, gender, race, # of family members, family income	• No significant associations between income inequality and general mood scores or odds of mental disorder	• N/A

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
McLaughlin et al., (2012) (78)	United States (Communities) Cross-Sectional	Mental Disorder (dichotomous) Mood Disorder (dichotomous) Anxiety Disorder (dichotomous) Disruptive Behaviour Disorder (dichotomous) Substance Disorder (dichotomous)	Gini coefficient (Z-transformed) range: ≤-0.65 (first quartile cut-off) to >0.59 (fourth quartile cut-off)	**Individual-level:** parent education, family income, age, gender, race/ethnicity, subjective social status, relative deprivation,	• Income inequality was not associated with any mental disorder (combined outcome) or any of the individual disorders	• N/A
Quon and McGrath (2015) (108)	Canada (Provinces) Cross-Sectional	Emotional Problems (continuous)	Gini coefficient Range: 0.265-0.325	**Individual-level:** age, ethnicity, education, residence (urban vs. rural), family size, monthly income **Area-level:** mean state income	• No direct associations between income inequality and emotional problems • No significant interactions between inequality and household income or parental education on emotional problems	• No effect

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Rai et al. (2013) (98)	International (Countries) Cross-Sectional	Depression (dichotomous)	Gini coefficient (0-100 percentile scale) range: 0.2500-0.7433	**Individual-level:** household spending, material assets, education, age, gender, marital status, area of residence (urban vs. rural)	• No direct associations between income inequality and depression • No associations between income inequality and depression across levels of economic development (no interaction)	• No effect
Sturm and Gresenz (2002) (116)	United States (Municipalities) Cross-Sectional	Mental Disorder (dichotomous)	Gini coefficient range: 0.38-0.54	**Individual-level:** age, sex, race/ ethnicity, family size **Area-level:** housing affordability, crime, unskilled wages, unemployment rate, % black, % Hispanic, county mean income, county mean education level, psychological services index, health services index	• No association between county-level income inequality and depression	• N/A

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Zimmerman and Bell (2006) (117)	United States (Counties) Cross-Sectional	Depression (dichotomous)	Percent rich range: does not specify	**Individual-level:** household income, sex, race, ethnicity, region of residence, employment status, education, health insurance (y/n), living situation (alone vs. with spouse or partner) **Area-level:** gross national income	• No association between country-level income inequality and depression • No significant association for depression when stratified by ethnicity	• No effect
Protective Associations (greater inequality associated with better mental health outcomes)						
Marshall et al. (2014) (122)	England (Neighbourhoods) Cross-Sectional	Depression (dichotomous)	Gini coefficient range: does not specify	**Individual-level:** sex, age, ethnicity, education, economic activity (e.g., retired) **Area-level:** mean neighbourhood price range, neighbourhood deprivation	• The odds of depression for those living in the most unequal neighbourhoods was lower (OR=0.78, 95% CI 0.40, 0.62) than for those living in the most equal neighbourhoods • For individuals in the lowest third individual income tertile, the odds of depression was lower (OR=0.71, 95% CI= 0.54, 0.94) for those living in the most unequal neighbourhoods compared to those living in the most equal neighbourhoods	• Association between inequality and depression strongest for lowest income individuals (income* inequality

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
San Sebastian et al. 2018 (115)	Sweden (Municipalities) Cross-Sectional	Psychological Distress (dichotomous)	Gini coefficient range: does not specify	**Individual-level:** sex, age, education, civil status, place of birth, occupational class, income **Area-level:** mean municipal income, municipality population size (four categories)	• No clear gradient between mental health and municipal income inequality • Individuals living in municipalities of second (prevalence ratio=0.89, 95% CI= 0.79, 0.99) and third (PR= 0.86, 95% CI= 0.75, 0.99) quintiles had better mental health compared to those from the first (most equal) quintile municipalities	• N/A
Mixed/Ambiguous Associations						
Fone et al. (2013) (92)	Wales (Neighbourhoods and Unitary Authorities) Cross-Sectional	Mental Disorder (dichotomous)	Gini coefficient range: 0.27-0.58 (neighbourhoods) and 0.39-0.45 (unitary authorities)	**Individual-level:** age, gender, employment status, education, social class, housing tenure **Area-level:** neighbourhood deprivation	• In areas of low deprivation, those living in high inequality neighbourhoods had lower odds of mental disorder (OR=0.92, 95% CI=0.88, 0.97) compared to those living in low inequality neighbourhoods • At the unitary authority level, income inequality was associated with higher odds of mental disorder (OR=1.13, 95% CI=1.04-1.22 • Cross level interaction of neighbourhood income inequality and deprivation with unitary level inequality not significant	• At the neighbourhood level, association only significant for low deprivation and high inequality (deprivation *inequality

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Henderson et al. (2004) (105)	United States (States) Cross-Sectional	Depressive Symptoms (dichotomous)	Gini coefficient range: 0.38-0.50	**Individual-level:** age, sex, parental education, household income **Area-level:** mean household income	• Bivariate relationship between inequality and depressive symptoms in men living in lowest quintile states ($p<0.05$) disappeared in regression analysis	• Only significant bivariate relationship for men (sex*inequality)
Vilhjalmsdottir et al. (2018) (125)	Iceland (Neighbourhoods) Repeated Cross-Sectional	Anxiety Symptoms (continuous) Depressive Symptoms (continuous)	Gini coefficient range: 0.15-0.71 (2006) and 0.15-0.35 (2014)	**Individual-level:** gender, age, family disruption, Icelandic only language spoken at home **Area-level:** Concentrated disadvantage index (includes equivalized disposable income, % of single parent households, and % immigrants), mobility rate, capital area, time (dummy variable)	• For pooled data, increasing inequality was associated with increasing anxiety ($\beta=0.387$, $SE=0.134$, $p<0.01$), but not with depression • In 2006, increasing inequality was associated with increasing anxiety symptoms ($\beta=0.337$, $SE=0.147$, $p<0.05$) • In 2014, increasing inequality was associated with decreasing depressive symptoms ($\beta=-0.958$, $SE=0.434$, $p<0.05$) • In 2006, income inequality strengthened the association between deprivation and increasing anxiety ($\beta=0.270$, $SE=0.125$, $p<0.05$) and depressive symptoms ($\beta=0.309$, $SE=0.132$, $p<0.05$)	• In 2006, detrimental effects of deprivation strengthened by inequality (deprivation *inequality)

Table 3.2. Summary of key findings from papers included in the narrative literature review (cont.)

Study	Location & Design	Relevant Outcome(s)	Inequality Range	Covariates	Key Findings	Evidence of Interaction
Weich et al. (2001) (102)	England, Wales, and Scotland (Regions) Cross-Sectional	Mental Disorders (dichotomous)	Gini coefficient range: does not specify	**Individual-level:** gender, age, housing tenure, social class, marital status, education, employment, ethnicity, # of current health problems **Area-level:** Concentrated disadvantage index, mobility rate, capital area, time (dummy)	• No direct association between inequality and mental disorders • Individuals in the highest income quintile living in high inequality areas had higher odds of mental disorders (OR=1.31, 1.05, 1.65) compared to those living in the low inequality areas • Individuals in the lowest income quintile living in high inequality areas had lower odds of mental disorders (OR=0.42, 0.31, 0.57) compared to those living in the low inequality areas	• Direction of association changes with level of income (income* inequality)
Yu (2018) (101)	International (Countries) Ecological	Depressive Disorder (continuous; rate ratios of females to males per 100,000 and DALYs per 100,000)	Gini coefficient range: does not specify	**Ecological-level:** age, super region (e.g. South Asia, North America), gender inequality index, per capita GDP	• Higher country-level inequality associated with higher depressive disorder rates (β=0.027, 95% CI=0.0001, 0.053) among males, but not among females or both genders • Higher country-level gini associated with lower depressive disorder rate ratios (Relative Ratio=0.976, 95% CI=0.976, 0.982)	• Associations between depressive disorder rates and inequality only for males (sex*inequality)

3.4.1 *Inverse Associations – Higher Inequality Related to Poorer Mental Health*

Of the eight studies that included measures of inequality at the country or international level, six (75%) found that increasing inequality was related to poorer mental health outcomes. The ecological study by Cifuentes et al. (95) found that among the 22 highest developed countries included in their 65 country cross-sectional analysis, every hundredth increase in a country's Gini coefficient corresponded to a 0.28% increase ($p<0.05$) in the prevalence of major depressive episodes among non-institutionalized adults. Similarly, multiple cross-sectional studies reported significant associations at the international level, with individuals from more unequal countries having a 9% higher odds of depression (100) and worse ($\beta=-8.160$, $p<0.001$) mental well-being (96). Additional studies found high inequality to be detrimental to mental health and happiness in specific cases, such as within the lowest household income groups (93), when experiencing financial scarcity (99), or when perceiving leisure activities to be unaffordable (97). Notably, in the studies that presented results stratified by sex, women were consistently reported as experiencing a higher burden and likelihood of being depressed (98,100).

Studies investigating inequality at the state or province level (i.e., within-country inequality) demonstrated similar trends, with five (63%) of the seven studies at this level reporting inverse associations. For example, an ecological analysis of 45 U.S. states revealed a significant correlation (correlation coefficient=10.9, $p=0.03$) between major depression and increasing income inequality, adjusting for state-level covariates such as per-capita income and percentage of the population above 65 years of age (106). These results are supported by studies reporting that higher inequality was associated with an increased risk of adverse mental health among adults (41,103) and specifically among women (42,107) living in states or provinces with higher levels of income inequality. Longitudinal analysis from Pabayo et al., (107) found that women living in the most unequal states had a 37% higher odds of developing depression compared to women living in the most equal states. These results are further reinforced by a cross-sectional study of mothers in the United States, which found that mothers living in moderately unequal states (Gini 0.416-0.430) had 40% higher odds of experiencing depression compared to those living in low inequality states (Gini$\leq$0.415), with the adverse effects of inequality felt more strongly among low income mothers (42). Aside from highlighting the susceptibility of those at the bottom end of the income spectrum, both ecological (106) and

individual-level (103,107) studies also reported statistical associations between income inequality and various covariates suspected to influence mental health, such as the level of educational attainment, proportion of individuals living under the poverty line, and state unemployment ratio.

The trend between increasing income inequality and deteriorating mental health also appears at lower geographic levels, however these results are more mixed. Specifically, five (42%) of 12 studies at the municipality level and seven (50%) of the 14 studies at the community and neighbourhood levels reported significant inverse associations. At the level of municipalities, higher income inequality was associated with more psychological health problems (99), and greater risk of depression (110) over time. Cross-sectionally, higher municipal income inequality was associated with increased psychological distress (119), mental well-being (113), and depressive symptoms and depression (111). At the level of neighbourhoods and communities, a longitudinal study of United States adults aged 25-74 found that increasing community-level income inequality resulted in worsening depressive symptoms (β=-0.21; 95%CI=-0.13, -0.28) over time (120). More recent cross-sectional studies provide similar evidence for females, as American adolescent girls living in higher Gini neighbourhoods experienced worse depressive symptoms (β=0.11, 95%CI=0.02, 0.20) than those living in more equal neighbourhoods (123). Interestingly, a study of adolescents (aged 15 and 16 years) found that increasing income equality was associated with decreasing anxiety symptoms (β=-0.367, SE=0.127, $p \leq 0.05$), but not depressive symptoms (126). Further discrepancies emerge from a study of Canadian adolescents (aged 13 to 16 years), reporting that increasing school district income inequality was significantly associated with worsening self-esteem (β=-0.04, $p<0.01$) and anger (β=-0.06, $p<0.05$), but not with anxiety or depressive symptoms (114). Two studies found that the adverse effects of neighbourhood income inequality were only significant in certain economic conditions, such as only impacting low income adults (118) or those living in neighbourhoods with the highest mean incomes (119). As with the international-level studies, women from studies at lower geographic levels demonstrated greater burdens of depression and higher depressive symptoms (110,111,123) anxiety, and any mental disorder (111), in comparison to men.

The instances of income inequality only relating to poorer mental health under certain conditions or for certain groups, as mentioned previously, provide evidence of effect

modification. In particular, individual and household income are frequently cited as influencing this relationship, with poorer individuals typically suffering more adverse mental health outcomes in areas of high income inequality compared to richer individuals (42,110,113,118). This trend also appears to hold true when considering economic vulnerability, with high income inequality having more detrimental psychological impacts on those experiencing financial scarcity (99). A potential explanation for these interactions is that those at the higher end of the income spectrum could have better access to higher-quality health care and support services, which could protect them against the detrimental health impacts of inequality (118). However, Erdem et al. (119) observed conflicting evidence that living in the highest inequality neighbourhoods was associated with 2% higher psychological distress compared to living in the lowest inequality neighbourhoods only for those from the neighbourhoods with the highest mean income. Furthermore, Du et al. (41) observed that increasing province-level inequality was associated with greater psychological distress among those in both the 20-40 percentile and 80-100 percentile income groups, suggesting that income inequality can influence the health of individuals at any point along the income spectrum.

Gender also emerged as a recurring effect modifier, with women consistently experiencing worse mental health outcomes compared to men across various levels of income inequality (97,107,123). For example, two studies in the United States found that income inequality was only associated with depressive outcomes for female, and not male, respondents (107,123). As discussed in chapter 2 (section 2.2.4), some potential mechanisms contributing to gender differences in response to income inequality include gendered differences in social comparisons, frames of references, compositions of social support networks, and receptiveness to social support (79,84–89). These factors could make women especially susceptible to stressful social comparisons, eroding social cohesion, and a loss of social capital resulting from high income inequality. The evidence for gender-based interaction supports the notion that women are especially at risk for poor mental health in the face of income inequality, highlighting the need for more studies in this vein aimed at women and mothers.

While ethnicity and level of education were also identified as potential effect modifiers in the literature, their influence is less understood in relation to mental health outcomes. After stratifying for ethnicity, higher county-level income inequality was associated with worse physical health (OR=2.6, 95% CI=1.22, 5.56) for white and Asian adults, but not for black and

Hispanic adults (117). No such association was found between income inequality and depression, however authors suggested that stratifying by ethnicity could have masked important variations in depressive symptomatology within the categories of ethnicity (117). Quon and McGrath (108) reported a significant interaction ($p<0.05$) between provincial Gini index and levels of parental education on adolescent hyperactivity and inattention. While this interaction was not present for adolescent mental health outcomes, the investigators acknowledged that these outcomes were not explored in-depth (108).

3.4.2 *No Associations – Inequality Not Related to Mental Health*

Of the studies captured in this narrative review, 10 (26%) did not report statistical evidence for associations between income inequality and mental health. Of these studies, the majority were conducted at smaller geographic scales, such as counties, communities, and neighbourhoods (n=8, 80%), and utilized primarily cross-sectional study designs (n=8, 80%). Many authors propose that other key factors and correlates of poor mental health could have masked the effects of income inequality, indicating that their results could have been biased due to residual confounding. For example, some authors suggest that the impacts of income inequality could have been eclipsed by the influence of absolute income (108,109,112,116,121), sex/gender (98,104), education (43,78,98,104,116), and marital or partner status (98,104), on mental health. Additionally, some studies proposed that a lack of material assets (98), lower self-perceived subjective social status (78), higher deprivation and major challenging life events (112), and tempering cultural factors such as post-apartheid hope for a better future (109) could be more influential for shaping mental health outcomes than income inequality. A lack of significant findings in certain areas could also suggest a threshold effect, whereby the impacts of income inequality might only be detectable in areas with especially high levels of inequality, such as Brazil, the United States, and China (63). Thus, the range of income inequality considered in some of the included studies could have been too low and narrow (e.g., Canadian provincial Ginis ranging from 0.265 to 0.323; neighbourhood inequality ranging from 0.332-0.391 in Chiba City, Japan) to detect impacts on mental health (108,112). Alternatively, Adjaye-Gbewonyo et al. (109) proposed a ceiling effect, in which the levels of inequality in their study were so high (district Gini ranging from 0.65-0.80) that any further increases in inequality over time might have only exerted minor impacts on depressive symptoms.

Furthermore, many authors reporting non-significant findings suggest that the geographic scale of their studies failed to capture the true variability and influence of income inequality; however, these assertions are mixed and conflicting. Some authors propose that smaller units of within-country analysis, such as districts and neighbourhoods, could be insufficient to capture the full range of social comparisons, systemic factors, and mental health variability related to income inequality. Thus, they propose that the influence of income inequality is likely stronger when aggregated at larger geographic levels (78,109,121). Conversely, others claim that analysis of province or country-level income inequality might be at too high a level to capture the relative and contextual effects of inequality on mental health (98,108,114). It is possible that the most appropriate geographic scale at which to study and capture the effects of income inequality depends on the mechanisms through which inequality is acting. For example, income inequality could be more influential at local levels if acting according to the social capital hypothesis (15,34,57,64,77,112). However, income inequality could be more influential on larger scales according to the neo-materialist hypothesis, as underinvestment in social infrastructure and resources (e.g., health services and insurance programs, food availability, financial policies) is likely more heterogeneous at higher geographic levels (15,57,92,112).

3.4.3 *Protective Associations – Higher Inequality Related to Better Mental Health*

Interestingly, two studies included in this review found protective relationships between income inequality and adverse mental health, reporting that higher inequality was associated with better mental health (115,122). In their cross-sectional analysis of adults aged 50+ in England, Marshall et al. (122) reported that the odds of experiencing depression was approximately 20% lower for those living in the most unequal neighbourhoods compared to adults living in the most equal neighbourhoods. Similarly, a cross-sectional study of individuals in Sweden found that those living in municipalities belonging to the second and third Gini quintiles had significantly lower prevalence ratios of psychological distress compared to those living in the most equal (i.e., first Gini) quintile municipalities (115).

While these results appear counterintuitive, Marshall et al. (122) provide a potential explanation for the observed protective relationship between income inequality and mental health. Specifically, they indicate that their results of a protective association offer evidence for the mixed neighbourhood hypothesis. This hypothesis posits that more socially-mixed

neighbourhoods offer protective health benefits due to an increase in varied social opportunities and wider social networks (122,128). Income inequality at the neighbourhood level could also result in better mental health through the sustainment of social and health services in the area by richer individuals that are then accessible to poorer individuals (129). Additionally, richer individuals in these areas might feel a heightened sense of achievement through social comparisons with their poorer neighbours, thus offering protective benefits against adverse mental health (122,129). While these unexpected findings could also be due to methodological limitations, such as the sensitivity of the geographic scale being considered (e.g., income inequality could be more harmful to health at larger scales) (115,122), as well as low mental health variability at the area level (e.g. municipal ICC of 0.00) and low response rate potentially leading to selection bias (115), the authors do not discuss these limitations in detail.

Despite some evidence for the protective effects of inequality, however, there is sizable evidence in the literature linking income inequality not only to poorer mental health (15,36), but to other adverse health outcomes such as mortality, heart disease, shorter life expectancy, and self-rated health (34,35,38,40,130). Therefore, despite some evidence that inequality can be protective for certain mental health outcomes, it is likely that widening income inequality is detrimental to health overall and that its specific health impacts depend largely on broader socioeconomic, cultural, and political contexts.

3.4.4 *Mixed or Ambiguous Associations*

Five (13%) of the studies in this review presented results that were less clear or consistent relative to the other associations reported. Of these studies, one was conducted at the international level (101), one at the U.S. state level (127), one at the region level (102), and two at the neighbourhood level (92,125). Fone et al. (92) also conducted analyses at the unitary authority level in Wales, which are units that encompass 22 larger administrative areas that include cities and towns and are similar in scale to counties and county boroughs. The large majority of these studies were cross-sectional (n=4, 80%), with one ecological study (101) and no longitudinal designs.

One form of ambiguity arises from findings that the association between income inequality and mental health changes direction based on other factors such as deprivation and absolute income (92,102). For example, a cross sectional study in the UK found that when

comparing those living in high inequality versus low inequality regions, individuals in the highest quintile of income had a 30% greater odds of having a mental disorder, whereas individuals in the lowest quintile of income had a 58% lower odds of having a mental disorder (102). As similar study in Wales found that higher income inequality was protective against having a mental disorder (OR=0.92, 95%CI=0.88, 0.97) at the neighbourhood level in low deprivation areas, but detrimental for all individuals (OR 1.13, 95%CI=1.04,1.22) at the unitary authority level (92). While these results appear contradictory, they present a potential argument that different mechanisms of income inequality act at different geographic scales. For example, it is possible lower income individuals have a more local scale of reference for social comparisons and thus perceive their own areas as having low income inequality, whereas richer individuals may be comparing themselves to more affluent individuals at regional and national levels and thus perceiving greater inequality at those scales (102,131). These richer individuals may also be comparing themselves to peer groups of similarly wealthy individuals that are not defined by a specific geographic scale. Additionally, other factors such as deprivation might be more important at more local levels, with the detrimental direct impacts of income inequality becoming more pronounced at larger levels of analysis (15,92,115,122).

Another source of ambiguity stems from studies that report associations in different directions depending on the specific mental health outcomes considered (101,125). In their repeated-cross sectional study (2006 and 2014 time points), Vilhjalmsdottir et al. (125) found that while 2006 and pooled results indicate that increasing income inequality was associated with worsening anxiety symptoms but not depressive symptoms, 2014 data indicate that increasing inequality was associated with decreasing depressive symptoms but not with anxiety symptoms. As this study involved comparing Iceland's national income inequality pre-recession (2006) and post-recession (2014), the authors suggest that the protective association for depression could be attributed to an increase in social cohesion brought about by the shared adversity of the 2008 economic recession, as well as growing economic prosperity in 2014 (125). Yu (101) also found discrepancies in the direction of association in their international ecological study, with higher country-level Gini associated with higher depressive disorder rates per 100,000 among males but lower depressive disorder rate ratios (females to males per 100,000). However, the authors clarify that the decreasing rate ratios were due to increased depressive disorder rates in males, as opposed to decreased rates among females (101). An association between inequality and mental

health among males but not females was also found in a cross-sectional analysis of US adults (127). However, this bivariate association disappeared in adjusted regression analysis, thus failing to provide clear evidence for a link between income inequality and depressive symptoms.

When considering these relatively ambiguous results, as well as the conflicting evidence from the studies that found inverse, protective, and no significant associations, the nature of the relationship between income inequality and mental health remains inconclusive. Due to this persisting uncertainty, more research is warranted to clarify and describe the health-inequality relationship.

3.4.5 *Limitations and Gaps*

The present narrative review identified various limitations in the existing literature that constrain the generalizability and internal validity of current knowledge. Perhaps most conspicuously, much of the research on income inequality and mental health to date has been cross-sectional (15,41). While a cross-sectional design is often an efficient and cost-effective first-step in epidemiological investigations, it is incapable of establishing temporality between study exposures and outcomes and thus cannot reject reverse causality (96,123,132). Since this design provides a snapshot of a single point in time, it also fails to account for the potential lag effects between income inequality and health outcomes (95,99,124,133,134). Additionally, the two ecological studies (101,106) are limited by the potential for ecological fallacy, which obscures interpretation of their population-level results in terms of individual health outcomes.

Based on the proposed mechanisms mentioned previously in chapter 2 (section 2.2.4), it is unlikely that exposure to income inequality results in immediate adverse health outcomes (37,95,133,134). Rather, the proposed mechanisms through which inequality engenders adverse health (e.g., erosion of social cohesion, underinvestment in social supports) likely accrue and act over time (35,37,57,126). Currently, the literature does not specify a definitive time frame for these lag effects, however some evidence suggests income inequality begins increasing the risk of mortality at five years with effects peaking at seven years (134), and that previous exposure to income inequality up to 15 years prior is associated with worse self-rated health (133). While there are multiple studies that have employed longitudinal designs to capture effects and mental health trends over time, many of these studies only included two or three time points

(41,107,109,110,120). These studies, especially those capturing only two time points, are more limited in detecting trends in mental health outcomes over time (135).

In terms of mental health outcomes, many previous studies used surveys and questionnaires to gather self-reported mental health data. These questionnaires have numerous advantages, as they offer a relatively inexpensive and easy way to collect a wide variety of data from large samples of individuals (136), and often employ standardized data collection tools (e.g., EPDS, CES-D) that have demonstrated reliability and validity in a variety of populations (19,137–139). However, self-report measures can pose issues for mental health and income inequality studies and introduce various forms of response bias,such as generating selection bias in cases where individuals with worse mental illness or less economic resources are less likely to respond to questionnaires. Further, misclassification bias could arise especially in cases that consider multiple study areas and groups, such as studies collecting and/or utilizing data from multiple countries. In these cases, responses could be highly variable depending on a variety of factors including language and translation barriers, literacy issues, comprehension of the questions being asked, and differences in cultural values and attitudes. For example, the level of individual openness about mental health issues could differ substantially between countries or districts with distinct cultural norms (96,98,111). Similarly, reports of mental health could be heavily influenced by specific societal contexts and histories, such as a prevailing sense of hope in post-apartheid conditions (109). Therefore, previous evidence from studies using questionnaires and self-report methods might not be generalizable to other populations that do not share similar demographic, geographic, and cultural contexts.

Another limitation of these studies is that many employed mental health measures that were dichotomized (e.g., ‘depressed’ versus ‘not depressed’) based on specific cut-off thresholds defined a priori (e.g., a cut-off score of 10 or greater indicated signs of major or minor depression, according to the EPDS). Using cut-off scores that do not accurately identify those with or without mental illness within a population could result in non-differential misclassification of the study outcome(s), thus likely biasing estimates of association towards the null. For example, a study of low-income urban mothers found that optimal cut-off scores for the EPDS were lower (≥9 for major depression, ≥7 for major or minor depression) than current recommended scores (≥13 for major depression, ≥10 for major for minor depression) when compared to structured clinical interviews, suggesting that different threshold scores could be

needed to accurately screen different populations (140). In the context of maternal mental health, failing to include continuous measures of mental health, such as symptom severity scores, could limit the potential of studies to accurately characterize maternal mental health outcomes and detect more subtle variations in symptomatology (109,117). Additionally, only including dichotomized outcome measures would omit mothers with symptoms who fall just below the cut-offs, despite evidence suggesting that levels of depressive symptoms that do not meet diagnostic criteria could still have a variety of adverse impacts during the postpartum period (141). Thus, this study (see chapter 4) utilized both dichotomized and continuous mental health outcome measures to capture a more accurate and complete picture of variations in mental health among pregnant and new mothers.

Finally, as with many epidemiological studies, the results from these papers were likely biased through residual confounding. Many investigators reported lacking data on well-known or suspected confounders and potential mediators, such as variables related to individual income (92,97,123); education and marital status (112); social capital and support (41,100,103,117); stress (100); perceived safety (120); major life events (104,112); cultural and political systems (96); discrimination and personality factors (119); and, perceived social position (41). Additionally, residual confounding could emerge through misclassification of confounders, whereby influential confounding variables are measured or characterized in a way that fails to account for their total confounding effects (e.g., poor respondent memory of smoking habits, short-term precision of biochemical markers, improperly categorizing continuous variables such as age) (142). This type of misclassification is especially pertinent in the presence of key confounders, such as absolute income and level of education, which have been strongly linked to mental health outcomes and income inequality (27,35). Failing to account for such important confounders could have resulted in overestimated, underestimated, or masked associations reported in the current literature. While randomization can be an appropriate means of adjusting for confounding, as confounders would likely be equally distributed among exposed and unexposed groups, it is not practical or ethical to ‘assign’ individuals to live in high inequality areas. Therefore, accounting for key known and potential confounders when possible and characterizing them appropriately are crucial steps to provide clearer evidence for associations between inequality and mental health outcomes.

In addition to these limitations, there are many gaps within the existing literature that muddy our understanding of the relationship between income inequality and mental health. As the majority of current findings linking inequality to adverse mental health utilize cross-sectional designs, the nature of this relationship over time is not well understood. Further, very little research has been conducted on income inequality and mental health outcomes in a Canadian context (108,114), which limits the generalizability of current evidence to Canadian populations. Thus, longitudinal studies within a Canadian context are needed to fully account for the specific factors influencing mental health, as well as the unique income distributions, structural supports and safety nets, and social milieu of Canadian provinces, cities, and neighbourhoods.

Many studies considering inequality and mental health have focused primarily on depression or overall mental health, and have neglected to treat anxiety as a distinct mental health outcome (15,96,118,121). Only five of the studies (13%) captured in this review considered anxiety or anxiety symptoms as a distinct mental health outcome in addition to depression (78,111,114,125,126), with mixed results. Two cross-sectional studies of adolescents in Iceland found that increasing income inequality was associated with increasing anxiety symptoms (β=0.387, SE=0.134, $p<0.01$) in pooled estimates (125), and that increasing equality was associated with decreasing anxiety symptoms (β=-0.367, SE=0.127, $p\leq0.05$) (126) but not with depressive symptoms. Conversely, cross-sectional evidence from São Paulo, Brazil, found that while men had a significantly lower odds of presenting both depression (OR= 0.44; 95%CI=0.34, 0.56) and anxiety (OR= 0.53; 95%CI=0.44, 0.65) compared to women, high levels of income inequality were only associated with an increased odds of depression (OR= 1.53; 95%CI=1.07, 2.19), and not with anxiety (111). McLaughlin et al. (78) reported no significant association between community income inequality and any mental health outcome (including mood, anxiety, and substances disorders) for American adolescents. Considering that anxiety and depression are highly comorbid (6,7,17) and especially prevalent in women (7), it is important that further research treat these conditions as distinct outcomes to clarify their association with income inequality. Failing to distinguish between these two outcomes could obscure the potentially unique pathways through which inequality relates to anxiety and depression, respectively (17,20,126).

Finally, there is a dearth of information linking income inequality to the mental health of women, pregnant women, and mothers specifically, despite their documented burden of and

susceptibility to adverse mental health conditions (1,6,29,30,51,100,7,10,16,17,20,21,25,27). As mentioned previously, only two (5%) of the 38 studies in this review focused specifically on these populations, with one study including a sample of US mothers (42) and the other focusing on a sample of West African women (43). While the cross-sectional study of US mothers (42) did find a significant association between state-level income inequality and depression, it served solely as a preliminary cross-sectional investigation that could not establish temporality between the exposure and outcome. The results of this study are over 20 years old, which highlights that more contemporary research on this specific population is needed, especially considering ongoing changes and increases in income inequality and socioeconomic landscapes both worldwide and within Alberta (44,45). The more recent findings from the City of Accra (Ghana) report that income inequality within in the city of Accra (Ghana) was not associated with depressive symptoms or feeling downhearted (43). Currently, no studies of inequality and mental illness include pregnant mothers as a distinct study population. Additional studies focusing on the effects of income inequality on the mental health of pregnant and new mothers, especially over time, are needed to provide more comprehensive insights into the socioeconomic and environmental factors affecting maternal mental health. These insights could help identify mothers who are at high risk of experiencing poor mental health based on where they live, target and support interventions aimed at reducing socioeconomic and health inequities, and further disentangle the complex interplay between systemic social determinants and individual and population health.

Of note, this review was limited by its non-systematic narrative approach. As this approach is not as methodologically rigorous as a systematic or scoping review, it is possible that articles may have been missed during searching and inclusion. Additionally, meta-analyses were not possible with the review methods employed in this thesis, thus precluding the generation of more pooled measures of quantitative associations between income inequality and mental health outcomes. Finally, this review only involved one searcher and screener (S. Lowe), which potentially led to a greater number of missed studies and a bias in terms of what studies were ultimately included, compared to a two a more standard two-screener protocol.

3.5 Conclusion

In summary, overall, the literature provides evidence of a link between income inequality and mental health outcomes, although current results are largely mixed across different health

outcomes, locations, and geographic scales. Of the studies that report significant associations, the large majority found that increasing inequality was related to poorer mental health. However, these findings are not conclusive, considering the high proportion of studies that found non-significant or ambiguous associations. Additionally, there are several limitations and gaps in the current literature, including a lack of longitudinal evidence among pregnant and new mothers in a Canadian context.

The analytic study in this thesis (see chapter 4) aimed to address the ambiguity and limitation of previous research by employing a longitudinal multilevel analysis of income inequality and the mental health of mothers from the All Our Families cohort in Calgary, Alberta. By analysing mental health data collected at six time points from <25 weeks of pregnancy to 3 years postpartum, this study was able to quantify how income inequality at the neighbourhood level related to changes in anxiety and depressive symptoms over time. By addressing gaps in the literature, this study provides a foundation for additional research into the specific mechanisms linking neighbourhood inequality to mental health, and how interventions aimed at reducing inequality could have beneficial implications for mental health and well-being.

– CHAPTER 4: ASSOCIATION STUDY –

It's an Unequal Day in the Neighbourhood: A Longitudinal Analysis of Neighbourhood Income Inequality and Maternal Mental Health

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Abstract

Objectives

Rising income inequality is a potential risk factor for poor mental health, however little work has investigated this link among mothers. Our goal was to determine if neighbourhood-level income inequality in Calgary was associated with maternal mental health among pregnant and new Calgary mothers over time.

Design

Secondary data analysis using a retrospective cohort study design.

Setting and participants

Data from the All Our Families (AOF) ongoing cohort study in the city of Calgary (Canada) were used, with our sample including 2,461 mothers. Participant data were collected at six time points from 2008 to 2014, corresponding to <25 weeks of pregnancy to 3 years postpartum. AOF mothers were linked to 196 geographically defined Calgary neighbourhoods using postal code information and 2006 Canada Census data.

Main outcome measures

Anxiety symptoms measured using the Spielberger State Anxiety Inventory, and depressive symptoms measured using the Edinburgh Postnatal Depression Scale and the Center for Epidemiologic Studies-Depression Scale.

Results

Multilevel regression modeling was used to quantify the association between neighbourhood-level income inequality and mental health symptoms (continuous and dichotomized) over time. For continuous anxiety symptoms, the interaction term between neighbourhood Gini and time was significant (β=0.0012, 95%CI=0.00020, 0.0023; p=0.020), indicating an excess rate of change over time. Specifically, a standardized deviation increase in Gini (Z-score) was associated with an average monthly rate increase in anxiety symptom scores of 1.001% per month. This statistically significant excess rate of change over time was also observed among mothers who did not have elevated anxiety symptoms at baseline (β=0.0017, 95%CI=0.00049, 0.0028; p=0.005). Although continuous depressive symptom scores followed similar longitudinal

trajectories across levels of income inequality, we did not find significant evidence for an association between inequality and depressive symptoms. There was no statistical evidence for associations between inequality and either dichotomous mental health outcome, and no statistical evidence of cross-level interactions between inequality and household income for any study outcome (continuous or dichotomous).

Conclusion

Income inequality within Calgary neighbourhoods appears to adversely impact the mental health trajectories of pregnant and new mothers who live there. Further research is needed to understand the mechanisms that explain this relationship, and how interventions to reduce income inequality could yield benefits for mental health.

4.1 Introduction

Mental illness presents a substantial burden for public health in Canada, with approximately one in five Canadians experiencing mental illness during their lifetime (3,6,10). The health burden of mental illness in Canada is as much as 1.5 times greater than that of all cancers (10), with mood and anxiety disorders affecting approximately 5.9% and 5.8% of Canadians in any given year, respectively (3). Mental illness also places considerable strain on the Canadian economy, with an estimated cost of $49-51 billion per year in direct health care costs, out of pocket expenses, lost productivity, declines in overall quality of life, and premature mortality (6,8,10). Those with mental illness are at higher risk of developing other mental and physical comorbidities (6,8), and experience lower life expectancy and higher risk of suicide compared to the general population (12).

Women in particular experience consistently higher burdens of various mental illnesses compared to men, such as anxiety and depression disorders (7,10,15). Women also experience these conditions as comorbidities more commonly than men. Estimates of Canadian anxiety and depression demonstrate higher prevalence of these disorders among women (3.2% and 5.8%) versus men (2.0% and 3.6%) (3,7). Some research suggests that the gender disparity in mental health between men and women could be more pronounced among parents compared to non-parents (143), with estimates demonstrating especially high prevalence of anxiety (15.0%-18.2%) and depression (18.5%-22.0%) among mothers during pregnancy (17), and depression (10%-42%) among mother of young children (18,19). This gender imbalance in mental health burden could be attributed to a variety of factors, such as women typically experiencing poorer employment conditions (e.g., lower pay, more workplace discrimination), more child-rearing and housework responsibilities, less opportunities for social connection outside of the home (when raising young children), and the physiological stresses of pregnancy and child birth (17,20,22,30,53,143). The high burden of and susceptibility to poorer mental health among women and mothers is worrisome, as maternal mental illness is both detrimental to the health and well-being of mothers (18), and has been linked to delayed emotional development and behavioural issues among their young children (26).

In addition to established individual risk factors for mental illness, such as age, income, and education (10,27), the social determinants of health, such as the characteristics of the environments in which individuals live and grow, could play an important role (30,35,40). One

such aspect of the socioeconomic environment identified as a potential risk factor for adverse mental health is income inequality, or the unequal distribution of incomes in a given area (30,34,35,40). While the specific mechanisms linking income inequality to mental health remain unclear, it is possible that widening inequality between the rich and the poor triggers invidious social comparisons and divisions between individuals and groups (34,35). These stressful comparisons could lead to feelings of shame, hostility, and isolation, ultimately manifesting in poor mental health (34,35). High levels of income inequality might also erode social cohesion, which could result in a breakdown in trust between members of a society and a decline in community engagement and cooperation (34,40). Strong social cohesion at the neighbourhood level has been shown as a protective factor against adverse mental health conditions (83).

A recent review and meta-analysis by Patel et al. (15) found that the majority of existing studies linking income inequality and depression reported significant associations between higher inequality and greater risk of depression, with a pooled risk ratio of 1.19 (95%CI=1.07,1.31). Various studies at neighbourhood and community levels have also reported significant associations between inequality and psychological and emotional distress (119,124), depression and depressive symptoms (118,120,123), and anxiety symptoms (125,126). However, other studies at the neighbourhood scale found no significant associations between inequality and mental health outcomes (78,112,121). The implications of current findings are limited, as many studies linking income inequality and mental health are cross-sectional (78,118,119,121,123–126), and thus do not account for potential associations and trends over time. More longitudinal studies at the neighbourhood level are needed to further clarify these associations, especially considering that the proposed mechanisms of invidious social comparisons and deteriorating social cohesion are likely especially relevant at this smaller geographic scale (15).

The research linking income inequality to maternal mental health, while sparse, has also yielded some insights. Only one study has focused specifically on mothers (42). This study of American mothers with children aged 26-48 months found that those living in moderately unequal states (Gini=0.416-0.430) had 40% higher odds of experiencing depression compared to those living in low inequality states (Gini≤ 0.415), with the adverse effects of inequality felt more strongly among low income mothers (42). However, this study only provided a cross-sectional snapshot from several decades ago, thus highlighting the need for more contemporary research with this population. Additionally, no studies have included pregnant women as a

distinct population, despite the unique physiological and social changes that they experience as they transition to parenthood (17,53).

Finally, very little of this research has been conducted within a Canadian context, with only two cross-sectional studies of income inequality and distinct mental health outcomes (108,114). One of these studies of adolescents living in Quebec found that higher income inequality at the school-district level was associated with worsening self-esteem and anger, but not with anxiety or depression (114). The other study did not find a significant association between province level income inequality and worsening emotional health (108). The authors suggested that the direct and contextual influences of inequality on mental health might be better captured on more local scales, as opposed to provincial and national scales where the range of inequality could be more narrow (108).

The current study addresses these gaps in the literature by conducting a longitudinal study of neighbourhood-level income inequality and mental health outcomes among pregnant and new mothers in a Canadian context. This multilevel approach accounted for various individual and neighbourhood level risk factors of poor mental health that are potentially linked to changes in income inequality (15,27,30,144). Based on previous findings (15,42,123,125,126) the study hypotheses were that 1) increasing levels of neighbourhood income inequality would be associated with worsening anxiety and depressive outcomes among these mothers, and 2) cross-level interactions would exist between income inequality and individual household income on maternal mental health, with poorer mothers experiencing worse mental health in high inequality areas compared to richer mothers.

4.2 Methods

4.2.1 *Study Design*

The current study involved the secondary data analysis of an ongoing cohort study to investigate the longitudinal associations between neighbourhood-level income inequality and maternal mental health in Calgary, Alberta. Utilizing retrospective cohort data presents numerous advantages for studying risk factor-outcome associations, including the ability to account for various risk factors as covariates and establish temporality between exposure to a risk factor (e.g., higher income inequality) and subsequent health outcomes (e.g., worsening mental health) (145,146).

4.2.2 *Data Sources*

The All Our Families Cohort Study

Data on maternal characteristics and mental health outcomes for this thesis were from the All Our Families (AOF) study. The AOF study is an ongoing population-based longitudinal cohort designed to explore how prenatal and early life periods relate to health outcomes for mothers and their children living in the city of Calgary, the largest city in the province of Alberta, Canada (147,148). This cohort follows a life course perspective from pregnancy through birth and into early childhood, which provides opportunities to investigate the effects of prenatal and early life conditions on maternal and child physical, mental, and development health outcomes over time (147).

Women were recruited into the AOF cohort using both active and passive recruitment strategies (147–149). One active approach involved identifying women who were receiving serology testing through Calgary Laboratory Services. Women receiving testing who consented to release their contact information to the AOF research staff were subsequently contacted via telephone to assess their eligibility, and were asked for their verbal consent to participate in the study (147,149). AOF research staff were also located on-site in primary care waiting rooms to provide information and actively recruit eligible women (147,148). Passive recruitment was conducted through posters and advertising materials displayed in various locations frequented by pregnant mothers (147,148). The largest proportion of participants (69%) were recruited via Calgary Laboratory Services (148).

Women met the eligibility criteria if they were at less than 25 weeks gestation at the time of recruitment, 18 years of age or older, already accessing prenatal care in Calgary, and were able to complete written questionnaires in English (147,149). Conversely, women were excluded if they planned to move outside of the greater Calgary area during their pregnancy, were carrying multiple babies during time of enrollment, had a substantial language barrier, and/or had any of the following medical conditions: type I or type II diabetes; high blood pressure; specific autoimmune disorders (i.e., lupus, rheumatoid arthritis, Sjogren's syndrome); conditions affecting the kidneys (e.g., chronic renal disease, nephritis, nephropathy, dialysis); a heart condition that had been treated with surgery; or, chronic infection (e.g., hepatitis, HIV) (148,149). In total, the original AOF cohort consisted of 3,387 women aged 18 to 47 years residing in Calgary, Alberta, who were recruited between May 2008 and May 2011 (147).

Between 2008 and 2014 (inclusive), these women were administered mailed written questionnaires at six points: two questionnaires during pregnancy at <25 weeks of gestation and at 34-36 weeks of gestation, as well as one questionnaire at 4 months and 1, 2, and 3 years postpartum (147). Follow-up at 5 and 8 years postpartum was conducted between 2013 and 2016, and 2017 and 2019, respectively. However, these data were not available through the Secondary Analysis to Generate Evidence analytic environment at the time of this study.

The AOF questionnaires, which captured information on a variety of factors such as socio-demographics, pregnancy experiences, maternal and child health outcomes, and childcare environments, were developed through collaboration between researchers, health care providers, community experts and decisions makers, and epidemiologists (147).

Canadian Census 2006

The Canadian census is formulated to gather information on the demographic, social, and economic characteristics of Canadian individuals and households. The 2006 Canada Census was conducted on May 16th, 2006, and counted 31,612,897 Canadians (150). Census data were linked to the AOF respondents using postal code information collected from the study participants at baseline.

4.2.3 *Data Access*

Access to the AOF data for this study was provided by PolicyWise for Children & Families through their Secondary Analysis to Generate Evidence (SAGE) research and data repository. The AOF data is housed within SAGE's online secured virtual desktop system, which provided remote access to the confidential data and statistical software used for this study. To access the data, the research team prepared a detailed data request identifying all variables of interest and accompanying rationales for why these variables were required for analysis. The request was reviewed and approved by PolicyWise staff, and the de-identified AOF data were then made available through the SAGE environment. A formal data access agreement was also signed by the research team and PolicyWise staff, which outlined the terms and conditions for access, use, analysis, and publication of the data. Additional data from the 2006 Canada Census required for this study were sent to PolicyWise staff who added the data into the SAGE virtual environment.

The SAGE analytic environment possesses various security features, such as requiring two-factor authentication when logging in. Additionally, the environment is moated, meaning that the internet and other outside applications could not be accessed from within the virtual environment (151). Once analyses were complete, all output and accompanying syntax were vetted by a PolicyWise data analyst and then released. These vetting procedures are in place to ensure that any output does not contain identifying information about the study participants. PolicyWise provided an onsite training session on proper data access, stewardship, and confidentiality protocols to S. Lowe and R. Pabayo.

4.2.4 *Ethical Consideration*

R. Pabayo prepared and submitted an ethics application (study ID:Pro00083081) to the University of Alberta's Research Ethics Board 2 to study neighbourhood income inequality and maternal and child mental health in Calgary. The ethics application was approved July 3rd, 2018, has been renewed with a current expiry date of May 18th, 2022 (Appendix A.2), and was included as required supporting documentation in the data access agreement with PolicyWise.

4.2.5 *Study Sample*

Of the original cohort of 3,387 women, the number of participants who completed questionnaires at each time are as follows: 3,223 women at <25 pregnant (Q1); 3,182 woman at 34-36 weeks pregnant (Q2); 3,057 women at 4 months postpartum (Q3); 1,573 women at 1 year postpartum (Q4); 1,595 women at 2 years postpartum (Q5); and 1,994 women at 3 years postpartum (Q6). The AOF investigators defined women as continuing participants if they completed at least one follow-up questionnaire during the 1, 2, and 3 years postpartum follow-up (147). Sample sizes for the Q4-Q6 follow-up points decreased due to issues with the timing of developing and administering questionnaires, securing ethics approval and funding, and additional constraints and attrition. Over the course of follow-up from Q1 to Q6, 938 participants (28% of the initial cohort) withdrew from the AOF study due to passive withdrawal (n=669, 20%), active withdrawal (n=235, 7%), or pregnancy loss or child death (n=34, 1%).

During the initial phase of recruitment, the AOF investigators compared various socio-demographic characteristics of their participants to women with young children in Calgary, Alberta, and Canada to assess the representativeness of the AOF sample (147). While similar in

terms of age, educational attainment, and nativity, the AOF cohort has a higher proportion of women who were married and had higher annual household incomes (>$60,000) compared to the parenting women from Calgary, Alberta, and Canada. Additionally, those who remained in the study over the course of follow-up tended to be older, born in Canada, in a stable relationship, have higher educational attainment and family incomes, and primarily speak English in their homes (147).

Of the 2,671 mothers who could be linked to census data, 210 women (7.9%) were excluded due to missing baseline data on mental health outcomes and individual-level covariates. Excluded mothers were more likely to have lower income ($p<0.0001$), and be non-white ($p=0.004$). In total, 2,461 mothers nested within 196 Calgary neighbourhoods were retained for analysis (Figure 4.1).

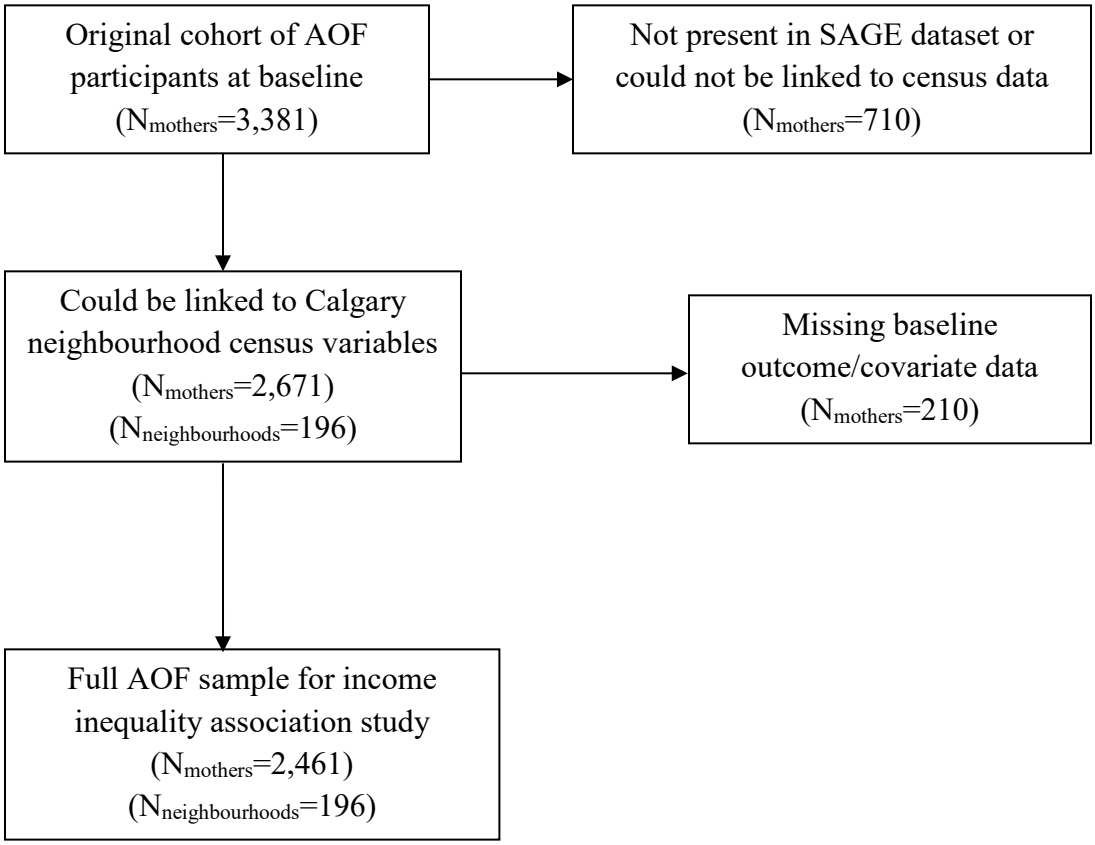

Figure 4.1. Flow chart of participant extraction, linking, and cleaning

Neighbourhoods for this study were characterized utilizing 2006 Canadian Census data at the dissemination area-level for the City of Calgary. Dissemination areas (DAs) represent the

smallest standard geographic units at which all Canadian census data are disseminated (152). These areas, which cover the entire territory of Canada and respect the boundaries of census tracts and subdivisions, typically encompass populations of 400 to 700 individuals (152). Each DA was spatially linked to the corresponding Calgary community neighbourhoods, with many neighbourhoods encompassing multiple dissemination areas. According to 2011 Calgary Civic Census data, residential Calgary community neighbourhoods ranged in population size from 24 residents to 19,851 residents (153).

4.2.6 *Study Variables*

Main Exposure

The main exposure of interest for this study was neighbourhood-level income inequality, which was measured using the Gini index. As described previously in section 2.2.2, The Gini index is a commonly used measure of inequality, with coefficients ranging from 0.0 (perfect equality, meaning every household in a neighbourhood would have the exact same income) to 1.0 (perfect inequality, meaning a single household would have all the income in a neighbourhood) (69,70). Gini coefficients are derived from the Lorenz curve by dividing the area between the Lorenz curve and the 45° line of perfect equality with the total area beneath the 45° line (69; Appendix A.1).

The Gini index possesses various advantages that make it a useful tool for measuring income inequality in this study context. As this index has been widely used at a variety of locations. time points, and geographic scales (15,69,96,114), it allows for comparability with many previous studies investigating income inequality and mental health outcomes. Gini coefficients are based on ratio analysis, and are thus fairly reliable and representative measures of inequality for the entire population (96). Additionally, Gini is not influenced by extreme income values within the income distribution, unlike more simple measures of inequality such as the coefficient of variation (69,96,114).

Gini values were calculated (154) for the 196 Calgary neighbourhoods by a health geographer using 2006 after-tax Canada census data, and standardized using Z-transformation. Utilizing Gini coefficients calculated based on after-tax income data accounted for some of the redistributive impacts of income taxation (66,70).

Outcomes

A primary mental health outcome for this study was depression; a disorder characterized by persistent feelings of sadness and apathy that can severely impact a person's daily life (13). Depression can manifest in a variety of ways, ranging from an increase in depressed mood and fatigue, a lack or excess of sleep, and difficulty concentrating, to intense feelings of worthlessness and suicidal ideation. From <25 of pregnancy to 1 year postpartum, maternal depressive symptoms were measured using the Edinburgh Postnatal Depression Scale (EDPS). This scale was designed to screen for depression specifically among pregnant and early postpartum women. As such, this scale does not include items for somatic symptoms common in other screening tools, as these symptoms are often indistinguishable from normal physical symptoms experienced during the perinatal period (19,155,156). When completing the AOF questionnaires, the mothers responded to 10 questions assessing depressive symptoms experienced in the past seven days, including "*I have looked forward with enjoyment to things*" and "*I have been so unhappy that I have had difficulty sleeping*". Responses were rated on a four-point Likert scale, and items were totaled into a summation score with higher scores indicating more severe depressive symptoms. Although this instrument is not a perfect substitute for in-person clinical assessment, a meta-analysis of various studies has demonstrated it to be valid and reliable in screening for depression among mothers from multiple countries during pregnancy and post-partum (157). Within a Canadian context, a study of 1,559 Québécois mothers reported the sensitivity and specificity of the EPDS tool at 0.91 and 0.76, respectively, when screening for depression at 6 to 8 weeks postpartum (138).

At 2 and 3 years postpartum, the AOF investigators changed from the EDPS to the Centre for Epidemiological Studies-Depression (CES-D) scale. This scale was developed to assess the epidemiology of depressive symptomatology in the general population (137), and includes 20 items of experiences of depression in the last seven days, including "*I was bothered by things that usually don't bother me*" and "*I felt that I could not shake off the blues even with help from my family or friends*". As with the EDPS, items were rated on a four-point Likert scale and higher scores indicated worse depressive symptoms. This scale has been used for measuring depressive symptoms among pregnant and postpartum mothers, with one study demonstrating a sensitivity of 1.00 and a specificity of 0.65 when screening a sample of pregnant and early postpartum low-income African American mothers for major and minor depression (19).

In this study, depression was treated as both a continuous and a dichotomous outcome to gauge how income inequality relates to both the odds of elevated symptoms and more subtle changes in continuous symptoms over time. To create dichotomous outcome variables, mothers were characterized as having elevated symptoms of major or minor depression at each time point if they had untransformed EDPS scores of 10 or higher at the first four time points) (156), and CES-D scores of 16 or higher at the last two time points) (137). To create a continuous measure of depression across all six time points, EPDS and CES-D depressive symptom scores were standardized using the percent of maximum possible (POMP) scaling method (158). This approach transforms each measure to a scale ranging from 0 (the minimum possible value) to 100 (the maximum possible value) using the following formula:

$$\text{POMP} = \frac{(observed\ value - minimum\ possible\ value)}{(maximum\ possible\ value - minimum\ possible\ value)} * 100$$

The benefits of this method include preserving the proportions of absolute distances between the observed values and interpreting scores as the percentages of possible maximum values (158). Conceptually, in terms of combining these scales, both measure similar key constructs of depressed affect and positive affect (137,159) and have been used in studies with pregnant and postpartum mothers (19,42,137,159). These POMP scores were then log-transformed to account for positive skewness, with an added coefficient to account for zero values in the outcome scores (i.e., log(y+c) transformation). Multiple constant values for c were tested, including 0.01, 0.05, 0.83 (smallest non-zero value divided by 2), and 1, with a constant of 1 providing the least skew and best fit when examining descriptive statistics and level-1 and level-2 residual plots. Thus a log transformation with an added constant (c) of 1 was used.

The other primary mental health outcome for this study was anxiety, which encompasses a variety of disorders that involve excessive and persistent fear and worry that hinder one's ability to function normally (14). Common symptoms of generalized anxiety disorders include heightened stress; fatigue; difficulty concentrating; physical restlessness and tension; and difficulty sleeping. Maternal anxiety symptoms were measured at each time point (<25 weeks of pregnancy through to 3 years postpartum) using the Spielberger State Anxiety Inventory (SSAI). This self-report tool is widely used to measure the presence and severity of current anxiety

symptoms, as well as susceptibility to worsening anxiety (160). Through the AOF questionnaires, the mothers were asked to respond to 20 statements about how they feel "at this moment", including items such as "*I am tense"; "I am worried"; "I feel calm";* and *"I feel secure"*. Participants responded to these items using a four-point Likert scale, with summation scores providing a continuous measure of anxiety symptoms. The SSAI has demonstrated sufficient construct validity with other anxiety scales (e.g., correlation of 0.85 with Cattell and Scheier's Anxiety Scale Questionnaire) and sufficient test-retest reliability (test-retest coefficient of up to 0.86) (160). Furthermore, a study assessing the psychometric properties of the SSAI reported high internal consistency and reliability of the scale when measuring the anxiety symptoms of AOF mothers during pregnancy and postpartum, thus supporting the scale's use with this population (161).

As with depressive symptoms, this study considered anxiety symptoms as both a continuous outcome and a dichotomous outcome, with an untransformed SSAI score of 40 or greater indicating elevated anxiety symptoms (160). Continuous SSAI scores were also standardized using the POMP scaling method (158) and log-transformed with an added constant of 1 to adjust for positive skewness and zero values.

Individual-Level Covariates

Key covariates that align with the SDOH framework, are risk factors for poor mental health, and are potentially linked to changes in income inequality were identified through a narrative review of existing literature (see chapter 2). Baseline, individual-level sociodemographic covariates included from the AOF dataset were household income, age, ethnicity, highest level of education completed, and marital status. Participants were categorized into higher (≥$80,000 per year) and lower ($79,999 or less per year) income groups using AOF income categories. Baseline age was mean-centered and included as a continuous measure, and the remaining covariates were dichotomized (white vs. non-white, high-school education or less vs. at least some post-secondary education, married or common-law vs. single/widowed/divorced). Follow-up time was characterized as the time in months from the first questionnaire to each subsequent data collection point.

Area-Level Covariates

Neighbourhood-level characteristics identified as important covariates were derived from 2006 Canada Census data. Economic neighbourhood characteristics included were the proportion of households with an annual income above 100K as an indication of neighbourhood income and wealth, and the proportion of households living below the after-tax low-income cut-off (LICO). LICO is a threshold used only in Canada that identifies families as low income if they spend a considerably higher proportion of their income (>20%) on essential resources (e.g., food, clothing, shelter) compared to an average family of comparable size (162). As such, LICO serves as an indication of the risk of experiencing poverty, financial strain, and relative deprivation. Demographic neighbourhood characteristics included were the proportion of recent immigrants (immigrated to Canada between 2001 and 2006) and the proportion of visible minority individuals. All area-level covariates were linked to AOF mothers using postal code information collected at baseline, and dichotomised using median scores as cut-offs.

4.2.7 *Statistical Analysis*

Growth curve multilevel modeling was used to quantify the relationships between neighbourhood income inequality and maternal anxiety and depressive outcomes over time, while adjusting for individual and area-level covariates. This step-up approach involved using both mixed-effects multiple linear regression models for continuous outcomes (anxiety and depressive symptoms) and mixed effects logistic regression models for dichotomous outcomes (elevated anxiety symptoms and elevated depressive symptoms). First, intercept-only models were constructed to calculate the intraclass correlation coefficients (ICC) for the continuous outcomes and 95% plausible range values for the dichotomous outcomes. ICCs indicate how much variability of anxiety and depressive symptoms can be attributed to neighbourhood and individuals levels. 95% plausible range values indicate the amount of variability in elevated anxiety and depressive symptoms across neighbourhoods (Appendix A.3). Following the intercept-only models, neighbourhood income inequality and time variables (model 1), individual-level covariates (model 2), and area-level covariates (model 3) were added into the models. Cross-level interaction terms between income inequality, household income, and time (model 4) were also tested to determine if associations between income inequality and mental health outcomes differed across levels of household income (i.e., effect modification).

The first set of analyses were conducted on our entire sample of mothers (n=2,461) nested within 196 neighbourhoods. Considering that prior experience of mental illness is often a strong risk factor for recurrent mental illness (6,18), and that we did not have access to variables specifically indicating a history of anxiety disorders or a history of depression disorders, a second set of analyses were conducted using a subsample of the AOF mothers who did not have elevated anxiety symptoms at baseline (for continuous and dichotomous anxiety outcome models) and a subsample who did not have elevated depressive symptoms at baseline (for continuous and dichotomous depressive outcome models). These analyses allowed us to adjust for maternal experiences of the specific mental health outcomes prior to follow-up, and were conducted on a subsample of 2,047 mothers (no elevated anxiety symptoms at baseline) nested within 192 neighbourhoods and a subsample of 2,047 mothers (no elevated depressive symptoms at baseline) nested within 191 neighbourhoods.

Sensitivity analyses were performed to gauge the robustness and consistency of the first two sets of analyses. Models were constructed using a subsample of mothers who did not have elevated anxiety symptoms (for anxiety outcome models) or elevated depressive symptoms (for depressive outcome models) at baseline and who did not indicate a history of any mental illness. Thus, these analyses utilized subsamples of 2,210 mothers nested in 194 neighbourhoods for the anxiety outcome models, and 2,208 mothers nested in 195 neighbourhoods for the depressive outcome models. For depressive outcomes, an analysis of the full sample of mothers (n=2,461) was also restricted to the first four time points (<25 weeks of pregnancy to 1 year postpartum) to determine if results differed when only using one depressive symptom scale (EPDS) compared to combining the two scales across all six data collection points.

To assess all models, log likelihood was used to gauge the relative fit of each step-up model in comparison to the null model, with less negative (i.e., closer to 0) values indicating better relative fit. Quadratic and cubic parameters for time were tested to account for potential non-linear trajectories of anxiety and depression symptoms over time. Polychoric correlation matrices were constructed to assess collinearity between neighbourhood level variables. Of note, this modelling approach of treating anxiety and depressive symptoms as continuous measures based on summations scores of Likert-scale items is consistent with the existing literature (41,92,125,126,97,99,113,119–121,123,124).

Multilevel growth curve modelling is able to account for three levels of clustering (i.e., repeated measures nested within mothers nested within neighbourhoods), and allows the intercepts of maternal and neighbourhood covariates to vary. Furthermore, this analytic approach can accommodate unequally spaced time points and missing outcome values over the course of follow-up (135). All statistical tests were two-sided ($p \leq 0.05$) and run using Stata (v.15.1) accessed via the SAGE secured virtual environment (151).

4.3 Results

Baseline characteristics of the full sample of AOF mothers (n=2,461), as well as the subsamples of mothers without baseline elevated anxiety symptoms (n=2,047) or elevated depressive symptoms (n=2,047), are presented in Table 4.1. A large proportion of mothers from the samples were married or common-law (94.6%-95.6%) white (78.9%-80.6%), higher income (70.1%-73.5%), and had at least some post-secondary education (90.5%-91.2%) The mean age of the mothers was 30.7 years (SD=4.5) for the full sample and 30.8 years (SD=4.4) for both of the subsamples. Neighbourhood characteristics of the Calgary neighbourhoods captured in both samples are also presented in Table 4.1. The mean neighbourhood Gini value for all samples was 0.35 (SD=0.06; range=0.20, 0.60), which is higher than 2006 after-tax Gini estimates for both Alberta (0.31) and Canada (0.32) (163). The three samples were highly similar in terms of individual and area-level characteristics. At the neighbourhood-level, polychoric correlation matrices revealed high correlation between % of neighbourhoods with incomes above 100K and % of neighbourhoods with residents below the LICO (corr coef=-0.89), and between the % of visible minority and recent immigrant individuals (corr coef=0.77) (Table A.2.). However, these variables measure conceptually different characteristics of the neighbourhoods (e.g., % visible minority captures racialized Canadian residents in addition to immigrants, whereas % recent immigrants captures those who have arrived in the country between 2001 and 2006), and thus all variables were retained. Additionally, STATA ran the multilevel models with all neighbourhood levels variables, indicating that model convergence was not impeded by collinearity.

Table 4.1. Baseline sociodemographic and neighbourhood characteristics of all included 'All Our Families' cohort mothers (n=2,471), as well as those without baseline elevated anxiety symptoms (n=2,047) or elevated depressive symptoms (n=2,047)

Maternal Characteristics	**Full sample of AOF Mothers (n=2,461)**	**Mothers without Baseline Anxiety (n=2,047)**	**Mothers without Baseline Depression (n=2,047)**
Maternal ethnicity (%)			
White	1,942 (78.9%)	1,639 (80.1%)	1,650 (80.6%)
Non-White	519 (21.1%)	408 (19.9%)	397 (19.4%)
Household Income (%)			
$80,000 or more	1,726 (70.1%)	1,497 (73.1%)	1,505 (73.5%)
$79,999 or less	735 (29.9%)	550 (26.9%)	542 (26.5%)
Maternal Education (%)			
At Least Some Post-Secondary	2,226 (90.5%)	1,867 (91.2%)	1,866 (91.2%)
High School or Less	235 (9.5%)	180 (8.8%)	181 (8.8)%
Marital Status (%)			
Married/Common-Law	2,327 (94.6%)	1,954 (95.5%)	1,956 (95.6%)
Single/Divorced/Widowed	134 (5.4%)	93 (4.5%)	91 (4.4%)
Maternal Age (mean years / SD)	30.7 (4.5) range: 18-47	30.8 (4.4) range: 18-47	30.8 (4.4) range: 18-47
Neighbourhood Characteristics		**Mean (SD) (n=192)**	**Mean (SD) (n=191)**
Gini Coefficient	0.35 (0.06) range: 0.20-0.60	0.35 (0.06) range: 0.20-0.60	0.35 (0.06) range: 0.20-0.60
Neighbourhood Income			
Household Above 100k (%)	29.7 (15.8) range: 3.3-75.7	30.0 (15.8) range: 3.3-75.7	30.0 (15.8) range: 3.3-75.7
LICO (%)	5.1 (5.5) range: 0.0-53.3	5.0 (5.5) range : 0.0-53.3	5.0 (5.5) range: 0.0-53.3
Neighbourhood Composition			
Visible Minority (%)	22.0 (16.8) range: 0.0-81.9	21.7 (16.7) range: 0.0-81.9	21.5 (16.1) 0.0-79.5
Recent Immigrant (%)	5.5 (4.3) range: 0.0-26.8	5.5 (4.3) range: 0.0-26.8	5.5 (4.3) range: 0.0-26.8

Anxiety and depressive symptom scores, as well as the proportions of mothers with elevated symptoms, are presented in Table 4.2 for each data collection point. Tracking the full sample of mothers from <25weeks of pregnancy to 3 years postpartum, mean anxiety and depressive symptom scores ranged from 17.4-20.6 and 12.8-17.7, respectively, with anxiety symptoms peaking at 34-36 weeks of pregnancy and depression symptoms peaking at <25 weeks of pregnancy. The prevalence of elevated symptoms ranged from 15.0%-20.3% for elevated anxiety symptoms and 12.3%-16.8% for elevated depressive symptoms. Compared to the full sample of mothers, mental health trends were similar among mothers who did not have elevated anxiety symptoms or who did not have elevated depressive symptoms at baseline, although the overall symptom scores and proportions of elevated symptoms in these subsamples were lower across the follow-up period. Additionally, within these subsamples, mean anxiety and depressive symptoms both peaked at 34-36 weeks of pregnancy. The cumulative incidence of first occurrence of elevated symptoms over the follow-up period was 267 cases/1,000 mothers for elevated anxiety symptoms and 210 cases/1,000 mothers for elevated depressive symptoms. These estimates suggest that the burden of anxiety and depressive symptoms presented substantial mental health burdens for mothers in the study, and are in-line with previous estimates (3,17–19), with anxiety contributing a higher burden and incidence throughout the course of the study.

Table 4.2. Maternal mental health outcomes at baseline and follow-up for pregnant women and mothers from the All Our Families Cohort (2008-2014)

	Pregnancy Period		Postpartum Period			
	<25 Weeks (Q1)	**34-36 Weeks (Q2)**	**4 Months (Q3)**	**1 Year (Q4)**	**2 Years (Q5)**	**3 Years (Q6)**
Full Sample of Mothers (n=2,461)						
Anxiety Scores*						
Anxiety Symptoms *(mean/sd)*	18.6 (14.7)	20.6 (15.1)	17.4 (15.5)	18.7 (15.2)	17.7 (13.7)	18.1 (152)
Elevated Anxiety Symptoms *(%)*	16.8% (n=414)	20.3% (n=469)	15.3% (n=337)	17.7% (n=197)	15.0% (n=177)	15.3% (n=231)
Total Observation (n)	2,461	2,307	2,200	1,115	1,177	1,506
Depression Scores**						
Depressive Symptoms *(POMP; mean/sd)*	17.7 (14.7)	16.7 (14.1)	14.5 (14.5)	14.7 (14.0)	13.0 (11.6)	12.8 (12.2)
Elevated Depression Symptoms *(%)*	16.8% (n=414)	14.8% (n=347)	12.5% (n=283)	12.4% (n=143)	12.8% (n=152)	12.3% (n=186)
Total Observation (n)	2,461	2,344	2,273	1,154	1,188	1,516
Mothers without Baseline Anxiety (n=2,047)						
Anxiety Scores*						
Anxiety Symptoms *(mean/sd)*	13.4 (8.8)	17.5 (12.7)	14.7 (13.2)	16.3 (13.7)	15.8 (12.6)	15.6 (13.3)
Elevated Anxiety Symptoms *(%)*	0% (n=0)	13.1% (n=252)	10.0% (n=185)	12.8% (n=121)	11.0% (n=111)	10.4% (n=132)
Total Observation (n)	2,047	1,928	1,850	945	1,010	1,269

Table 4.2. Maternal mental health outcomes at baseline and follow-up for pregnant women and mothers from the All Our Families Cohort (2008-2014) (cont.)

	Pregnancy Period		Postpartum Period			
	<25 Weeks (Q1)	**34-36 Weeks (Q2)**	**4 Months (Q3)**	**1 Year (Q4)**	**2 Years (Q5)**	**3 Years (Q6)**
Mothers without Baseline Depression (n=2,047)						
Depression Scores**						
Depressive Symptoms *(POMP; mean/sd)*	12.5 (9.1)	13.9 (12.0)	12.1 (12.4)	12.5 (12.3)	11.4 (10.2)	11.2 (10.7)
Elevated Depression Symptoms *(%)*	0% (n=0)	8.6% (n=168)	7.9% (n=150)	8.1% (n=79)	9.1% (n=92)	8.9% (n=114)
Total Observation (n)	2,047	1,963	1,902	981	1,007	1,278

*Anxiety symptoms were measured using the Spielberger State Anxiety Inventory (SSAI) at time points Q1-Q6 (untransformed score ≥ 40 or POMP score ≥ 33.3= elevated anxiety symptoms). Continuous scores are presented on percent of maximum possible (POMP) scale.

**Depressive symptoms were measured using the Edinburgh Postnatal Depression Scale (EPDS) at time points Q1-Q4 (untransformed score ≥ 10 or POMP score ≥ 33.3= elevated depressive symptoms) and the Centre for Epidemiologic Studies Depression Scale (CES-D) at time points Q5-Q6 (untransformed score ≥ 16 or POMP score ≥26.7= elevated depressive symptoms). Continuous scores are presented on percent of maximum possible (POMP) scale.

When fitting step-up models for all mental health outcomes (continuous and dichotomous), each subsequent step-up model following the null models resulted in less-negative log likelihood values, indicating better model fit with the addition of individual- and area-level covariates. For continuous models (anxiety symptoms and depressive symptoms), quadratic and cubic parameters for time were not statistically significant, so only linear measures of time were retained in the multilevel models.

According to the intercept-only models for the continuous outcomes of the full sample of mothers, the ICC was 0.0091 for anxiety symptoms and 0.0088 for depressive symptoms, suggesting that 0.91% and 0.88% of the variance in anxiety symptoms and depressive symptoms were explained by area-level characteristics, respectively. For model 1, while neighbourhood Gini was not significantly associated with continuous anxiety symptoms at baseline, there was a significant interaction between Gini and time in months (β=0.0012, 95%CI=0.00020, 0.0023; p=0.020) indicating an excess rate of change in average anxiety symptom scores over time by level of income inequality (Table 3; Figure 2.a). In this model, a standardized deviation increase in income inequality was associated with an excess average monthly rate increase of 0.0012 log anxiety units, corresponding to an excess 1.0012% increase (e^0.0012) in average anxiety scores per month. This association remained consistent after adjusting for individual and neighbourhood-level covariates (models 2 and 3), and when testing inequality and household income interactions (model 4). However, linear combination (lincom) estimates indicate that despite this excess rate of change in anxiety symptoms by level of income inequality, higher levels of inequality were not associated with significantly higher anxiety symptom scores during the follow-up period to 3 years postpartum. For depressive symptoms, there was no statistical evidence of a significant association between income inequality and changing symptoms at baseline or over time, despite depressive symptom scores demonstrating similar effect sizes and average score trajectories to anxiety symptoms (Table 4.3, Figure 4.2). There was no evidence of interaction between inequality and household income for either anxiety or depressive symptoms.

For elevated symptoms, the 95% plausible range values were 0.0446-0.121 (overall probability of 0.0742) for elevated anxiety symptoms and 0.0307-0.0983 (overall probability of 0.0555) for elevated depressive symptoms, indicating that the prevalence for elevated anxiety and depression symptoms ranged across neighbourhoods from 4.5% to 12.1% (average=7.4%) and from 3.1% to 9.8% (average=5.6%), respectively. In all models, there was no evidence for

an association between increasing income inequality and the odds of elevated anxiety or depressive symptoms, with non-significant interaction terms between Gini and time for elevated anxiety symptoms (OR=1.004, 95%CI=0.998, 1.010; p=0.190) and elevated depressive symptoms (OR=1.003, 95%CI=0.997, 1.010; p=0.320) in the fully adjusted models (Table 4.4). For both outcomes, there was also no evidence of an interaction between inequality and household income (Table 4.3, 4.4).

Table 4.3. Associations between neighbourhood income inequality and continuous anxiety and depressive symptoms among mothers (n=2,461) from the All Our Families cohort (2008-2014)[a]

	Anxiety Symptoms (Log Transformed)			
	Model 1 β (95% CI)	**Model 2 β (95% CI)**	**Model 3 β (95% CI)**	**Model 4 β (95% CI)**
Months	**-0.0015 (-0.0024, -0.00056)**	**-0.0014 (-0.0024, -0.00049)**	**-0.0014 (-0.0024, -0.00049)**	-0.00079 (-0.0019, 0.00031)
Gini	-0.031 (-0.074, 0.011)	-0.027 (-0.066, 0.011)	-0.029 (-0.071, 0.014)	-0.040 (-0.089, 0.0087)
*Months	**0.0012 (0.00020, 0.0023)**	**0.0013 (0.00021, 0.0023)**	**0.0013 (0.00021, 0.0023)**	**0.0013 (0.00006, 0.0025)**
Household Income (ref: $80,000 or more)				
$79,999 or less		**0.22 (0.15, 0.29)**	**0.20 (0.13, 0.27)**	**0.24 (0.16, 0.32)**
*Months				**-0.0024 (-0.0045, -0.00023)**
*Gini				0.041 (-0.043, 0.12)
*Months*Gini				-0.00004 (-0.0025, 0.0024)
Ethnicity (ref: white)				
Non-White		**0.081 (0.0050, 0.16)**	0.068 (-0.0076, 0.14)	0.068 (-0.0085, 0.14)
Education (ref: at least some post-secondary)				
High School or Less		0.069 (-0.042, 0.18)	0.063 (-0.047, 0.17)	0.062 (-0.048, 0.17)
Marital Status (ref: other)				
Married/Common-law		**-0.28 (-0.42, -0.14)**	**-0.27 (-0.41, -0.13)**	**-0.26 (-0.40, -0.12)**
Age (years)		0.0034 (-0.0037, 0.011)	0.0045 (-0.0028, 0.012)	0.0048 (-0.0025, 0.012)
High Proportion LICO (ref: low)			-0.032 (-0.13, 0.062)	-0.032 (-0.13, 0.062)
High Proportion Income >100k (ref: low)			**-0.12 (-0.20, -0.030)**	**-0.12 (-0.21, -0.031)**
High Proportion Visible Minority (ref: low)			0.020 (-0.055, 0.094)	0.019 (-0.056, 0.094)
High Proportion Recent Immigrant (ref: low)			0.029 (-0.047, 0.11)	0.028 (-0.048, 0.10)

Table 4.3. Associations between neighbourhood income inequality and continuous anxiety and depressive symptoms among mothers (n=2,461) from the All Our Families cohort (2008-2014)[a] (cont.)

	Depressive Symptoms (Log Transformed)			
	Model 1 β (95% CI)	**Model 2 β (95% CI)**	**Model 3 β (95% CI)**	**Model 4 β (95% CI)**
Months	**-0.0040 (-0.0051, -0.0028)**	**-0.0039 (-0.0050, -0.0027)**	**-0.0039 (-0.0050, -0.0027)**	**-0.0035 (-0.0048, -0.0021)**
Gini	-0.015 (-0.065, 0.034)	-0.082 (-0.051, 0.035)	-0.010 (-0.059, 0.039)	-0.023 (-0.78, 0.033)
*Months	0.0012 (-0.00011, 0.0025)	0.0012 (-0.00009, 0.0025)	0.0012 (-0.00009, 0.0025)	0.0014 (-0.00011, 0.0029)
Household Income (ref: $80,000 or more)				
$79,999 or less		**0.32 (0.24, 0.40)**	**0.30 (0.22, 0.39)**	**0.33 (0.23, 0.42)**
*Months				-0.0014 (-0.0040, 0.0012)
*Gini				0.044 (-0.053, 0.14)
*Months*Gini				-0.00073 (-0.0037, 0.0023)
Ethnicity (ref: white)				
Non-White		**0.16 (0.077, 0.25)**	**0.15 (0.061, 0.24)**	**0.15 (0.060, 0.23)**
Education (ref: at least some post-secondary)				
High School or Less		0.036 (-0.090, 0.16)	0.031 (-0.095, 0.16)	0.030 (-0.096, 0.16)
Marital Status (ref: other)				
Married/Common-law		**-0.30 (-0.45, -0.14)**	**-0.28 (-0.44, -0.12)**	**-0.28 (-0.44, -0.12)**
Age (years)		-0.0020 (-0.010, 0.0062)	-0.00076 (-0.0090, 0.0075)	-0.00052 (-0.088, 0.0078)
High Proportion LICO (ref: low)			-0.019 (-0.13, 0.088)	-0.019 (-0.13, 0.088)
High Proportion Income >100k (ref: low)			-0.093 (-0.19, 0.0061)	-0.094 (-0.19, 0.0048)
High Proportion Visible Minority (ref: low)			0.058 (-0.026, 0.14)	0.058 (-0.026, 0.14)
High Proportion Recent Immigrant (ref: low)			0.0032 (-0.082, 0.089)	0.0020 (-0.083, 0.088)

[a] bolded values indicate statistical significance at $p \leq 0.05$

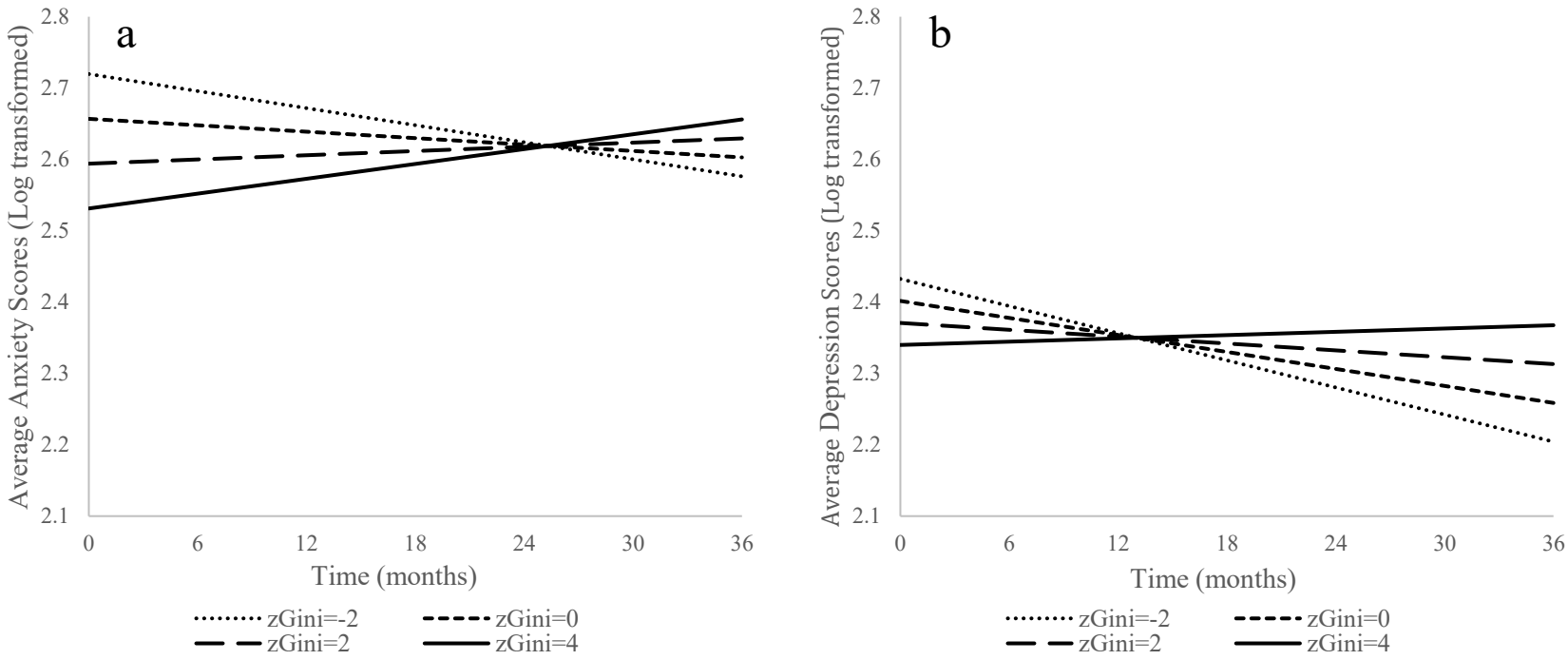

Figure 4.2. Estimated trajectories of log transformed anxiety symptoms (**a**, left) and depressive symptoms (**b**, right) of AOF mothers (n=2,461) over time by level of neighbourhood income inequality

Table 4.4. Associations between neighbourhood income inequality and dichotomous elevated anxiety and depressive symptoms among mothers (n=2,461) from the All Our Families cohort (2008-2014)[a]

	Elevated Anxiety Symptoms			
	Model 1 OR (95% CI)	**Model 2 OR (95% CI)**	**Model 3 OR (95% CI)**	**Model 4 OR (95% CI)**
Months	0.995 (0.991, 1.000)	0.996 (0.991, 1.001)	0.996 (0.991, 1.001)	1.003 (0.997, 1.009)
Gini	0.920 (0.786, 1.076)	0.916 (0.794, 1.057)	0.925 (0.789, 1.085)	0.837 (0.693, 1.011)
*Months	1.001 (0.996, 1.007)	1.001 (0.996, 1.007)	1.001 (0.996, 1.007)	1.004 (0.998, 1.010)
Household Income (ref: $80,000 or more)				
$79,999 or less		**2.197 (1.703, 2.834)**	**2.086 (1.608, 2.707)**	**2.864 (2.124, 3.860)**
*Months				**0.979 (0.969, 0.989)**
*Gini				1.352 (0.991, 1.843)
*Months*Gini				0.992 (0.980, 1.004)
Ethnicity (ref: white)				
Non-White		**1.403 (1.074, 1.833)**	**1.349 (1.030, 1.766)**	**1.343 (1.025, 1.761)**
Education (ref: at least some post-secondary)				
High School or Less		1.241 (0.845, 1.824)	1.235 (0.840, 1.815)	1.227 (0.834, 1.806)
Marital Status (ref: other)				
Married/Common-law		**0.349 (0.219, 0.555)**	**0.358 (0.225, 0.569)**	**0.367 (0.230, 0.586)**
Age (years)		1.023 (0.997, 1.050)	1.026 (0.999, 1.053)	**1.028 (1.002, 1.055)**
High Proportion LICO (ref: low)			0.970 (0.692, 1.361)	0.968 (0.689, 1.359)
High Proportion Income >100k (ref: low)			0.832 (0.608, 1.138)	0.822 (0.600, 1.127)
High Proportion Visible Minority (ref: low)			1.017 (0.779, 1.327)	1.019 (0.780, 1.330)
High Proportion Recent Immigrant (ref: low)			1.267 (0.966, 1.663)	1.258 (0.958, 1.653)

Table 4.4. Associations between neighbourhood income inequality and dichotomous elevated anxiety and depressive symptoms among mothers (n=2,461) from the All Our Families cohort (2008-2014)[a] (cont.)

	Elevated Depressive Symptoms			
	Model 1 OR (95% CI)	**Model 2 OR (95% CI)**	**Model 3 OR (95% CI)**	**Model 4 OR (95% CI)**
Months	**0.991 (0.986, 0.996)**	**0.992 (0.987, 0.997)**	**0.992 (0.987, 0.997)**	0.996 (0.990, 1.002)
Gini	0.907 (0.769, 1.069)	0.912 (0.787, 1.056)	0.938 (0.797, 1.105)	0.905 (0.746, 1.097)
*Months	1.003 (0.997, 1.008)	1.003 (0.997, 1.008)	1.003 (0.997, 1.008)	1.003 (0.997, 1.010)
Household Income (ref: $80,000 or more)				
$79,999 or less		**2.329 (1.798, 3.018)**	**2.245 (1.722, 2.927)**	**2.646 (1.951, 3.588)**
*Months				**0.988 (0.978, 0.999)**
*Gini				1.115 (0.814, 1.529)
*Months*Gini				0.998 (0.985, 1.010)
Ethnicity (ref: white)				
Non-White		**1.497 (1.142, 1.962)**	**1.409 (1.073, 1.851)**	**1.408 (1.071)**
Education (ref: at least some post-secondary)				
High School or Less		1.066 (0.719, 1.581)	1.064 (7.17, 1.577)	1.058 (0.713, 1.569)
Marital Status (ref: other)				
Married/Common-law		**0.392 (0.245, 0.625)**	**0.397 (0.248, 0.633)**	**0.401 (0.251, 0.642)**
Age (years)		1.007 (0.981, 1.034)	1.011 (0.985, 1.038)	1.011 (0.985, 1.038)
High Proportion LICO (ref: low)			1.007 (0.711, 1.426)	1.007 (0.711, 1.427)
High Proportion Income >100k (ref: low)			0.956 (0.693, 1.320)	0.954 (0.691, 1.318)
High Proportion Visible Minority (ref: low)			1.285 (0.979, 1.687)	1.287 (0.980, 1.690)
High Proportion Recent Immigrant (ref: low)			1.147 (0.869, 1.515)	1.143 (0.865, 1.509)

[a] bolded values indicate statistical significance at $p \leq 0.05$

Among mothers without elevated anxiety symptoms at baseline (n=2,047), 0.42% of the variance in anxiety symptoms was explained by neighbourhood-level characteristics (ICC=0.0042, 95%CI=0.00042, 0.040). Similarly to the models for the full sample of mothers, model 1 demonstrated a significant interaction between income inequality and time (β=0.0017, 95%CI=0.00049, 0.0028; p=0.005), with a standardized deviation increase in income inequality associated with an excess average monthly increase of 0.0017 log anxiety units, or an excess 1.0017% increase in average anxiety symptom scores, per month (Table 4.5, Figure 4.3). This association remained consistent after adjusting for individual and neighbourhood-level covariates (models 2 and 3), and was slightly attenuated but remained significant when testing inequality and household income interactions (model 4). Lincom estimates also indicate that this excess rate of change did not result in significantly higher anxiety symptom scores with higher levels of income inequality during the study period. There was no evidence for cross-level interaction.

Among mothers without elevated depressive symptoms at baseline (n=2,047), 0.27% of the variation in depressive symptoms was explained by neighbourhood-level characteristics (0.0027; 95%CI=0.00019, 0.037). While the effect sizes for the inequality time interaction term and the average score trajectories were again similar to those of anxiety symptoms (Table 4.5, Figure 4.3), there was no evidence of significant associations with income inequality or inequality and household income interactions for depressive symptoms.

For the dichotomous models, the prevalence of elevated anxiety symptoms across neighbourhoods ranged from 3.3% to 6.8% with an average of 4.8% (95% plausible range=0.0334, 0.0681; overall probability of 0.0478). The prevalence of elevated depressive symptoms ranged from 2.7% to 3.5% with an average of 3.1% (95% plausible range=0.0272, 0.0346; overall probability of 0.0306). For both outcomes, there was no evidence of associations with income inequality or cross-level interactions (Table 4.6)

Table 4.5. Associations between neighbourhood income inequality and anxiety and depressive symptoms among mothers without elevated anxiety (n=2,047) or depressive (n=2,047) symptoms at baseline from the All Our Families cohort (2008-2014)[a]

	Anxiety Symptoms (Log Transformed)			
	Model 1 β (95% CI)	**Model 2 β (95% CI)**	**Model 3 β (95% CI)**	**Model 4 β (95% CI)**
Months	0.00017 (-0.00088, 0.0012)	0.00021 (-0.00084, 0.0013)	0.00021 (-0.00084, 0.0013)	0.00037 (-0.00083, 0.0016)
Gini	-0.025 (-0.066, 0.017)	-0.019 (-0.058, 0.020)	-0.027 (-0.071, 0.018)	-0.028 (-0.078, 0.022)
*Months	**0.0017 (0.00049, 0.0028)**	**0.0017 (0.00049, 0.0028)**	**0.0017 (0.00049, 0.0028)**	**0.0014 (0.00004, 0.0027)**
Household Income (ref: $80,000 or more)				
$79,999 or less		**0.13 (0.057, 0.21)**	**0.11 (0.035, 0.19)**	**0.13 (0.039, 0.21)**
*Months				-0.00057 (-0.0030, 0.0019)
*Gini				0.0057 (-0.085, 0.097)
*Months*Gini				0.0013 (-0.0015, 0.0041)
Ethnicity (ref: white)				
Non-White		0.062 (-0.017, 0.14)	0.051 (-0.028, 0.13)	0.051 (-0.028, 0.13)
Education (ref: at least some post-secondary)				
High School or Less		0.062 (-0.054, 0.18)	0.055 (-0.61, 0.17)	0.056 (-0.061, 0.17)
Marital Status (ref: other)				
Married/Common-law		**-0.17 (-0.32, -0.014)**	**-0.16 (-0.31, -0.0014)**	-0.15 (-0.31, 0.0025)
Age (years)		0.0000 (-0.0074, 0.0074)	0.0010 (-0.0064, 0.085)	-0.012 (-0.0063, 0.0087)
High Proportion LICO (ref: low)			-0.012 (-0.11, 0.085)	-0.012 (-0.11, 0.085)
High Proportion Income >100k (ref: low)			**-0.10 (-0.19, -0.013)**	**-0.10 (-0.19, -0.013)**
High Proportion Visible Minority (ref: low)			0.017 (-0.060, 0.093)	0.016 (-0.060, 0.093)
High Proportion Recent Immigrant (ref: low)			0.010 (-0.067, 0.088)	0.0098 (-0.068, 0.087)

Table 4.5. Associations between neighbourhood income inequality and anxiety and depressive symptoms among mothers without elevated anxiety (n=2,047) or depressive (n=2,047) symptoms at baseline from the All Our Families cohort (2008-2014)[a] (cont.)

	Depressive Symptoms (Log Transformed)			
	Model 1 β (95% CI)	**Model 2 β (95% CI)**	**Model 3 β (95% CI)**	**Model 4 β (95% CI)**
Months	**-0.0012 (-0.0025, -0.00009)**	**-0.0011 (-0.0024, 0.00018)**	**-0.0011 (-0.0024, 0.00019)**	**-0.0013 (-0.0028, -0.00020)**
Gini	0.0014 (-0.046, 0.048)	0.0064 (-0.039, 0.052)	-0.0059 (-0.057, 0.045)	-0.010 (-0.068, 0.048)
*Months	0.0012 (-0.00024, 0.0026)	0.0012 (-0.00023, 0.0026)	0.0012 (-0.00023, 0.0026)	0.0011 (-0.00054, 0.0027)
Household Income (ref: $80,000 or more)				
$79,999 or less		**0.22 (0.13, 0.31)**	**0.20 (0.11, 0.29)**	**0.20 (0.096, 0.30)**
*Months				0.00076 (-0.0023, 0.0038)
*Gini				0.015 (-0.089, 0.12)
*Months*Gini				0.00050 (-0.0029, 0.0039)
Ethnicity (ref: white)				
Non-White		**0.13 (0.042, 0.23)**	**0.12 (0.032, 0.22)**	**0.12 (0.031, 0.22)**
Education (ref: at least some post-secondary)				
High School or Less		0.046 (-0.088, 0.18)	0.037 (-0.097, 0.17)	0.038 (-0.096, 0.17)
Marital Status (ref: other)				
Married/Common-law		**-0.19 (-0.37, -0.0074)**	**-0.18 (-0.36, -0.0011)**	-0.18 (-0.36, 0.0041)
Age (years)		-0.0067 (-0.015, 0.0019)	-0.0056 (-0.014, 0.0031)	-0.0054 (-0.014, 0.0033)
High Proportion LICO (ref: low)			0.023 (-0.088, 0.14)	0.024 (-0.088, 0.14)
High Proportion Income >100k (ref: low)			-0.068 (-0.17, 0.035)	-0.069 (-0.17, 0.034)
High Proportion Visible Minority (ref: low)			0.040 (-0.048, 0.13)	0.040 (-0.048, 0.13)
High Proportion Recent Immigrant (ref: low)			-0.012 (-0.10, 0.078)	-0.012 (-0.10, 0.077)

[a] bolded values indicate statistical significance at $p \leq 0.05$

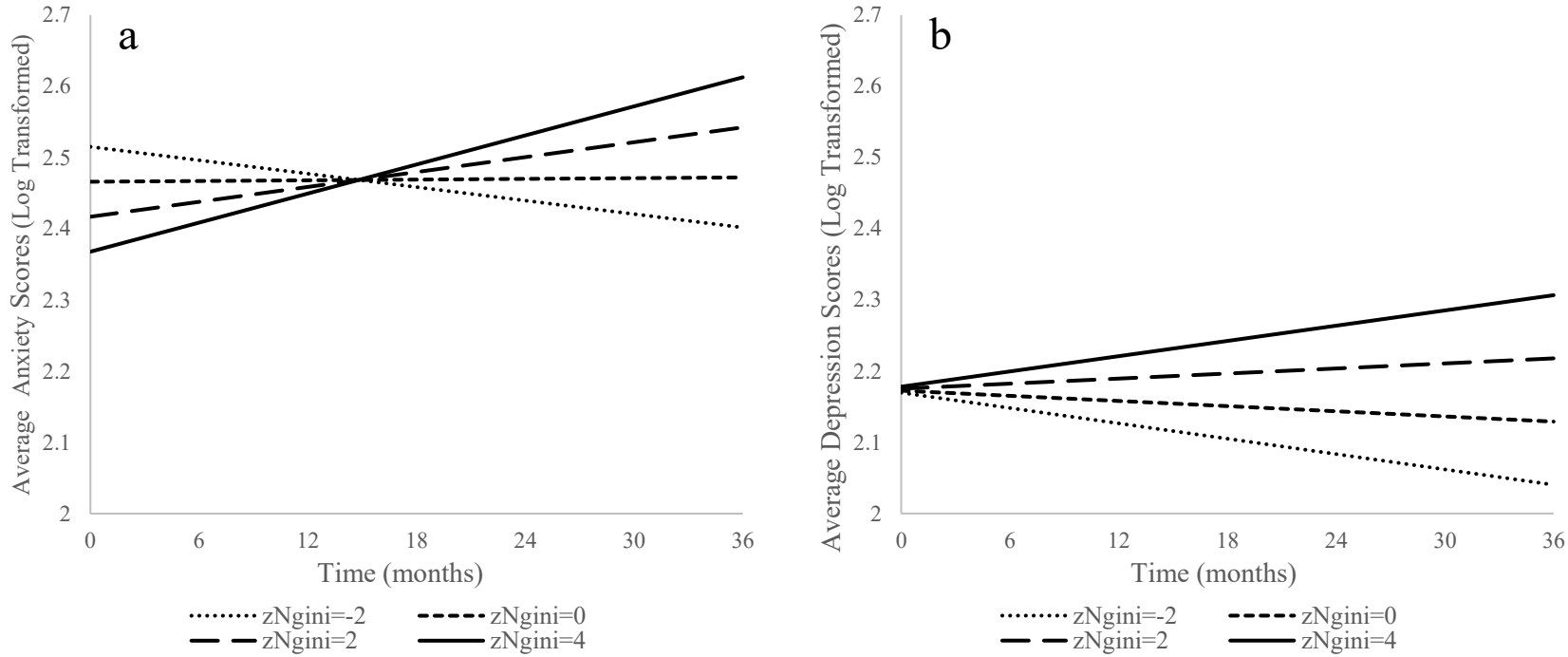

Figure 4.3. Estimated trajectories of log transformed anxiety symptoms (**a**, left) and depressive symptoms (**b**, right) of AOF mothers without elevated baseline anxiety (n=2,047) or depressive (n=2,047) symptoms over time by level of neighbourhood income inequality

Table 4.6. Associations between neighbourhood income inequality and dichotomous elevated anxiety and depressive symptoms among mothers without elevated anxiety (n=2,047) or depressive (n=2,047) symptoms at baseline from the All Our Families cohort (2008-2014)[a]

	Elevated Anxiety Symptoms			
	Model 1 OR (95% CI)	**Model 1 OR (95% CI)**	**Model 1 OR (95% CI)**	**Model 1 OR (95% CI)**
Months	**1.022 (1.016, 1.027)**	**1.022 (1.016, 1.028)**	**1.022 (1.016, 1.028)**	**1.025 (1.018, 1.031)**
Gini	0.928 (0.784, 1.098)	0.938 (0.798, 1.102)	0.929 (0.779, 1.109)	0.891 (0.727, 1.093)
*Months	1.004 (0.998, 1.010)	1.004 (0.998, 1.010)	1.004 (0.998, 1.010)	1.004 (0.997, 1.011)
Household Income (ref: $80,000 or more)				
$79,999 or less		**1.383 (1.070, 1.787)**	**1.313 (1.010, 1.706)**	**1.564 (1.120, 2.184)**
*Months				0.992 (0.980, 1.004)
*Gini				1.161 (0.810, 1.663)
*Months*Gini				1.002 (0.988, 1.017)
Ethnicity (ref: white)				
Non-White		**1.338 (1.025, 1.746)**	1.297 (0.991, 1.697)	1.296 (0.990, 1.696)
Education (ref: at least some post-secondary)				
High School or Less		1.191 (0.807, 1.759)	1.189 (0.805, 1.756)	1.195 (0.809, 1.765)
Marital Status (ref: other)				
Married/Common-law		0.628 (0.384, 1.025)	0.638 (0.391, 1.041)	0.657 (0.402, 1.073)
Age (years)		1.007 (0.981, 1.033)	1.009 (0.984, 1.035)	1.010 (0.985, 1.037)
High Proportion LICO (ref: low)			1.096 (0.782, 1.536)	1.099 (0.784, 1.541)
High Proportion Income >100k (ref: low)			0.928 (0.678, 1.271)	0.926 (0.676, 1.268)
High Proportion Visible Minority (ref: low)			1.001 (0.767, 1.306)	1.001 (0.767, 1.306)
High Proportion Recent Immigrant (ref: low)			1.226 (0.933, 1.610)	1.223 (0.931, 1.607)

Table 4.6. Associations between neighbourhood income inequality and dichotomous elevated anxiety and depressive symptoms among mothers without elevated anxiety (n=2,047) or depressive (n=2,047) symptoms at baseline from the All Our Families cohort (2008-2014)[a] (cont.)

	Elevated Depressive Symptoms			
	Model 1 OR (95% CI)	**Model 1 OR (95% CI)**	**Model 1 OR (95% CI)**	**Model 1 OR (95% CI)**
Months	**1.027 (1.020, 1.033)**	**1.027 (1.021, 1.034)**	**1.027 (1.021, 1.034)**	1.027 (1.019, 1.034)
Gini	0.909 (0.755, 1.094)	0.917 (0.763, 1.102)	0.900 (0.738, 1.099)	0.929 (0.739, 1.168)
*Months	1.005 (0.998, 1.012)	1.005 (0.998, 1.012)	1.005 (0.998. 1.012)	1.003 (0.996, 1.011)
Household Income (ref: $80,000 or more)				
$79,999 or less		**1.433 (1.074, 1.911)**	**1.359 (1.012, 1.825)**	1.132 (0.889, 1.936)
*Months				1.002 (0.988, 1.015)
*Gini				0.890 (0.589, 1.343)
*Months*Gini				1.006 (0.991, 1.022)
Ethnicity (ref: white)				
Non-White		1.310 (0.967, 1.775)	1.252 (0.922, 1.701)	1.253 (0.923, 1.701)
Education (ref: at least some post-secondary)				
High School or Less		1.144 (0.741, 1.765)	1.130 (0.732, 1.744)	1.133 (0.734, 1.750)
Marital Status (ref: other)				
Married/Common-law		0.819 (0.457, 1.467)	0.823 (0.460, 1.471)	0.821 (0.458, 1.471)
Age (years)		0.980 (0.952, 1.009)	0.983 (0.955, 1.012)	0.983 (0.955, 1.012)
High Proportion LICO (ref: low)			1.340 (0.913, 1.967)	1.338 (0.911, 1.964)
High Proportion Income >100k (ref: low)			1.161 (0.814, 1.656)	1.158 (0.812, 1.652)
High Proportion Visible Minority (ref: low)			1.135 (0.843, 1.527)	1.135 (0.843, 1.527)
High Proportion Recent Immigrant (ref: low)			1.261 (0.929, 1.710)	1.261 (0.929, 1.711)

[a] bolded values indicate statistical significance at $p \leq 0.05$

Sensitivity Analyses

For mothers without elevated anxiety symptoms at baseline who also did not indicate a history of any mental disorder (n=2,210), 0.68% of the variance in anxiety symptoms was attributable to the neighbourhood level (ICC=0.0068, 95%CI=0.00014, 0.031). These models demonstrated similar results to the previous two sets of anxiety models, including a significant excess rate of change in average anxiety symptom scores over time by level of neighbourhood inequality (β=0.0014, 95%CI=0.00010, 0.0027; p=0.034) in the final adjusted model (Table A.1), and higher income inequality not relating to significantly higher anxiety scores during the follow-up period. For mothers without elevated depressive symptoms at baseline who also did not indicate a history of any mental disorder (n=2,208), 0.58% of the variance in depressive symptoms was attributable to the neighbourhood level (ICC=0.0058, 95%CI=0.0012, 0.027). As with the previous sets of depressive models, these analyses did not find evidence of a significant association between neighbourhood income inequality and changing depressive symptoms (Table A.1). For both outcomes, there was no evidence of cross-level interaction.

The dichotomous models indicated that the prevalence of elevated anxiety symptoms and elevated depressive symptoms across neighbourhoods ranged from 3.8% to 8.5% (with an average of 5.7%) and 2.4% to 6.8% (with an average of 4.0%), respectively. For both outcomes, there was no evidence of significant associations with income inequality or cross-level interactions (Table A.2)

When considering the first four time points, 0.75% of the variance in continuous depressive symptoms was attributable to the neighbourhood level (ICC=0.0075, 95%CI=0.0019, 0.029), with the prevalence of elevated depressive symptoms across neighbourhoods ranging from 2.8% to 9.3% with an average of 5.2%. As with the previous depressive models that included all six time points, both continuous and dichotomous models did not find significant associations with income inequality or cross-level interactions (Table A.3, A.4).

4.4 Discussion

To our knowledge, this current work is one of few longitudinal studies that investigates the relationships between income inequality and maternal mental health, and the first to include pregnant mothers and consider maternal mental health in a Canadian context. This research builds on previous work demonstrating that increasing inequality is linked to poorer mental health among mothers of young children (42). Our results indicate that income inequality is associated with different rates of change of maternal mental health symptoms over time, with high levels of inequality relating to upward trends in average anxiety symptom scores, and steeper trends among mothers without a baseline experience of anxiety. We did not find statistically significant interaction effects between income inequality and household income on maternal mental health outcomes, suggesting that inequality impacts mothers regardless of their absolute income. This study's findings provide reinforcement for previous studies linking inequality to adverse mental health outcomes (118,119,123–126). In particular, studies of adolescents in Iceland demonstrated repeated cross-sectional associations between increasing income inequality and higher anxiety symptoms (125), and between decreasing community-level income inequality and decreasing anxiety symptoms (126). As with our results, these studies did not find significant associations between income inequality and changing depressive symptoms.

While the specific mechanisms linking income inequality to adverse health are still unclear (chapter 2), especially among women and mothers, proposed mechanisms including stressful social comparisons and a decline in social cohesion (34,40) could account for neighborhood-level associations. In neighbourhoods with a greater gap between rich and poor residents, invidious social comparisons could emerge due to a growing sense of relative deprivation (164). These comparisons could elicit feelings of stress, inferiority, and shame, and lead to adverse mental health outcomes such as elevated anxiety symptoms (40,77). Although we did not include an individual measure of relative deprivation (e.g., Yitzhaki Index) in our study, this theory is consistent with association between area-level income inequality and individual health (40,123,164). Widening income inequality could also lead to an erosion of social cohesion and a decline in community engagement, which could incite poor mental health through heightened social isolation, mistrust, and a lack of social capital (34,77). While some studies have found evidence supporting this mechanism (77,93), others reported that social cohesion and social capital failed to act as mediators between income inequality and mental health outcomes

(123,124). Further research on these mechanisms is needed to clarify how inequality engenders adverse mental health outcomes among pregnant women and mothers.

This study found an excess rate of change in anxiety symptoms over time by increasing levels of income inequality, with larger effect sizes and steeper trajectories among mothers with no baseline experience of elevated anxiety symptoms. Considering that mental health comorbidities and history of mental illness are strong predictors of adverse mental health (6,18,20,23,28), it is possible that high income inequality impacts those without previous experiences of mental illness more strongly. Further, the results of this study indicate that higher income inequality was associated with an excess rate of change in anxiety symptoms over time, but not with significantly higher anxiety scores during our follow-up to 3 years postpartum, which supports the notion of a lag period between exposure to income inequality and the onset of adverse health outcomes (40,133,134,165). Studies have provided evidence that income inequality begins increasing the risk of mortality at five years with effects peaking at seven years (134), and that previous exposure to income inequality up to 15 years prior is associated with worse self-rated health (133). Currently, no study specifies a specific time frame for the lagged influence of income inequality on mental health outcomes. Longitudinal studies with longer follow-up periods, as well as studies employing predictive modelling approaches, could address this gap.

Our results conflict with previous work reporting associations between income inequality and depression outcomes (15,42,118,120,123). These studies provide cross-sectional and longitudinal evidence at the neighbourhood (118,120,123), state (42), and pooled meta-analysis (15) levels that increasing inequality is linked to higher levels of depressive symptoms and depression. While this study reinforces the results of Kahn et al., (42) of an association between income inequality and maternal mental health outcomes, we did not found a significant association with depressive symptoms. A potential explanation for this discrepancy is that heightened anxiety could be a more sensitive and immediate response to high income inequality (126). For example, exposure to income inequality could trigger stress and status anxiety directly, while prompting feelings of depression through the more gradual erosion (i.e. longer lag period) of social connection and emergence of distinct social strata (34,35,40,126). The discrepancy could also be due to contextual differences between the AOF sample of Calgary neighbourhoods and other areas, as much of the literature linking inequality and mental health is

based in the United States (15,35). Depression could be impacted by inequality more heavily in the United States, as the US has notably high levels of inequality and social stratification, and poor social safety nets (30,35). However, when comparing the estimated trajectories of average mental health symptom scores and model coefficients, we observed similar trajectories for depressive and anxiety symptoms by level of neighbourhood income inequality despite a lack of statistical significance for depressive symptoms. From a practical standpoint, these trends suggest that higher levels of neighbourhood income inequality could be prompting the divergence of various mental health symptom trajectories over time, and that the current study was simply unable to capture the statistical significance of this relationship.

When testing for cross-level interactions, this study did not find evidence of differential associations between income inequality and mental health across levels of household income. While these findings align with results of previous studies from Canada (108) and Japan (112) that also found no interactions between income inequality and individual income, they diverge from other studies reporting that associations between income inequality and mental health outcomes are more pronounced (42,110,125) or exist only (107,118,123) among lower income and economically-disadvantaged populations and individuals. Despite this lack of interaction, these results still support the income inequality hypothesis, which posits that income inequality can be detrimental to everyone in a given area regardless of individual socioeconomic standing (35,124,126,166). If income inequality influences mental health trajectories and elicits poor health outcomes via invidious social comparisons and eroding social cohesion, its impacts (e.g., mistrust, social isolation, loss of social capital) would likely be felt by all members of a community, not just the poorest and the most disadvantaged (34,166).

Additionally, after running the dichotomous models, we did not find any evidence of significant associations between income inequality and changes in the odds of elevated anxiety or depressive symptoms. Although a lack of significant findings with dichotomous outcomes conflicts with previous findings that higher inequality is associated with an increased odds of depression (15,42,100,107,110,111,118), there are various potential explanations for this lack of statistical significance. When an outcome variable is dichotomized, a portion of the variability in that outcome is being hidden within each category (167). Despite using validated cut-off scores (137,156,160), dichotomization characterizes individuals scoring just below or just above the cut-off threshold as markedly different, despite possessing similar levels of symptoms (167).

Further, dichotomizing an outcome involves a loss of information and subsequent reduction in statistical power, thus supporting the inclusion of continuous outcome measures where possible (167).

It is worth noting that while we did find a significant link between neighbourhood inequalities and excess rates of change in anxiety symptoms, that the neighbourhood-level variance for the mental health outcomes in this study was low. This low level of variance suggests that area-level characteristics such as income inequality can only account for a small portion of individual health outcomes (126). However, income inequality is a feature of the shared socioeconomic environment, meaning that everyone living within an unequal area is exposed to that inequality. Thus, while inequality might only explain a modest amount of variation for a given individual health outcome, it is still of concern to public health as it could impact a large variety of health and social outcomes (30,34,35,39,61,126). This rationale aligns with Geoffrey Rose's population strategy approach to health, whereby attempting to shift the distribution of exposure in a 'healthier' direction (e.g., towards a more equitable distribution of income) could have considerable benefits for the population as a whole (168). Therefore, when combining the current studies' findings with existing literature, there is sufficient indication that mitigating the impacts of inequality could have a variety of benefits for social equity and population health.

A main strength of this study was its longitudinal multilevel approach that included six data collection points over a six-year period. Multilevel modelling allowed us to analyze longitudinal trends while accounting for unequally spaced time points and incomplete outcome data (135). This longitudinal approach established temporality of exposure to income inequality as preceding observed changes in mental health outcomes; a key criterion for robust epidemiological associations (40). The lengthy follow-up period of six years allowed us to capture the divergence of longitudinal mental health symptom trends over time, which could have been missed with a cross-sectional approach. Unlike many previous studies, this study considered anxiety and depressive symptomatology as distinct mental health outcomes, rather than focusing solely on depression or general mental illness. This distinction prevents the conflation of different forms of adverse psychological outcomes, and accounted for the potentially distinct pathways between inequality and the specific mental health outcomes. Finally, by conducting this study at the level of city neighbourhoods, we were presented with a

broad range of income inequality between neighbourhoods. Choosing this geographic scale mitigated the constraints of previous Canadian work at the province level, which highlighted the small range of income inequality between Canadian provinces as a potential explanation for non-significant findings (108).

The findings from this study should be interpreted within the context of study limitations. Data on residence following baseline was not available, so some mothers might have moved during the study period, thus affecting their exposure and introducing exposure misclassification. Mothers who were lost to follow-up differed from retained participants in terms of various characteristics that are potential risk factors for mental illness (age, relationship status, education, income) (147), thereby potentially introducing selection bias and limiting the generalizability of the results. It is possible that income inequality also influences mental health through mechanisms at larger scales (e.g., provinces and country levels), such as via the neo-materialist pathway (34,35,57,77), so results could have underestimated the relationship between income inequality and maternal mental health (40). This study's reliance on self-report outcome measures instead diagnostic assessments by trained mental health professionals could have introduced outcome misclassification, and using two different tools (EPDS and CES-D) to construct a continuous longitudinal measure of depressive symptoms could have generated measurement bias, despite the POMP scaling approach. However, both depression scales focus on constructs surrounding depressed and positive affect (137,159), have been validated and widely-used in both perinatal and general population settings (19,42,137,159), and have demonstrated the same level of accuracy when screening the same sample of pregnant and postpartum mothers (19). Furthermore, the results from the sensitivity analysis of depressive symptoms at the first four time points (assessed using only the EDPS) did not differ substantially from the analyses using all time points and both scales. Due to the observational nature of this study, we were unable to account for all potential confounders, such as economic deprivation, perceived social cohesion, stressful life events, and subjective social status (78,107,123). Thus, the results might be influenced by residual confounding. Finally, the generalizability of the study findings is limited to urban areas with comparable population sizes and sociodemographic profiles to Calgary (161), especially considering the high proportion of women in the study sample who were white, married, highly educated, and of relative high SES.

This investigation considered how 2006 levels of income inequality related to maternal mental health outcomes over a six-year period, and as such, did not account for changes in income inequality over time. Historical and contemporary trends in income distributions demonstrate that inequality is highly dynamic at both local and international levels (44,45,61,65–67), with Calgary in particular having experienced large increases in income inequality over the past four decades (44,67). By including only 2006 levels of inequality, it is possible that this study underestimated the longitudinal associations between neighbourhood-level income inequality and maternal mental health. Additionally, depending on the degree of increase of neighbourhood-level income inequality, significant associations for both anxiety and depressive outcomes could have emerged had this study accounted for changing and growing trends in Calgary income inequality.

This issue of changing trends in inequality is especially relevant in the context of the current novel coronavirus SARS-CoV2 pandemic (COVID-19); an ongoing public health crisis that has been linked to steep declines in mental health among women (169–171) and mothers (56,172,173). For example, a study of 641 mothers sampled via online surveys during the COVID-19 pandemic reported prevalence estimates of maternal anxiety and depression ranging from 29.59%-36.27% and 33.16%-43.37%, respectively; considerably higher than non-pandemic estimates (172). Currently, the impacts of COVID-19 on income inequality are less clear. However, evidence compiled from previous major epidemics suggests that COVID-19 could widen income inequalities across countries and populations, with negative impacts felt especially among vulnerable populations including low-income and low-educated groups (174). This assertion is supported by evidence of a 'k-shaped' economic recovery, wherein certain industries and groups have experienced relative economic stability and growth during the pandemic (e.g., financial and information industries, investors, those who can work from home) while others have experienced increased unemployment and financial strain (175). Future studies should consider how changing levels of income inequality relate to mental health outcomes over time, especially within the context of large-scale events like COVID-19 that have extensive health and economic implications.

The current study addresses gaps in the literature by exploring longitudinal associations between neighbourhood income inequality and mental health among pregnant and new mothers living in Calgary, and provides a foundation for future studies in a similar vein. Although the

AOF study population is fairly representative of other parenting women in Calgary (147,161), it would be beneficial to repeat this study with a more diverse sample of pregnant and new mothers. For example, since only one study captured in the narrative review of association studies (117; see chapter 3) stratified their analysis by ethnicity, repeating our analyses using more racially heterogeneous study samples could provide deeper insights into the role of race and ethnicity as potential effect modifiers. Additionally, while age does not appear as an effect modifier in the literature (see chapter 3), a study by Dorling et al. (176) found in their analysis of 30 OECD countries that the association between income inequality and mortality varied with age. Specifically, higher Gini was significantly associated with higher mortality among younger age bands (e.g., 15-19 years, 20-24 years, 25-29 years), but not among older age bands (e.g., 55-59, 60-64, and older) (176). Thus, future studies of income inequality and maternal mental health could analyse samples with broader age ranges and stratify to determine if inequality impacts various age groups differently.

While this study focused specifically on pregnant and new mothers to account for the unique physiological and social changes and pressures that these women experience, similar studies that include all residents of the neighbourhoods included in this study would be useful to determine if associations between income inequality and mental health outcomes also exist for more general urban populations. Alternatively, conducting association studies with specific vulnerable populations, such as single mothers, adolescents, LGBTQ2S+ and other gender non-conforming individuals, and persons living with disabilities, could highlight aspects of intersectionality in relation to income inequality and mental health.

As the specific mechanisms linking inequality to health remain unclear, research on the mediating role of stressful social comparisons, deprivation, community engagement, and social cohesion could help clarify these associations. Work investigating potential mechanisms could take the form of statistical mediation analyses, such as latent growth-curve and autoregressive modeling (177), or follow-up qualitative investigations to gain a better sense of the lived experiences of mothers living in high income inequality areas (31,178). Of note, the timeframe of AOF data included in this study (2008-2014) aligns with a substantial rise in social media usage and the emergence and popularisation of social media platforms such as Facebook, Twitter, Instagram, and Snapchat (179). While the literature on social media use and adverse mental health outcomes is mixed (180), there is evidence that social media use can promote

negative social comparisons leading to increasing rumination (repeated focusing on distress), which can in turn lead to depressive symptoms (181). Considering the ubiquity of social media in contemporary society, future studies exploring the potential mechanisms linking income inequality to mental health, especially the social comparison pathway, should consider social media use as a possible mediating factor.

Finally, we recommend future studies on the mental health impacts of interventions that aim to address the broader socioeconomic contexts of income inequality. To clarify, intervening to address income inequality does not mean striving for complete social homogeneity. This clustering of 'like with like' in a given area could engender an array of adverse health and socio-economic impacts through decreased social opportunities and mobility, poor or absent health services, increased segregation, and the concentration and stigmatization of poverty (122,129,182). Rather, equitable interventions should aim to narrow the widening gaps between those at opposing ends of the income spectrum without compromising other important aspect of socio-economic, societal, and cultural heterogeneity. Legislation of minimum wage increases is one such intervention that could serve as a topic of future study (35). By furthering our understanding of the health impacts of inequality while evaluating and promoting equitable interventions, we can address mental health in a more comprehensive way for mothers, their children, and the general population.

The overall public health implications of this study in combination with prior work linking income inequality to adverse mental health outcomes are two-fold. Finding associations between income inequality and maternal mental health symptoms specifically at the neighbourhood-level suggests that more proximal interventions would be appropriate for addressing the negative health impacts of income inequality. Targeted mental health screening of mothers living in high inequality areas could help ensure that those with heightened levels of symptomatology are identified and treated. This approach of early identification, combined with other interventions including digital self-care materials (e.g., evidence-based apps) and individual and group therapies (e.g., cognitive behavioral therapy), can be effective during the subclinical stages of mental illness in preventing the onset of more severe symptoms (15,183). The perinatal period presents an optimal time for these individual-level interventions, as mothers are frequently interacting with health providers and services during this time (52).

However, focusing solely on interventions at the individual-level would fail to address the exposure of income inequality itself, which is a characteristic of the shared environment that relates to the broader social, economic, political, and cultural contexts of a given area (15,30,35,66). Thus, population-based structural interventions aimed at reducing the gap between the rich and the poor are also warranted. Enacting progressive taxation policies (i.e., higher tax rates for those in higher income brackets) at larger scales (e.g., provincial, federal) is one such approach (15,184). Evidence from the United States suggests that periods of national progressive taxation reduce income inequality and provide mental health benefits to poorer individuals without noticeable detriment to richer individuals (184). Increasing the minimum wage is another approach aimed at narrowing the income gap (35), however its impacts on mental health outcomes require further investigation. Employing both individual and structural-level interventions such as these should allow decision makers and healthcare providers to address income inequality and its health impacts in a more holistic way, and ultimately promote a more equitable distribution of the social determinants of health.

– CHAPTER 5: CONCLUSION –

This thesis sought to further clarify the associations between income inequality and adverse mental health outcomes. The main objectives were to: 1) conduct a narrative review of existing association studies linking income inequality and mental health outcomes to identify limitations and gaps in current knowledge; 2) quantify the relationships between neighbourhood income inequality and maternal anxiety and depressive symptoms by applying a multilevel modelling approach to a Canadian study population; and, 3) determine if these relationships vary by level of household income. A narrative review of the literature on association studies (chapter 3) was conducted in response to the first objective, and focused on identifying the trends, limitations, and gaps of the current literature. To address the following two objectives, a secondary data analysis using retrospective cohort data from the AOF study was conducted (Chapter 4) using a longitudinal multilevel approach to investigate the associations between neighbourhood-level income inequality and continuous and elevated maternal anxiety and depressive symptoms. Ultimately, both the literature review and analytic study in this thesis provide support for the income inequality hypothesis.

The narrative literature captured 38 studies that encompassed various study populations, geographic locations and scales, study designs, mental health outcomes and measures, and inequality measures. Despite mixed findings, the majority of these studies demonstrated that higher levels of income inequality were associated with poorer mental health. This review provided important insights into some of the common limitations of previous work, including an abundance of cross-sectional studies, frequent use of non-distinct mental health target outcomes (e.g., general mental health, distress, combined anxiety and depression) and dichotomous outcomes, and inability to include important covariates (e.g., absolute income, educational attainment, marital status). In addition, the review highlighted several gaps, including a paucity of studies that focus on women and mothers, Canadian populations, or anxiety as a distinct mental health outcome. These gaps and limitations informed the direction of this thesis, as well as the design and conduct of the analytic study chapter. As such, literature reviews (narrative, systematic, scoping, and otherwise) should be recognised and upheld as key components of the research process, and should be updated on an ongoing basis as our knowledge of income inequality and mental health continues to evolve and deepen.

Overall, findings from the analytic study of this thesis provide support for the hypothesis that income inequality is associated with worsening mental health over time. Among this sample of AOF mothers, higher income inequality was significantly associated with an excess upwards rate of change in anxiety symptom scores that was more pronounced among mother without elevated anxiety symptoms at baseline. There was no statistical evidence of the same association for depressive symptom scores, despite demonstrating similar trajectories when graphed, which could be indicative of different pathways or time periods through which income inequality impacts anxiety and depression, respectively. Despite the limitations of this study, such as a lack of inequality measures during follow-up, changing depressive symptom scales, and a potential lack of generalizability, it addressed various gaps in the literature by including both pregnant and new mothers as target populations, employing a longitudinal approach consisting of six time points, and considering anxiety and depression as distinct mental health outcomes. This work provides a foundation for future studies exploring income inequality and mental health, such as similar approaches that consider other sub-populations of interest (e.g., adolescents, LGBTQ2S+ individuals, and single mothers), mediation analyses to uncover the specific mechanisms linking income inequality and maternal mental health, and investigations into how intervention to reduce income inequality might also promote better mental health.

This study, when taken together with existing evidence, highlights the importance of prioritizing the social determinants of health when considering research priorities, resource allocation, and intervention areas. Specifically, the findings provide evidence that higher levels of neighbourhood income inequality are adversely impacting the mental health trajectories of mothers over time. Thus, proximal community-based interventions, such as targeted mental health screening in high inequality neighbourhoods and providing more accessible professional and self-care resources (e.g., counselling centres, group therapy, mental wellness apps), could be effective in mitigating the adverse mental health impacts of inequality especially when offered during the perinatal period (15,52,183). Considering the systemic nature and ubiquity of income inequality, broader population-based interventions are also required to narrow this inequality and improve mental health overall. Some existing evidence suggests that implementing progressive taxation programs can reduce inequality while providing mental health benefits (15,184). Other, less well-studied interventions such as increasing the provincial or national minimum wage (35), could be implemented to reduce inequality by providing a more livable income to those working

lower-paying jobs. Taking both individual- and systems-level approaches to reduce income inequality and its adverse health impacts could have various public health benefits beyond improved mental health, such as reducing deprivation and social isolation, rates of cardiac disease, and mortality (30,34,35,38–40). As levels of income inequality continue to rise, this line of work in the field of social epidemiology should encourage health practitioners and policy-makers to pursue more equitable approaches to supporting and promoting public health for all.

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APPENDICES

Appendix A.1 – The Lorenz Curve and Gini Index

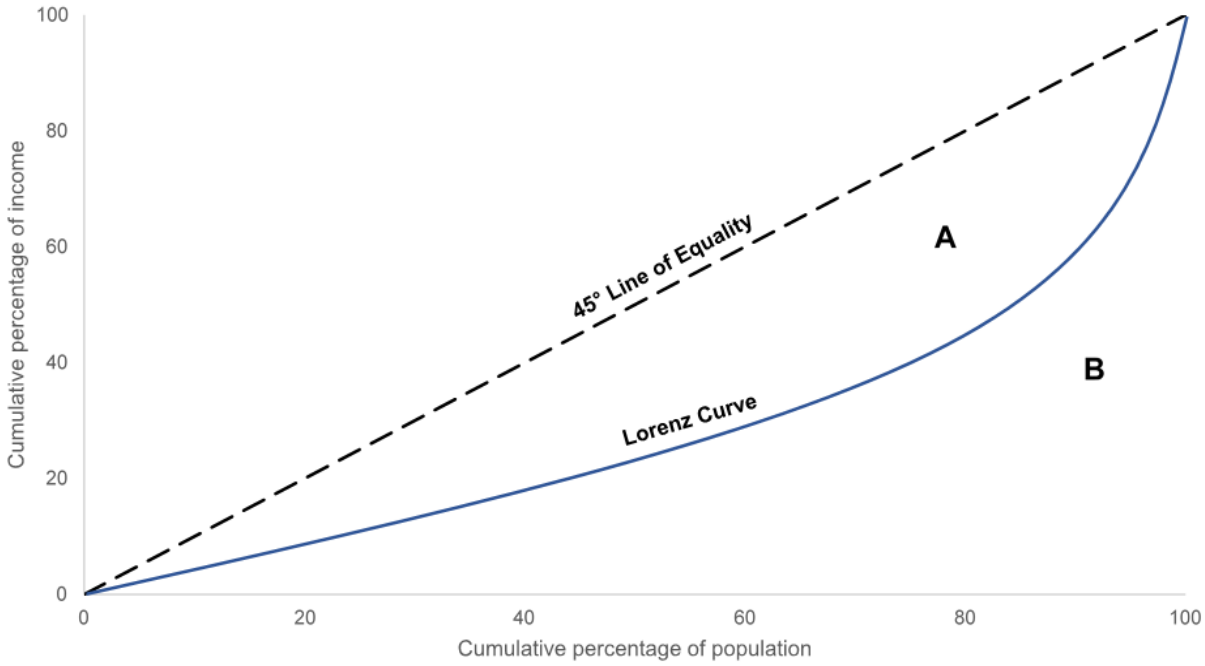

Figure A.1. The Lorenz curve based on a hypothetical distribution of income, Gini coefficients are calculated by dividing the area between the 45° line of equality and the Lorenz curve (**A**) with the total area beneath the 45° line of equality (**A+B**); adapted from De Maio (2007)

Appendix A.2 – Ethics Information

Notification of Approval (Renewal)

Date:	May 19, 2021
Amendment ID:	Pro00083081_REN3
Principal Investigator:	Roman Pabayo
Study ID:	MS4_Pro00083081
Study Title:	Neighborhood income inequality and maternal and child mental health in Calgary
Sponsor/Funding Agency:	CIHR - Canadian Institutes for Health Research CIHR MSI Foundation MSI

RSO-Managed Funding:

Project ID	Title	Grant Status	Sponsor	Project Start Date	Project End Date	Purpose	Other Information
RES0040557							
RES0040064RA							

Approval Expiry Date: May 18, 2022

Thank you for submitting this renewal application. Your application has been reviewed and approved.

Approved Documents:

This re-approval is valid for one year. If your study continues past the expiration date as noted above, you will be required to complete another renewal request. Beginning at 30 days prior to the expiration date, you will receive notices that the study is about to expire. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

Sincerely,

Kimberley Kordov, REB Specialist, on behalf of

Ubaka Ogbogu, LLB, BL, LLM, SJD
Chair, Research Ethics Board 2

Note: This correspondence includes an electronic signature (validation and approval via an online system).

Appendix A.3 – Equation for 95% Plausible Range Values

Overall predicted probability and plausible value range

Overall predicted probability: $1 / 1 + e^{-\gamma 00}$

Where
e = exponential
$\gamma 00$ = Coefficient of the intercept

Plausible value range:
Lower bound: $1 / 1 + e^{-[\gamma 00 - 1.96\sqrt{\tau 00}]}$
Upper bound: $1 / 1 + e^{-[\gamma 00 + 1.96\sqrt{\tau 00}]}$

Where
e = exponential
$\gamma 00$ = Coefficient of the intercept
$\tau 00$ = residual area-level variation

(Adapted for supplementary material of Pabayo et al., 2015)

Appendix A.4 – Examples of Fixed and Random Effects for Multilevel Models

Table A.1. Example of fixed and random effects from modelling continuous anxiety symptoms for the full sample of mothers (n=2,461) with both individual and area-level covariates (model 3)

Dependent Variable: continuous anxiety symptoms	**Coefficient**	**Standard Error**	**P-Value**
Fixed effects			
Intercept	2.87	0.084	<0.001
Level-1			
Months	-0.0014	0.00048	0.003
Level-2			
Low/Moderate Income	0.20	0.038	<0.001
Non-White	0.069	0.039	0.077
HS Education	0.063	0.056	0.26
Marital Status	-0.27	0.070	<0.001
Age	0.0045	0.0037	0.23
Level-3			
Gini	-0.029	0.022	0.19
% Over 100K	-0.12	0.044	0.008
% LICO	-0.032	0.048	0.50
% Visible Minority	0.020	0.038	0.61
% Recent Immigrant	0.029	0.039	0.45
Cross-Level Interaction			
Gini*Months	0.0013	0.00053	0.019
Random effects			
Level-3 variance (intercept)	0.00070	0.0031	<0.05
Level-2 variance (intercept)	0.46	0.017	<0.05
Residual variance	0.44	0.0068	<0.05

Equations for Continuous Anxiety Step-Up Model 3 (individual and area-level covariates)

Outcome = anx_cont (continuous anxiety symptoms)
Level-1 vars = months
Level-2 vars = income, ethnicity, education, marital status, maternal age
Level-3 vars = Gini, income_100k (income >100K), LICO, visible minority, recent immigrant
Interaction term = Gini*months
No random slopes

Level-1 equation

$anx\_cont_{ijk} = \pi_{0jk} + \pi_{1jk}months_{ijk} + \varepsilon_{ijk}$

Level-2 equation

$\pi_{0jk} = \gamma_{00k} + \gamma_{01k}Income_{jk} + \gamma_{02k}Ethnicity_{jk} + \gamma_{03k}Education_{jk} + \gamma_{04k}MarStatus_{jk} + \gamma_{05k}Age_{jk} + u_{0jk}$

$\pi_{1jk} = \gamma_{10k}$

Level-3 equation

$\gamma_{00k} = \delta_{000} + \delta_{001}Gini_k + \delta_{002}Income\_100K_k + \delta_{003}LICO_k + \delta_{004}VisibleMinority_k + \delta_{005}RecentImmigrant_k + \upsilon_{00k}$

$\gamma_{01k} = \delta_{010}$

$\gamma_{02k} = \delta_{020}$

$\gamma_{03k} = \delta_{030}$

$\gamma_{03k} = \delta_{030}$

$\gamma_{04k} = \delta_{040}$

$\gamma_{05k} = \delta_{050}$

$\gamma_{10k} = \delta_{100} + \delta_{110}Gini_k$

where $i=1, 2,..,n_j$; $j=1, 2,\ldots,2{,}461_k$; and $k=1,2,...,196$

Composite Model/Equation

$anx\_cont_{ijk} = \delta_{000} + \delta_{100}Months_{ijk} + \delta_{110}Gini_k*Months_{ijk} + \delta_{010}Income_{jk} + \delta_{020}Ethnicity_{jk} + \delta_{030}Education_{jk} + \delta_{040}MarStatus_{jk} + \delta_{050}Age_{jk} + \delta_{001}Gini_k + \delta_{002}Income100K_k + \delta_{003}LICO_k + \delta_{004}VisibleMinority_k + \delta_{005}RecentImmigrant_k + u_{0jk} + \upsilon_{00k} + \varepsilon_{ijk}$

where
ε_{ijk} is assumed to be independent of u_{0jk}, and υ_{00k}; and
u_{0jk} is independent of υ_{00k}; and
$\varepsilon_{ijk} \sim N(0,\sigma_e^2)$, $u_{0jk} \sim N(0,\sigma_{u0}^2)$, and $\upsilon_{00k} \sim N(0,\sigma_{\upsilon 0}^2)$

Appendix A.5 – Correlation matrix for neighbourhood-level (level 3) variables

Table A.2. Polychoric correlations of neighbourhood-level (level-3) covariates

	Gini	% Over 100K	% LICO	% Visible Minority	% Recent Immigrant
Gini	-				
% Over 100K	-0.29	-			
% LICO	0.54	-0.89	-		
% Visible Minority	-0.21	-0.06	0.02	-	
% Recent Immigrant	-0.25	-0.11	0.04	0.77	-

Appendix A.6 – Sensitivity Analyses

Table A.3. Associations between neighbourhood income inequality and continuous anxiety symptoms and depressive symptoms among mothers without elevated baseline anxiety symptoms and a history of any mental illness (n=2,210) or mothers without elevated baseline depressive symptoms and a history of any mental illness (n=2,208) from the All Our Families cohort (2008-2014)[a]

	Anxiety Symptoms (Log Transformed)			
	Model 1 β (95% CI)	**Model 2 β (95% CI)**	**Model 3 β (95% CI)**	**Model 4 β (95% CI)**
Months	-0.00070 (-0.0017, 0.00031)	-0.00063 (-0.0016, 0.00038)	-0.00063 (-0.0016, 0.00038)	-0.00020 (-0.0014, 0.00097)
Gini	-0.032 (-0.074, 0.010)	-0.024 (-0.063, 0.015)	-0.031 (-0.074, 0.013)	-0.034 (-0.083, 0.016)
*Months	**0.0016 (0.00043, 0.0027)**	**0.0016 (0.00044, 0.0027)**	**0.0016 (0.00043, 0.0027)**	**0.0014 (0.00010, 0.0027)**
Household Income (ref: $80,000 or more)				
$79,999 or less		**0.17 (0.093, 0.17)**	**0.15 (0.071, 0.22)**	**0.17 (0.088, 0.26)**
*Months				-0.0017 (-0.0040, 0.00067)
*Gini				0.010 (-0.078, 0.098)
*Months*Gini				0.00071 (-0.0020, 0.0034)
Ethnicity (ref: white)				
Non-White		**0.098 (0.021, 0.17)**	**0.086 (0.0085, 0.16)**	**0.086 (0.0083, 0.16)**
Education (ref: at least some post-secondary)				
High School or Less		0.054 (-0.059, 0.17)	0.047 (-0.066, 0.16)	0.047 (-0.066, 0.16)
Marital Status (ref: other)				
Married/Common-law		**-0.21 (-0.36, -0.061)**	**-0.19 (-0.34, -0.047)**	**-0.19 (-0.34, -0.043)**
Age (years)		0.00011 (-0.0072, 0.0074)	0.0011 (-0.0062, 0.0085)	0.0013 (-0.0061, 0.0086)
High Proportion LICO (ref: low)			-0.015 (-0.11, 0.080)	-0.014 (-0.11, 0.081)
High Proportion Income >100k (ref: low)			**-0.11 (-0.20, -0.024)**	**-0.11 (-0.20, -0.025)**
High Proportion Visible Minority (ref: low)			0.012 (-0.063, 0.087)	0.012 (-0.063, 0.087)
High Proportion Recent Immigrant (ref: low)			0.016 (-0.060, 0.092)	0.015 (-0.061, 0.091)

Table A.3. Associations between neighbourhood income inequality and continuous anxiety symptoms and depressive symptoms among mothers without elevated baseline anxiety symptoms and a history of any mental illness (n=2,210) or mothers without elevated baseline depressive symptoms and a history of any mental illness (n=2,208) from the All Our Families cohort (2008-2014)[a] (cont.)

	Depressive Symptoms (Log Transformed)			
	Model 1 β (95% CI)	**Model 2 β (95% CI)**	**Model 3 β (95% CI)**	**Model 4 β (95% CI)**
Months	**-0.0025 (-0.0038, -0.0013)**	**-0.0024 (-0.0037, -0.0012)**	**-0.0024 (-0.0037, -0.0012)**	**-0.0022 (-0.0036, -0.00075)**
Gini	-0.0080 (-0.056, 0.040)	0.0010 (-0.043, 0.045)	-0.008 (-0.058, 0.041)	-0.014 (-0.071, 0.043)
*Months	0.0013 (-0.00011, 0.0026)	0.0013 (-0.00011, 0.0026)	0.0013 (-0.00012, 0.0026)	0.0013 (-0.00032, 0.0028)
Household Income (ref: $80,000 or more)				
$79,999 or less		**0.27 (0.18, 0.35)**	**0.25 (0.16, 0.33)**	**0.26 (0.16, 0.36)**
*Months				-0.00086 (-0.0037, 0.0020)
*Gini				0.019 (-0.081, 0.12)
*Months*Gini				0.000 (-0.0032, 0.0032)
Ethnicity (ref: white)				
Non-White		**0.18 (0.088, 0.26)**	**0.16 (0.074, 0.25)**	**0.16 (0.074, 0.25)**
Education (ref: at least some post-secondary)				
High School or Less		0.019 (-0.11, 0.15)	0.012 (-0.12, 0.14)	0.012 (-0.12, 0.14)
Marital Status (ref: other)				
Married/Common-law		**-0.23 (-0.40, -0.064)**	**-0.22 (-0.39, -0.054)**	**-0.22 (-0.39, -0.050)**
Age (years)		-0.0081 (-0.016, 0.00037)	-0.0068 (-0.015, 0.0017)	-0.0067 (-0.015, 0.0018)
High Proportion LICO (ref: low)			0.011 (-0.098, 0.12)	0.011 (-0.098, 0.12)
High Proportion Income >100k (ref: low)			-0.081 (-0.18, 0.020)	-0.081 (-0.18, 0.019)
High Proportion Visible Minority (ref: low)			0.050 (-0.036, 0.14)	0.050 (-0.036, 0.14)
High Proportion Recent Immigrant (ref: low)			-0.0072 (-0.095, 0.080)	-0.0078 (-0.095, 0.080)

[a] bolded values indicate statistical significance at $p \leq 0.05$

Table A.4. Associations neighbourhood income inequality and dichotomous elevated anxiety and depressive symptoms among mothers without elevated baseline anxiety symptoms and a history of any mental illness (n=2,210) or mothers without elevated baseline depressive symptoms and a history of any mental illness (n=2,208) from the All Our Families cohort (2008-2014)[a]

	Elevated Anxiety Symptoms			
	Model 1 OR (95% CI)	**Model 1 OR (95% CI)**	**Model 1 OR (95% CI)**	**Model 1 OR (95% CI)**
Months	**1.007 (1.002, 1.01)**	**1.008 (1.003, 1.01)**	**1.008 (1.003, 1.01)**	**1.01 (1.007, 1.02)**
Gini	0.88 (0.75, 1.04)	0.90 (0.77, 1.04)	0.88 (0.75, 1.04)	0.84 (0.69, 1.02)
*Months	1.005 (0.99, 1.01)	1.006 (0.999, 1.01)	1.006 (0.99, 1.01)	1.006 (0.99, 1.01)
Household Income (ref: $80,000 or more)				
$79,999 or less		**1.64 (1.27, 2.10)**	**1.54 (1.19, 2.00)**	**2.04 (1.50, 2.77)**
*Months				**0.98 (0.97, 0.99)**
*Gini				1.17 (0.85, 1.62)
*Months*Gini				1.001 (0.99, 1.01)
Ethnicity (ref: white)				
Non-White		**1.59 (1.23, 2.059)**	**1.54 (1.19, 2.01)**	**1.54 (1.19, 2.00)**
Education (ref: at least some post-secondary)				
High School or Less		1.20 (0.82, 1.75)	1.19 (0.82, 1.74)	1.19 (0.81, 1.73)
Marital Status (ref: other)				
Married/Common-law		**0.48 (0.30, 0.77)**	**0.49 (0.31, 0.78)**	**0.51 (0.32, 0.81)**
Age (years)		1.005 (0.98, 1.03)	1.007 (0.98, 1.03)	1.01 (0.98, 1.03)
High Proportion LICO (ref: low)			1.10 (0.79, 1.53	1.10 (0.79, 1.54)
High Proportion Income >100k (ref: low)			0.90 (0.66, 1.22)	0.89 (0.66, 1.22)
High Proportion Visible Minority (ref: low)			0.96 (0.74, 1.24)	0.96 (0.74, 1.24)
High Proportion Recent Immigrant (ref: low)			1.23 (0.94, 1.60)	1.22 (0.93, 1.60)

Table A.4. Associations between neighbourhood income inequality and dichotomous elevated anxiety and depressive symptoms among mothers without elevated baseline anxiety symptoms and a history of any mental illness (n=2,210) or mothers without elevated baseline depressive symptoms and a history of any mental illness (n=2,208) from the All Our Families cohort (2008-2014)[a] (cont.)

	Elevated Depressive Symptoms			
	Model 1 OR (95% CI)	**Model 1 OR (95% CI)**	**Model 1 OR (95% CI)**	**Model 1 OR (95% CI)**
Months	**1.007 (1.001, 1.01)**	**1.007 (1.002, 1.01)**	**1.007 (1.002, 1.01)**	**1.01 (1.005, 1.02)**
Gini	0.90 (0.76, 1.07)	0.92 (0.79, 1.08)	0.91 (0.77, 1.08)	0.93 (0.76, 1.14)
*Months	1.005 (0.99, 1.01)	1.005 (0.99, 1.01)	1.005 (0.99, 1.01)	1.00 (0.99, 1.01)
Household Income (ref: $80,000 or more)				
$79,999 or less		**1.86 (1.44, 2.42)**	**1.76 (1.35, 2.30)**	**2.12 (1.53, 2.93)**
*Months				**0.99 (0.97, 0.99)**
*Gini				0.94 (0.67, 1.31)
*Months*Gini				1.006 (0.99, 1.02)
Ethnicity (ref: white)				
Non-White		**1.71 (1.31, 2.23)**	**1.62 (1.23, 2.12)**	**1.62 (1.23, 2.12)**
Education (ref: at least some post-secondary)				
High School or Less		0.97 (0.65, 1.45)	0.96 (0.65, 1.44)	0.96 (0.64, 1.43)
Marital Status (ref: other)				
Married/Common-law		0.61 (0.37, 1.01)	0.62 (0.38, 1.02)	0.63 (0.38, 1.03)
Age (years)		0.98 (0.95, 1.00)	0.98 (0.95, 1.01)	0.98 (0.95, 1.01)
High Proportion LICO (ref: low)			1.21 (0.85, 1.73)	1.22 (0.85, 1.74)
High Proportion Income >100k (ref: low)			1.05 (0.76, 1.46)	1.05 (0.76, 1.46)
High Proportion Visible Minority (ref: low)			1.21 (0.92, 1.60)	1.21 (0.92, 1.60)
High Proportion Recent Immigrant (ref: low)			1.16 (0.87, 1.54)	1.16 (0.87, 1.54)

[a] bolded values indicate statistical significance at $p \leq 0.05$

Table A.5. Associations between neighbourhood income inequality and continuous depressive symptoms among mothers (n=2,461) from <25 weeks of pregnancy to 1 year postpartum from the All Our Families cohort (2008-2012)[a]

	Depressive Symptoms (Log Transformed)			
	Model 1 β (95% CI)	**Model 2 β (95% CI)**	**Model 3 β (95% CI)**	**Model 4 β (95% CI)**
Months	**-0.018 (-0.021, -0.015)**	**-0.018 (-0.021, -0.015)**	**-0.018 (-0.021, -0.015)**	**-0.017 (-0.021, -0.013)**
Gini	-0.017 (-0.071, 0.038)	-0.0099 (-0.058, 0.039)	-0.011 (-0.065, 0.044)	-0.022 (-0.084, 0.041)
*Months	0.0020 (-0.0015, 0.0056)	0.0019 (-0.0016, 0.0055)	0.0019 (-0.0016, 0.0055)	0.0018 (-0.0024, 0.0059)
Household Income (ref: $80,000 or more)				
$79,999 or less		**0.33 (0.24, 0.42)**	**0.31 (0.22, 0.40)**	**0.33 (0.23, 0.44)**
*Months				-0.0017 (-0.0088, 0.0053)
*Gini				0.038 (-0.071, 0.15)
*Months*Gini				0.00089 (-0.0072, 0.0090)
Ethnicity (ref: white)				
Non-White		**0.18 (0.089, 0.28)**	**0.17 (0.073, 0.26)**	**0.17 (0.072, 0.26)**
Education (ref: at least some post-secondary)				
High School or Less		0.012 (-0.12, 0.15)	0.0079 (-0.13, 0.14)	0.0082 (-0.13, 0.15)
Marital Status (ref: other)				
Married/Common-law		**-0.29 (-0.46, -0.12)**	**-0.28 (-0.45, -0.11)**	**-0.27 (-0.45, -0.10)**
Age (years)		-0.00051 (-0.0094, 0.0084)	0.00071 (-0.0083, 0.0097)	0.00099 (-0.0080, 0.0099)
High Proportion LICO (ref: low)			-0.012 (-0.13, 0.10)	-0.012 (-0.13, 0.10)
High Proportion Income >100k (ref: low)			-0.083 (-0.19, 0.024)	-0.085 (-0.19, 0.022)
High Proportion Visible Minority (ref: low)			0.045 (-0.046, 0.14)	0.045 (-0.046, 0.14)
High Proportion Recent Immigrant (ref: low)			0.028 (-0.065, 0.12)	0.027 (-0.066, 0.12)

[a] bolded values indicate statistical significance at p≤0.05

Table A.6. Associations between neighbourhood income inequality and dichotomous elevated depressive symptoms among mothers (n=2,461) from <25 weeks of pregnancy to 1 year postpartum from the All Our Families cohort (2008-2012)[a]

	Elevated Depressive Symptoms			
	Model 1 OR (95% CI)	**Model 1 OR (95% CI)**	**Model 1 OR (95% CI)**	**Model 1 OR (95% CI)**
Months	**0.97 (0.96, 0.99)**	**0.97 (0.96, 0.99)**	**0.97 (0.96, 0.99)**	0.99 (0.97, 1.005)
Gini	0.88 (0.73, 1.06)	0.89 (0.75, 1.05)	0.93 (0.77, 1.11)	0.86 (0.69, 1.07)
*Months	1.009 (0.99, 1.02)	1.009 (0.99, 1.02)	1.008 (0.99, 1.02)	1.02 (0.99, 1.03)
Household Income (ref: $80,000 or more)				
$79,999 or less		**2.52 (1.94, 3.43)**	**2.51 (1.88, 3.36)**	**3.21 (2.27, 4.54)**
*Months				**0.96 (0.93, 0.99)**
*Gini				1.23 (0.86, 1.76)
*Months*Gini				0.98 (0.94, 1.01)
Ethnicity (ref: white)				
Non-White		**1.54 (1.15, 2.07)**	**1.45 (1.08, 1.96)**	**1.45 (1.08)**
Education (ref: at least some post-secondary)				
High School or Less		1.07 (0.70, 1.64)	1.07 (0.70, 1.64)	1.06 (0.69, 1.63)
Marital Status (ref: other)				
Married/Common-law		**0.38 (0.23, 0.62)**	**0.38 (0.23, 0.63)**	**0.38 (0.23, 0.64)**
Age (years)		1.02 (0.99, 1.05)	1.02 (0.99, 1.05)	1.03 (0.99, 1.06)
High Proportion LICO (ref: low)			0.96 (0.65, 1.41)	0.96 (0.65, 1.41)
High Proportion Income >100k (ref: low)			0.96 (0.67, 1.37)	0.95 (0.67, 025)
High Proportion Visible Minority (ref: low)			1.21 (0.89, 1.62)	1.21 (0.89, 1.63)
High Proportion Recent Immigrant (ref: low)			1.25 (0.92, 1.70)	1.24 (0.91, 1.68)

[a] bolded values indicate statistical significance at p≤0.05